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May 2006

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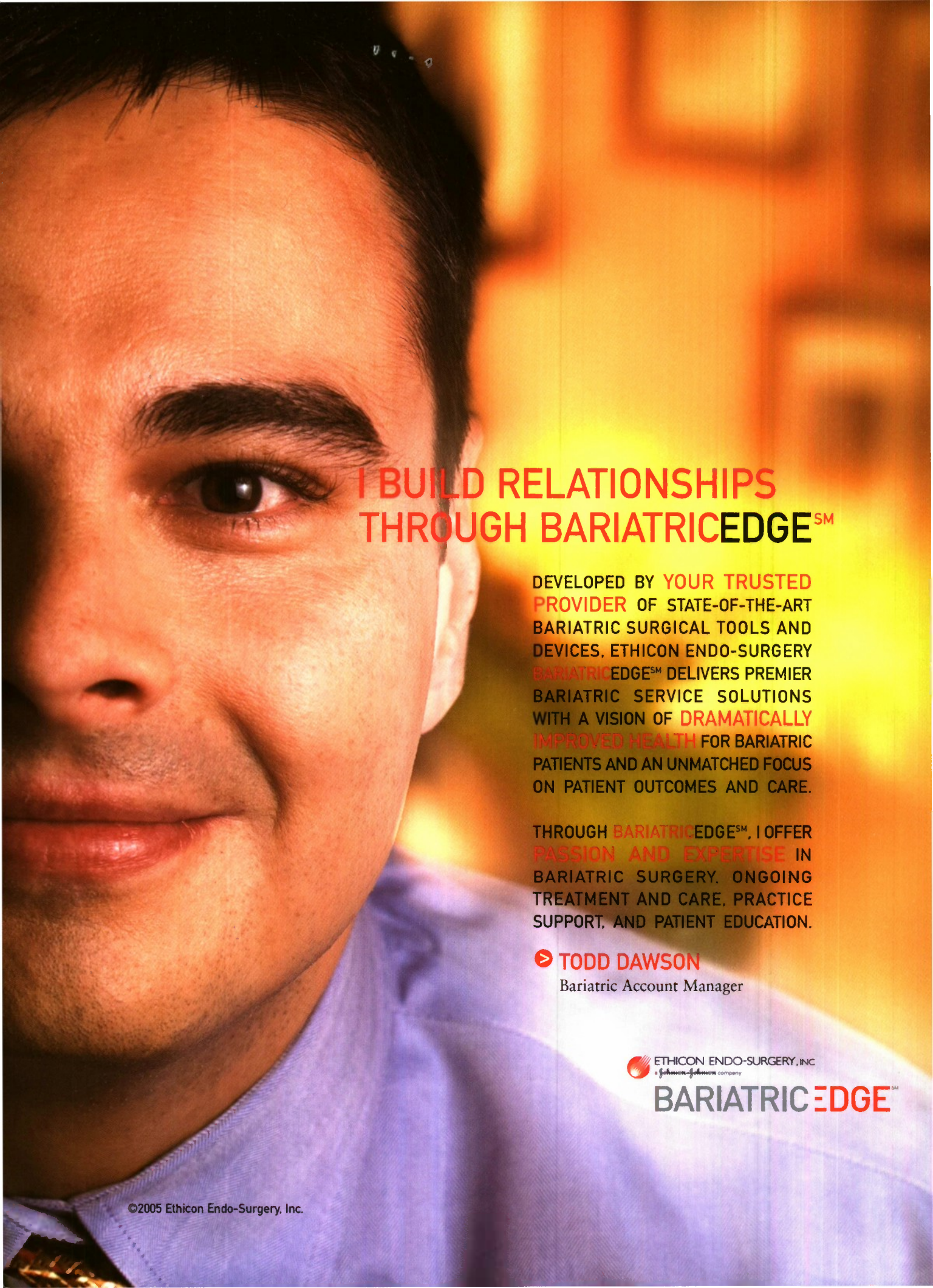
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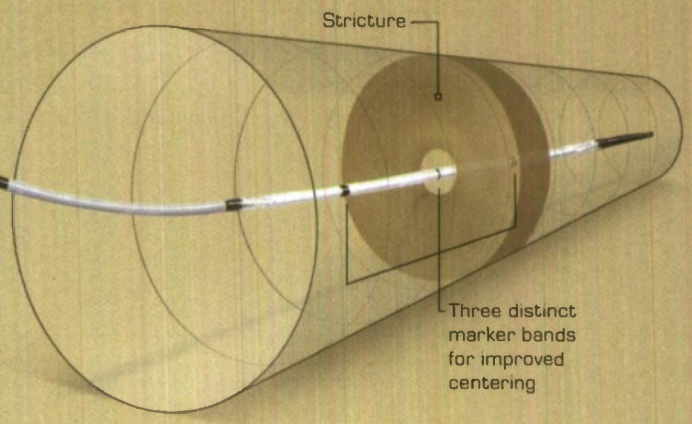

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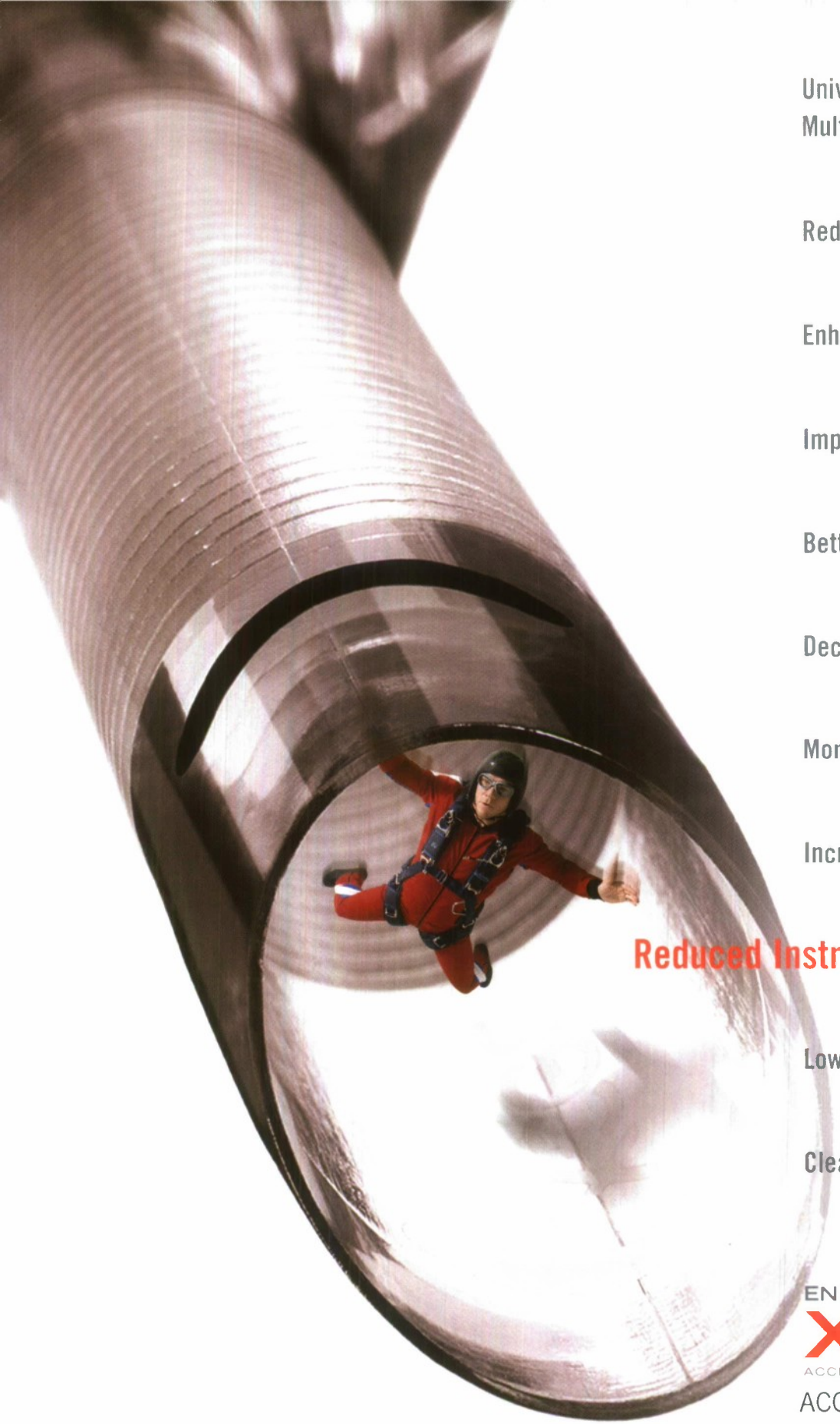

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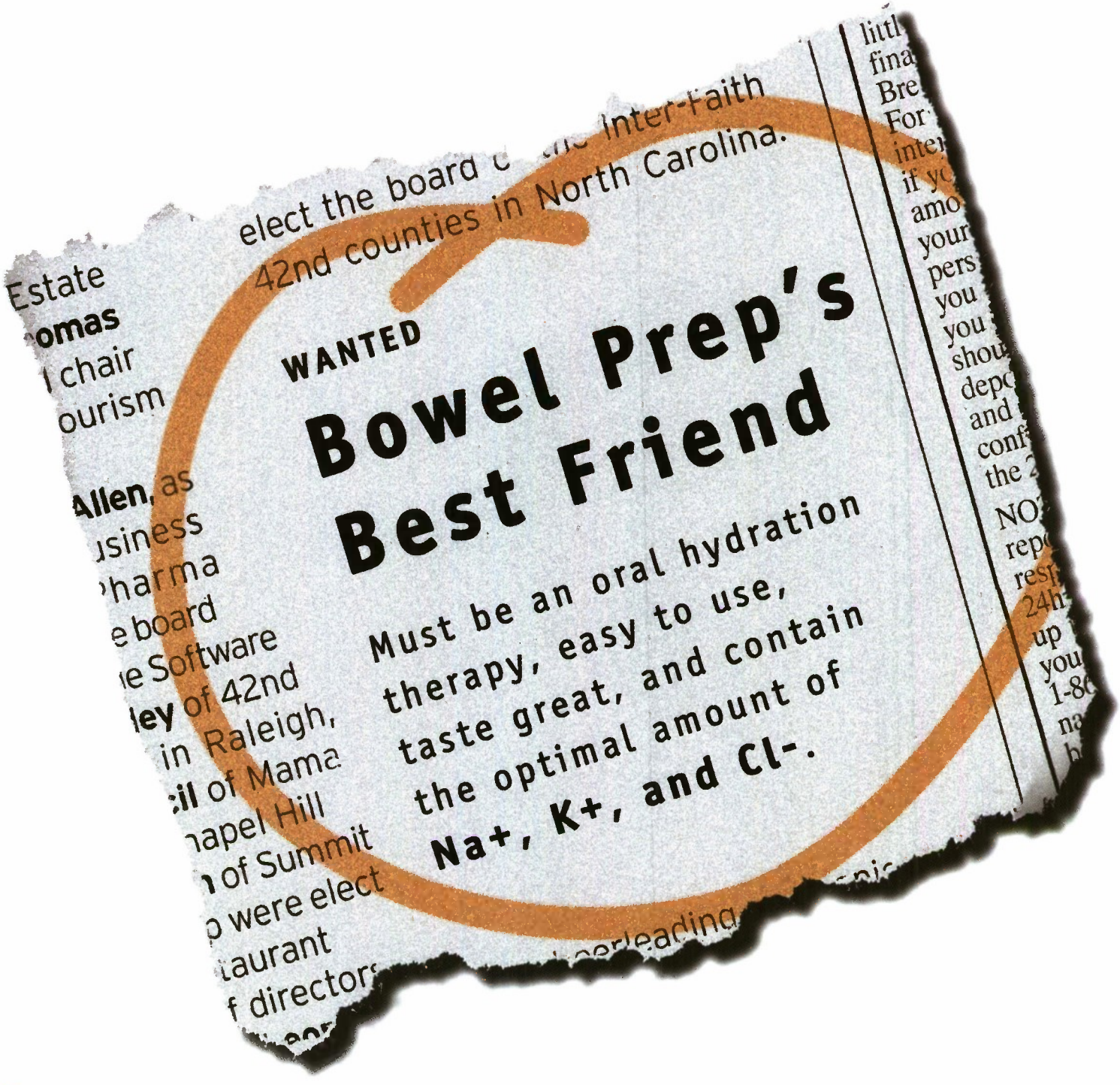

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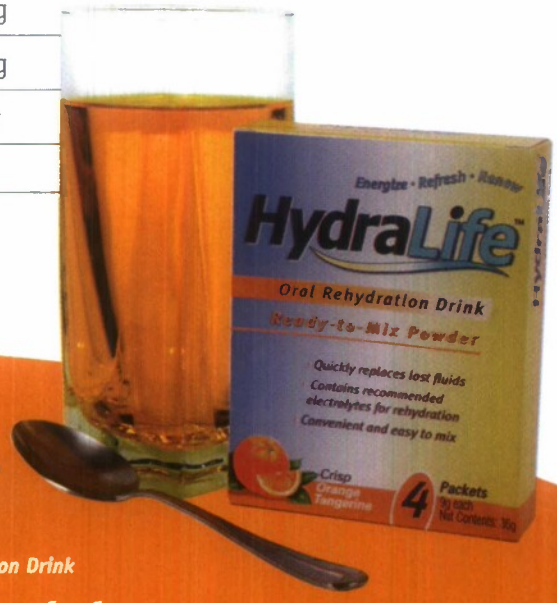

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Surg Endosc (2006) 20: 711–712
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SURGICAL ENDOSCOPY
and Other Interventional Techniques

NOTES: Gathering Momentum

It has been several years since Kalloo in Baltimore and Reddy and Rao in Hyderabad, India began accessing the peritoneal cavity via a transgastric route. Though initially greeted with skepticism–some even called it blasphemy- the idea that intraperitoneal surgery might be performed without an abdominal incision appears to be worth pursuing. In a relatively short time span, the Hopkins group demonstrated the feasibility of performing a gastrojejunostomy via a totally endoscopic/transgastric route. Even more stunning are the reports from Hyderabad of a series of 7 transgastric human appendectomies with good results.

Acknowledging the potential of this novel approach, the leadership of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the American Society for Gastrointestinal Endoscopy (ASGE) appointed a group of 14 members to study and comment on this new technique. This group met in New York City in July 2005 and published its deliberations as the NOTES Working Group White Paper [1]. The White Paper delineated the anticipated technical barriers to further development of NOTES, emphasized the need for development to be carried out by interdisciplinary teams of surgeons and gastroenterologists and emphasized that any human procedures be performed only with IRB approval. Since the White Paper was authored by a small group, it also mandated that a next step should be a larger and more inclusive gathering of interested parties to challenge the tenets put forth in the White Paper and to create a roadmap for NOTES development.

The first international conference on NOTES was held in Scottsdale, Arizona March 9–11, 2006. One hundred forty physicians from 11 countries came as teams (each team had at least one gastroenterologist and one surgeon with access to animal lab facilities). After a morning of lectures describing accomplishments to date as well as the challenges anticipated to move the field forward, participants were assigned to eight separate working groups with the task of developing a detailed roadmap for overcoming the eight technical barriers that had been identified in the original White Paper. The roadmaps from the Working Groups were presented at the closing session the following day. These presentations as well as the White Paper and other related resources have been posted on a Web site, www.nosear.org, for interested parties to see. Equally important was the launch of NOSCAR–the Natural Orifice Surgery Consortium for Assessment and Research.

NOTES is an emerging transdisciplinary therapy based upon a disruptive technology. If NOTES is to reach a stage of widespread clinical applicability there will need to be further innovation and true collaboration on multiple fronts. Experimental work needs to be done to understand the physiologic disruption and infectious complications of NOTES. Better devices are needed for gastric closure, suturing, tissue grasping and manipulation, and anastomosis. Further research is needed to optimize procedure performance. Ultimately, there will be a need for collaborative clinical trials to test the value of NOTES. The establishment of NOSCAR represents a collaborative vision built on the strength and leadership of two strong innovative organizations- SAGES and ASGE. It is our hope that NOSCAR can provide leadership as well as a collaborative common ground to prospectively shape this emerging therapeutic discipline. In short, The NOSCAR group is a rare attempt to prospectively manage a disruptive technology.

We see NOSCAR as the appropriate vehicle for the following tasks:

1) Produce White Papers that define the large challenges needing thought and research.
2) Track portfolios - i.e. groups of similar research projects that address challenges laid out in the White Paper.
3) Provide organization for research projects in such a way as to enhance collaboration and attract funding to key areas of study.
4) Collect (and, in fact, require) submission of data to build a robust outcomes database.
5) Foster collaborative clinical trials.

We anticipate that SAGES and ASGE will establish a joint committee that will guide NOSCAR to identify and foster needed research directions. NOSCAR, through its parent societies is likely to establish a request for proposal process, raise research funds, vet grant applications and oversee a consortium of labs and clinical study

groups. In this fashion, NOSCAR should become the repository for maintaining a portfolio of research projects from interested groups around the world.

As NOTES matures and enters clinical trials it is envisioned that NOSCAR will create and maintain a clinical case registry. Ad hoc NOTES meetings seem likely in the future and NOSCAR, under societal guidance, would organize such meetings. Down the road, if NOTES is shown to be a beneficial technology, NOSCAR might help define scope of practice, competency measures, and work with regulatory agencies on reimbursement issues.

All this is heady talk given the paucity of data currently available. However, the overwhelming sense among the 140 physicians in Scottsdale was that NOTES will develop into a mainstream clinical capability in the near future. Times have changed since the introduction of laparoscopic cholecystectomy nearly two decades ago. The public and profession are no longer willing to accept indiscriminate introduction of new technology, and physicians are focused on keeping quality patient care first. By creating NOSCAR, we hope to introduce NOTES in a safe and responsible way that will provide an even less invasive way of undergoing surgical procedures.

Reference

1. Rattner DW, Kalloo A, SAGES/ASGE working group on natural orifice translumenal endoscopic surgery (2006) White paper. Surg Endosc 20: 329–333

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SURGICAL ENDOSCOPY
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Laparoscopic management of gastrointestinal stromal tumors

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Abstract
Background: Surgery remains the standard for nonmetastatic gastrointestinal stromal tumors (GISTs). Laparoscopic surgery should be considered for these tumors as their biologic behavior lends them to curative resection without requiring large margins or extensive lymphadenectomies.
Methods: A retrospective review was performed of patients who underwent laparoscopic treatment of GISTs by surgeons at the Mount Sinai Medical Center from 2000-2005. Records were reviewed with respect to patient demographics, medical history, diagnostic workup, operative details, postoperative course, and pathologic characteristics.
Results: Laparoscopic surgery was attempted in 43 patients with GISTs. The average age was 65 years and 21 were women. Fifty-six percent of patients presented with anemia or gastrointestinal bleeding. The tumors were located in the stomach (65%) and in the small bowel (35%). The mean tumor sizes were 4.6 cm (stomach) and 3.7 cm (small bowel). Gastric operations included laparoscopic wedge (29%), sleeve (21%), and partial (29%) gastrectomies. The three gastric conversions were due to local invasion of tumor into adjacent organs or proximity to the gastroesophageal junction. Small bowel operations included laparoscopic resections with extracorporeal (47%) and intracorporeal anastamoses (33%). Conversion in small bowel operations was associated with coincidental pathology in addition to the GIST. This consisted of an associated bowel perforation and a synchronous colonic carcinoma. There was one mortality and a 9% morbidity rate, including an evisceration requiring reoperation. All tumors were pathologically confirmed with CD117 immunohistochemistry.
Conclusions: In light of their biologic behavior, GISTs should be considered for laparoscopic resection. This minimally invasive approach to these tumors can be performed safely and reliably.

Correspondence to: C. M. Divino

Key words: Abdominal — Digestive — General — GI — SAGES

Although gastrointestinal stromal tumor (GIST) has been recognized clinically for almost two decades, recent advances in understanding its molecular pathogenesis have brought about rapid improvements in its management. The observation that almost all GISTs express CD117 antigen has led to the use of Imatinib for targeted systemic therapy. However, surgery still remains the primary therapy for nonmetastatic GISTs. Total excision of the tumor is the most significant factor for outcome, with 5 year survival rates of 40% to 55% after complete resection [6, 9].

Surgery for GIST involves en bloc resection of the tumor along with any involved structures. Large margins are unnecessary because these tumors usually grow out of the primary organ instead of diffusely infiltrating. Lymphadenectomy usually is unwarranted because nodal involvement is rare [6, 9]. Typically, wedge resection of the stomach or segmental resection of the intestine is adequate therapy. Laparoscopic surgery may be considered ideal for these tumors because their biologic behavior predisposes them to curative resection without the requirement of large margins or extensive lymphadenectomies. In addition, many of these tumors are diagnosed at pathologic analysis after surgery. Therefore, a diagnostic laparoscopic exploration with excisional biopsy also can be a curative resection. Nevertheless, there is a paucity of data in the literature on the use of minimally invasive surgery for these tumors. This study aimed to investigate the feasibility and safety of laparoscopic surgery for the resection of GIST tumors.

Patients and methods

A retrospective review of patients who underwent laparoscopic surgery for GISTs by surgeons at the Mount Sinai Medical Center from 2000 to 2005 was performed. Cases were identified through the use of a

Table 1. Presenting symptoms

Anemia
Gastrointestinal bleeding
Dysphagia/gastrocsophagcal diseasc
Abdominal pain
Abdominal abscess/perforation
Small bowel obstruction
Incidental finding at surgery
Incidental finding at workup for another illness

hospital pathologic specimen database. Records were reviewed with respect to patient demographics, medical history, presenting symptoms, diagnostic workup, operative details, postoperative course, and pathologic characteristics. Institutional review board approval was obtained before the study was begun.

Results

Laparoscopic surgery was attempted for 43 patients with GISTs during the study period. The average patient age was 65 years (range, 41–92 years), and 22 of the patients were men. Most of the patients presented with signs or symptoms of anemia such as syncope, fatigue, or light-headedness (Table 1). One patient had experienced cryptogenic recurrent minor bleeding for many years, but presented with an acute abdomen attributable to tumor perforation. One-fifth of the GISTs were found incidentally at the workup for other illnesses or at exploration for other causes.

The diagnostic methods used to find the GISTs in this study are outlined in Fig. 1. All the tumors were located in the stomach (67%) or the small bowel (33%). All GISTs originating from the stomach were found using esophagogastroduodenoscopy or computed tomography (CT) scan, except in two patients, whose GISTs were found incidentally at surgery. Patients with small bowel tumors typically underwent numerous diagnostic procedures such as upper and lower endoscopies, contrast studies, capsule studies, and endoscopic ultrasound before the tumors were ultimately found. In two patients presenting with acute bleeding, small bowel tumors were eventually found at urgent exploration after a multitude of negative diagnostic examinations.

Laparoscopic resection was attempted for all the patients (Table 2). The mean gastric tumor size was 4.6 cm (range, 0.4–11.5 cm). Most gastric tumors were removed via laparoscopic wedge resection, partial gastrectomy, or sleeve gastrectomy. These tumors were located at the fundus or along the greater curvature. The largest tumor (11.5 cm), located at the greater curvature, was removed successfully by laparoscopic sleeve resection. Three patients underwent laparoscopic subtotal gastrectomy with gastrojejunostomy for antral tumors. One patient with enlarged retroperitoneal lymph nodes found during exploration underwent laparoscopic lymphadenectomy after gastric sleeve resection of a 8.5 cm fundal tumor. A laparoscopic distal pancreatectomy also was performed in a patient undergoing partial gastrectomy for a tumor invading posteriorly into the pancreas. One cardiac lesion was intraluminally resected via a combined laparoscopic–endoscopic technique.

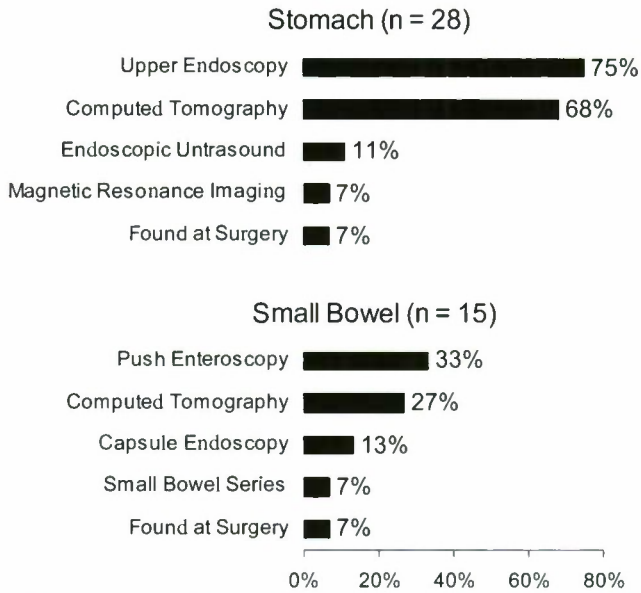

Fig. 1. Diagnostic methods used to diagnose gastrointestinal stromal tumors (GISTs). Multiple methods may have been used to diagnose each case.

Laparoscopic intragastric trocars were used to shell out the tumor, and the mucosal defect was endoluminally closed using suture with endoscopic assistance.

Three gastric operations were converted to open surgery (11%). One patient had a cardiac lesion, requiring conversion for an esophagogastrectomy. Another patient had a fundal tumor. However, laparoscopic wedge resection was difficult because of the tumor's proximity to the gastroesophageal junction. The last gastric conversion occurred in the case of a 10.5 cm tumor that had locally invaded the transverse colon and pancreas. After laparoscopic sleeve resection, the case was converted to a distal pancreatectomy, splenectomy, and transverse colectomy.

Laparoscopic surgery was attempted in 15 patients with small bowel tumors (Table 2). The mean small bowel GIST was 3.7 cm (range, 0.4–8.5 cm) in size. Most of the patients underwent laparoscopic segmental bowel resection with intra- or extracorporeal anastamoses. The largest small bowel tumor (8.5 cm) was successfully removed laparoscopically. One tumor in the proximal ileum had a lengthy serosal stalk, and an excision at the base was performed without bowel resection. Two conversions occurred for the patients with small bowel tumors (13%). One patient underwent a converted ileocolic resection for a colonic carcinoma, and an adjacent GIST tumor was found at pathologic examination. The other conversion involved a patient who underwent a laparoscopic exploration for a spontaneous intraabdominal abscess. The source of the abscess was a perforated GIST, and an open small bowel resection was performed.

The operative and postoperative data are outlined in Table 3. All the tumors were pathologically confirmed to be GISTs by CD117 immunohistochemistry. There were no incidences of tumor rupture or spillage during the laparoscopic operations. However, the large gastric tumor involving the pancreas and colon could not be

Table 2. Operations performed

Stomach (n = 28)	n (%)	Small Bowel (n = 15)	n (%)
Laparoscopic	25 (89)	Laparoscopic	13 (87)
Wedge resection	8 (29)	SBR-extracorporeal anastamosis	7 (47)
Partial gastrectomy	8 (29)	SBR-intracorporeal anastamosis	5 (33)
Sleeve gastrectomy	6 (21)	Excision at tumor stalk	1 (7)
Subtotal gastrectomy	3 (11)		
Esophagogastrectomy	1 (4)		
Intraluminal excision at stalk	1 (4)		
Converted	3 (11)	Converted	2 (13)
Partial gastrectomy	1	Ileocolic resection	1
Sleeve gastrectomy	1	SBR	1
Esophagogastrectomy	1		

SBR = Small bowel resection

Table 3. Operative and postoperative characteristics

	Range
Median Blood loss	50 cc (20–1000 cc)
Median Operative time	143 min (46–336 min)
Median Length of Stay	4 days (1–50 days)
Morbidity	4 (9%)
Evisceration/Pancreatic stump leak	1
Myocardial Infarction	1
Pneumonia	1
Anastamotic bleed	1
Mortality	1 (2%)
Reoperation	1 (2%)

completely removed en bloc, even after conversion to open surgery.

One death occurred in our group, giving a mortality rate of 2%. The patient who died had undergone a partial gastrectomy for a 7 cm GIST. Early in the postoperative period, a colonic carcinoma was diagnosed, and the patient underwent a laparoscopic left hemicolectomy. His recovery was complicated by renal failure and sepsis, leading to death.

Four postoperative complications occurred, giving a morbidity rate of 9%. An anastamotic bleed in a patient with a midjejunal lesion was controlled using push enteroscopy with cauterization. The patient who underwent conversion for sleeve resection, colectomy, pancreatectomy, and splenectomy had to return to the operating room 7 days postoperatively after a coughing spell causing evisceration. At exploration, a panereatic stump leak also was noted. Drains were placed, and the patient was placed on total parenteral nutrition and bowel rest. The patient eventually recovered and was discharged on postoperative day 50.

Discussion

Every GIST is considered to have malignant potential, and complete surgical resection is the primary treatment method. The tumor should be removed en bloc along with any involved structures and organs. Even small tumors (<2 cm) should be approached with aggressive management rather than watchful waiting. Wide margins are not necessary, and lymphadenectomy usually is not required because lymph node involvement is rare [7, 11]. Gentle dissection and avoidance of tumor rupture with subsequent peritoneal seeding are imperative. Therefore, some believe that traditional open surgery should be the mainstay of operative therapy [3].

Our series comprised a group of patients successfully treated with laparoscopic surgery. We believe that laparoscopic techniques may be ideal for GISTs because wide resections and extensive lymphadenectomies usually are not needed. Limited resections with negative margins usually are adequate. Most gastric tumors are in locations accessible by laparoscopic wedge resection or partial gastrectomy, and nearly all small bowel lesions can be removed via laparoscopic small bowel resection. The no-touch technique is imperative to minimize the risk of tumor rupture. We had no cases of tumor rupture, and only one tumor could not be removed en bloc because of local invasion and size.

Few other reports of laparoscopic GIST management exist in the literature. Our study represents the largest series reported to date. Most other studies involve case reports or small series of gastric submucosal tumors with a proportion of GISTs [2, 4, 5, 15, 17]. One group used laparoscopic wedge resection for 34 gastric submucosal tumors, 14 of which were GISTs [14]. In this series, tumor size usually was small, but limited resections were successfully performed laparoscopically, and there were no reports of tumor rupture. Matthews et al. [12], comparing laparoscopic and open resection of gastric GIST, found equivalent operating time and blood loss between the two groups, but shorter hospital stay in the former group.

Three cases (11%) of gastric GISTs required conversion. One of these cases required conversion because the aforementioned tumor was invading adjacent organs. The remaining cases were converted because of the tumor's proximity to the gastroesophageal junction or because of local invasion of adjacent organs. This is consistent with reports in the literature, which suggest that laparoscopic resection without anastamosis should be avoided near the esophagogastric junction due to the risk of clinically significant deformity or stenosis of the area [1, 16]. Laparoscopic intraluminal resections have been described for tumors in this area, limiting the need for extensive resections. With this technique, transgastric trocars and instruments are

used to enucleate submucosal lesions or excise stalked tumors at their mucosal base [16, 18]. One GIST in our series was successfully removed using this laparoscopic transgastric technique. For another patient who underwent conversion, a gastrostomy was made, and the stalked tumor was excised from its intraluminal base.

There is a paucity of literature regarding laparoscopic resection for small bowel GISTs. Furthermore, only case report describes laparoscopic management of small bowel tumors in general [10, 13]. In our series, small bowel GISTs were resected laparoscopically in 15 cases, with only two conversions. These conversions were not because of difficulty with laparoscopic resection. The one patient had an intestinal perforation of an unknown cause, and the other GIST was found incidentally during an operation for another malignancy. In the remaining cases, laparoscopic small bowel resection was performed without difficulty, even for tumors up to 8.5 cm in diameter. No small bowel tumors ruptured intraoperatively. Despite the lack of data in the literature regarding laparoscopic surgery for small bowel GISTs, our series suggests that laparoscopic resection is feasible for these tumors.

There was acceptable morbidity and mortality in our series. The one death actually was unrelated to the operation for the GIST. It occurred after a secondary operation for another malignancy found in the early postoperative period. Most of the other morbidities were managed conservatively, except in the case of one patient requiring reoperation for evisceration.

Because GISTs usually are not confirmed until pathologic analysis, a preoperative diagnosis is rare. Therefore, clinicians must be suspicious of all gastrointestinal submucosal tumors. Recent consensus reports have stated that these tumors are of uncertain malignant potential, and that all tumors should be resected despite an uncertain diagnosis [3, 8]. Therefore, laparoscopic resection may be ideal in these cases because it prevents morbidity when large laparotomies are performed for lesions of unclear pathology. Limited resections can be performed in a minimally invasive manner to achieve both tissue diagnosis and curative resection. However, little information is known regarding the long-term safety of laparoscopic GIST resection. Longer follow-up evaluation is needed to assess the recurrence rate and the survival of patients undergoing laparoscopic surgery, as compared with traditional open operations.

Conclusion

In light of their biologic behavior, GISTs may be good candidates for minimally invasive surgery. Because large margins and extensive lymphadenectomies are rarely indicated, laparascopic resection usually is feasible and can be performed safely. Conversion is associated with proximity of the tumor to the gastroesophageal junction, local tumor invasion into adjacent organs, and coincidental intraabdominal pathology.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Morbidity of laparoscopic surgery for complicated appendicitis: an international study

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Abstract

Background: Although laparoscopic appendectomy has some advantages over open appendectomy, some reports do show more postoperative intraabdominal abscesses.

Methods: A retrospective review of complicated appendicitis managed surgically by eight surgical groups from six countries was undertaken. Among 3,433 patients with appendicitis, 1,017 (29.5%) had complicated appendicitis, which included perforated or gangrenous appendicitis with or without localized or disseminated peritonitis. There were 74 preoperative abscesses (7.4%) and 5 small bowel obstructions.

Results: One patient died. There were 29 postoperative intraabdominal abscesses (2.8%) and 112 mostly minor complications. Conversion to laparotomy was necessary for 28 patients (2.7%). The surgical time ranged from 32 to 132 min (mean, 62 min), and the hospital stay ranged from 1 to 18 days (mean, 3.5 days).

Conclusions: The morbidity rates, particularly for intraabdominal abscesses, were less for laparoscopic appendectomy in complicated appendicitis than those reported in the literature for open appendectomy, whereas operating times and hospital stays were similar.

Key words: Laparoscopic appendectomy — Complicated appendicitis — Postoperative intraabdominal abscesses

Although not considered the "gold-standard," laparoscopic appendectomy (LA) is widely used, and it is generally accepted that it has several advantages over the conventional open appendectomy (OA). On the other hand, some studies report that LA results in increased costs, a longer operating time, and more intraabdominal abscesses (IAAs), but these issues remain controversial. In 1995, the European Association for Endoscopic Surgery endorsed the procedure and stated that there was no evidence of increased prevalence of postoperative septic complications, and that the results were directly proportional to the experience and skills of the surgical group [11]. Several recent metaanalyses and other reports agree with those statements and document the efficacy and safety of LA [2, 6–9, 13, 14, 17–21, 23, 25–31, 33, 34, 36–38, 41, 42]. To document the morbidity of LA in complicated appendicitis (CA), an international retrospective study was undertaken.

Material and methods

Eight groups from six countries participated in a retrospective review of CA. Among 3,433 patients with appendicitis, 1,017 had CA (29.5% of all appendectomies). Complicated appendicitis rates varied in the series of the different contributors from 13% to 48% (Table 1). There were 511 male and 506 female patients. Complicated appendicitis was diagnosed at the time of operation, pathologic examination, or both as gangrenous appendicitis, perforation with local peritonitis (purulent material in the periappendicular area or in the sac of Douglas), or diffuse peritonitis with or without abscess. The complications reported were mortality, residual IAA, port-site cellulitis, localized collections (PI), and reoperations. Duration of the procedure and hospital stay also were analyzed.

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Table 1. Results of laparoscopic appendectomy for complicated appendicitis (CA)

	Total Appys	CA	G	LP	DP	Abscess (preop)	OR time (min) *n* (range)	Conversion	Hospital stay (days) *n* (range)	Complications IAA
D'Allemagne	574	154	52	54	48	0	—	—	5.8	9
Fajardo	445	121	21	65	35	11	52 (31–114)	3	2.3 (2–9)	3
Franklin	342	46	22	15	9	0	48 (38–128)	0	1.8 (1–3)	1
Poggi	634	315	144	101	70	22	70 (40–130)	2	2 (2.5–13)	3
TEC's group	537	94	38	40	16	0	57 (35–140)	0	2.6 (1–4)	4
Delgado's group	620	209	107	92	10	30	74 (40–120)	11	5	7
Cucto	281	78	25	40	13	11	60 (30–132)	2	5 (3–18)	2
Total	3,433	1,017	409	407	201	74	57.4 (30–140)	18		29

Appys, appendectomies; G, gangrene; LP, local peritonitis; DP, diffuse peritonitis; OR, operating room; IAA, intraabdominal abscesses

Results

Of the 1,017 CA patients, 409 had gangrenous appendicitis, 407 had local peritonitis, and 201 had diffuse peritonitis. Preoperatively, 74 patients had an abscess (7.4%) and 5 had small bowel obstruction.

A 92-year-old woman with diffuse peritonitis died of multiple organ failure. Postoperatively, IAA developed in 29 patients (2.8%). A total of 17 underwent reoperation, with 8 undergoing laparoscopy, 8 requiring laparotomy, and 1 undergoing transrectal drainage. Nine abscesses were drained by CT-guided puncture, whereas three patients with localized small collections received only antibiotics. One fistula developed after percutaneous drainage in a diabetic patient, which healed with conservative treatment.

A total of 112 minor complications (11%) were found. In 78 patients, PI developed, including port-site cellulites and 11 small purulent collections, all of which were treated successfully with drainage, antibiotics, and local wound care on an outpatient basis. A prolonged hospital stay for 13 patients was necessitated by ileus ($n = 9$), pneumonitis ($n = 3$), and parenteral nutrition ($n = 1$). There was conversion to laparotomy for 28 patients (2.7%), and surgical time ranged from 32 to 132 min (mean, 62 min). The hospital stay ranged from 1 to 18 days (mean, 3.5 days), although it must be considered that the criteria for discharge varies in different countries. For noncomplicated appendicitis managed by LA (2,415 patients), the surgical groups reported 4 IAAs that required relaparoscopy. This occurred at the beginning of the laparoscopic experience in the surgical groups.

Discussion

Although appendectomy accounts for 6% of all surgical procedures [10] and is among the most common surgical emergency procedures, it has not yet become the "gold-standard" as has laparoscopic cholecystectomy. This might be attributable to the fact that laparoscopic operating rooms, instruments, and nursing staff may not be available or adequate at some hospitals during the night or holiday shifts. As a matter of fact, in many surgical teaching programs, appendectomy, traditionally considered an "easy operation" by many, still is practiced routinely by the conventional method. On the other hand, LA is performed by surgical groups with special interest in mini-invasive surgery, as mentioned by Kazemier et al. [24]. Nevertheless, the procedure is being used with increasing frequency. In several meta-analysis and prospective studies [2, 6–9, 13, 14, 17–21, 23, 25–31, 33, 34, 36–38, 41], its advantages and benefits have been objectively documented. The two main objections cited for its acceptance are higher costs [5, 18] and increased IAA [12, 16, 35, 39, 43] in CA, as reported by the Cochrane review [40]. In that report, the prevalence of IAA was 2.7% in OA, as compared with 4.7% in LA. These data are in direct conflict with the aforementioned studies.

The results presented in this report support the conclusions of Kazemeier et al. [23, 30], Ball et al. [3], Guller et al. [17] and others [9, 19, 30, 42], showing that IAA is less frequent after LA than after OA. It might be said that our results are biased because the participating surgical groups had special interest and expertise in laparoscopic surgery, but they nevertheless prove that if the group is properly equipped and trained, LA in CA can be used with extremely low morbidity, offering the advantages already recognized with this approach.

In these series, more abscesses (IAA) were found preoperatively ($n = 74$, 7.4%) than postoperatively ($n = 29$, 2.8%) ($p < 0.05$). In the noncomplicated appendicitis group, LA for 2,715 patients resulted in only 4 postoperative IAAs, and these reportedly occurred at the beginning of the group's laparoscopic experience. There was one fecal fistula after a CT-guided drainage for an IAA in a 62 year-old diabetic patient with diffuse peritonitis and a pelvic abscess. This fistula closed spontaneously with parenteral nutrition and intravenous antibiotics.

It is precisely in CA that the well-known advantages of LA can benefit a patient: thorough inspection of the entire peritoneal cavity, debridement, irrigation and lavage under direct visualization, avoidance of large abdominal incisions, less immunologic compromise, and fewer pulmonary complications. In a recent review by Novitsky et al. [32], the advantages of laparoscopic surgery over laparotomy in terms of acute inflammatory reaction as well as cell-mediated and peritoneal immunity are emphasized. Whether these advantages result from avoidance of large abdominal incisions, minimal organ manipulation and/or exposure of the abdominal viscera to room air, or decreased postoperative pain and/or pulmonary morbidity remains to be elucidated.

The reoperation rate of 1.7% is very low. With regard to postoperative IAA, all the authors in this study prefer a CT-guided drainage as the first line of treatment. If this fails, a relaparoscopy is the procedure of choice.

The prevalence of CA in this group of patients is 28% (13–48% range between the different groups), which is in agreement with classical and recent studies such as that of Al-Omran et al. [1]. The percentage of patients with CA presenting with gangrenous appendicitis, local peritonitis, and diffuse peritonitis also appears to be in line with the reports for this emergency procedure.

Some of the patients with CA may represent a formidable challenge for exposure, dissection, suturing, and thorough irrigation and lavage. Thus, the procedure cannot be called an "easy operation." In the past 15 years, since the introduction and popularization of laparoscopic cholecystectomy, we all have experienced a learning curve for complicated endoscopic procedures. Certainly, many cases of CA fit into this category. Ball et al. [3] strongly emphasized the fact, supported by observations made in teaching hospitals, that appendectomies frequently are performed as an emergency procedure during the night, and if the resident staff does not have the experience, skills, and guidance to perform such surgery, then residual sepsis will follow. Sometimes, when technical difficulties appear, an inexperienced surgeon will opt for an "early conversion," and then infection of the wounds may complicate the postoperative period, with direct bearing on the expenses.

On the other hand, in the series described in this report, very few PIs (local wound infections) occurred, a fact consistently reported in all papers comparing OA and LA [2, 5, 15, 16–18, 23, 24, 27, 30, 34, 39, 41, 42]. It is important to retrieve the purulent/gangrenous appendiceal specimens in a sterile bag [44], and to perform trocar-site lavage to prevent septic complications.

In the Cochrane study [40], the reviewers concluded that "where surgical expertise and equipment is available and affordable, LA seems to have various advantages over OA." They also concluded that "laparoscopic surgery should routinely be employed at least in special cases, for instance, in young females and in obese patients." An increasing number of surgeons, including the authors of this report, already use LA routinely in all cases of acute appendicitis.

The duration of the operation was 14 min longer for LA in the Cochrane review [40], but many recent reports show similar operating room times, and this finding affects the direct costs of the procedure. Although these may be higher in some instances, the hospital stay, the use of analgesics, and the period of convalescence were less in the current series, all of which must also be considered.

The diagnostic advantage of laparoscopy needs to be stressed because the preoperative etiology cannot be established in 15% to 35% of patients with acute abdomen, as shown in the Cochrane review [40] and in a previous report from our group [7]. This is especially true for women of reproductive age, for individuals at both extremes of life, and for patients currently receiving antibiotics, steroids, or chemotherapy. A diagnostic laparoscopy not only establishes or confirms the diagnosis, but also is a very efficient therapeutic tool.

The hospital stay reported earlier must be seen in a special context because the social security systems of some European countries are at variance with routine practice in the United States. For example, patients in those countries are not required to comply with a limited hospital stay, but can have what would be considered a long hospital stay in our practices. In a recent report [4], LA in CA is followed by a very short hospital stay, sometimes less than 24 h, a fact that our group considers risky because it is our policy to provide at least 48 to 72 h of intravenous antibiotics. This is important because a substantial number of OAs, whether performed for noncomplicated appendicitis or CA, result in wound infections and abscesses, which may delay the hospital stay or require readmission and/or prolonged outpatient care, which must be taken into account when costs are analyzed.

The conversion rate for CA in this study was very low, and this may reflect the experience of the surgeons involved. Before converting to laparotomy in CA, as with any other complicated endoscopic procedures, clinicians must consider the insertion of one or more trocars for additional traction, suction, suturing instruments, and the like. One example of this may be a retrocecal appendix, which frequently in OA requires enlargement of the incision, which subsequently may become infected. Anecdotally, for one patient in our group with an abscess and bowel obstruction, even after placement of an additional trocar, technical difficulties persisted, and Katkhouda et al.'s [22] recommendation of a "finger-assisted procedure" was carried out in a trocar site enlarged to 12 mm, avoiding a laparotomy.

Finally, the definitive proof of the statement that LA in CA has as good if not better results than OA, particularly with regard to the development of IAA, can be confirmed only in a prospective randomized study.

Conclusions

Laparoscopic appendectomy has special advantages for treating patients with CA. In this study, it is shown that morbidity, particularly IAA, was less than that reported for both OA and LA in other studies. Operating times were similar to those for OA, but the hospital stay was shorter. These findings have led many surgeons to adopt LA because of its diagnostic and therapeutic advantages over OA.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Utility of staging laparoscopy in subsets of biliary cancers

Laparoscopy is a powerful diagnostic tool in patients with intrahepatic and gallbladder carcinoma

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Abstract
Background: The aim of this study was to evaluate the utility of staging laparoscopy in patients with biliary cancers in the era of modern diagnostic imaging.
Methods: From September 2002 through August 2004, 39 consecutive patients with potentially resectable cholangiocarcinoma underwent preoperative staging laparoscopy before laparotomy. Preoperative imaging included ultrasonography and triphasic computed tomography for all patients and magnetic resonance cholangiography in 35 patients (90%). Final pathological diagnosis included 20 hilar cholangiocarcinomas (HC), 11 intrahepatic cholangiocarcinomas (IHC), and eight gallbladder carcinomas (GBC).
Results: During laparoscopy, unresectable disease was found in 14/39 patients (36%). The main causes of unresectability were peritoneal carcinomatosis (11/14) and liver metastases (5/14). At laparotomy, nine patients (37%) were found to have advanced disease precluding resection. Vascular invasion and nodal metastases were the main causes of unresectability during laparotomy (eight out of nine). In detecting peritoneal metastases and liver metastases, laparoscopy had an accuracy of 92 and 71%, respectively. All patients with vascular or nodal involvement were missed by laparoscopy. For prediction of unresectability disease, the yield and accuracy of laparoscopy were highest for GBC (62% yield and 83% accuracy), followed by IHC (36% yield and 67% accuracy) and HC (25% yield and 45% accuracy)
Conclusion: Staging laparoscopy ensured that unnecessary laparotomy was not performed in 36% of patients with potentially resectable biliary carcinoma after extensive preoperative imaging. In patients with biliary carcinoma that appears resectable, staging laparoscopy allows detection of peritoneal and liver metastasis in one third of patients. Both vascular and lymph nodes invasions were not diagonsed by this procedure. Due to these limitations, laparoscopy is more useful in ruling out dissemination in GBC and IHC than in HC.

Key words: Biliary carcinoma — Laparoscopy — Staging

Biliary cancers are aggressive tumors with poor prognosis, resulting in formidable diagnostic and therapeutic challenges. Resection is the only potentially curative treatment. Complete tumor extirpation is paramount for long-term survival. The majority of patients have advanced disease at presentation, precluding radical excision. Despite improvements in preoperative imaging modalities, the resectability rate has not increased beyond 40–60% [6, 9, 13, 15, 18]. Laparoscopy has been proposed as a staging modality to identify patients with occult disseminated disease that is missed on preoperative evaluation and thereby avoid the drawbacks of performing unnecessary laparotomy [8, 14, 24]. Laparoscopy resulted in decreased hospital stay and expenses and reduces delay to referral for palliative care [7]. The yield of laparoscopy could vary according to the type of tumor and the preoperative investigations performed for staging the disease. The aim of this study was to evaluate the utility of staging laparoscopy in patients with biliary cancers in the era of modern diagnostic imaging and to identify patients with occult advanced disease.

Materials and methods

From September 2002 through August 2004, 39 consecutive patients with potentially resectable biliary cancers underwent preoperative staging laparoscopy at our institution. Patients with potentially

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resectable intrahepatic cholangiocarcinoma (IHC), hilar cholangiocarcinoma (HC), and gallbladder carcinoma (GBC) were included in the study. There were 25 men and 14 women, with a median age of 56 years (range, 26–76). Chest and abdominal triphasic computed tomography (CT) with vascular reconstruction was performed in all patients. A magnetic resonance cholangiopancreatography (MRCP) was obtained in most patients and in some cases allowed more precise determination of the degree of biliary tree involvement than could be obtained with CT. When a vascular invasion (vena porta, hepatic artery, and their proximal branches) was suspected on CT scan or MRI, an angiography was performed. Cholangiography with biliary drainage (either endoscopic or percutaneous transhepatic) was performed in patients with biliary obstruction to decrease the serum bilirubin level below 50 μmol/L. Preoperative portal embolization was performed in patients who needed extensive liver resection (remnant liver volume < 30% of total liver volume). Clinicopathological data and radiological investigations were examined in a weekly multidisciplinary conference, and only patients ascertained to have potentially resectable disease were included in the study. Pathological diagnosis was confirmed in all patients pre-, intra-, or postoperatively. Previous upper abdominal surgery was not a contraindication for inclusion in the study.

Staging laparoscopy was performed immediately prior to laparotomy in eight patients; for the other patients, laparotomy was delayed until the bilirubin level was < 50 μmol/L. For patients in whom portal vein embolization was planned as a preparation for resection, laparoscopy was performed prior to embolization. Staging laparoscopy was performed according to the standard described technique. Pneumoperitoneum was performed with open technique through an umbilical incision. Insufflation was performed with CO_2 gas to a pressure of 15 mmHg. A 0° laparoscope was used. Additional ports were placed to facilitate liver retraction and perform adhesiolysis when necessary. A complete laparoscopic examination entailed satisfactory assessment of all the greater sac structures: the diaphragmatic and undersurface of the liver, the lesser and greater omentum, the serosal surface of the hollow viscera, and parietal peritoneum of the pelvis and anterior abdominal wall. In the presence of ascites, peritoneal fluid was harvested for cytology. All doubtful lesions located on the peritoneum or on the liver far away from the main lesion were biopsied and sent for frozen section examination. If cytopathology confirmed malignancy, the procedure was terminated. Peritoned cytology was not performed due to its slight additional values [12].

Patients with no evidence of dissemination at laparoscopy underwent laparotomy and resectability was confirmed. An aggressive approach was adopted for resections to achieve a tumor-free resection margin. Our surgical philosophy and approach toward patients with IC and those undergoing liver resections have been previously reported [2, 22].

Clinicopathological details, investigation records, operative findings, and postoperative outcome in patients with unresectable diseases were entered prospectively in a database and analyzed. Yield of laparoscopy was calculated as the ratio of patients identified by laparoscopy harboring occult advanced disease to the number of patients undergoing the procedure. Accuracy of laparoscopy was the proportion of patients with unresectable disease who were diagnosed by laparoscopy.

Results

Preoperative imaging and pathological diagnosis

Concerning preoperative imaging, all patients underwent ultrasonography and chest and abdominal CTs. Thirty-five patients (90%) had a MRCP. Vascular examination was completed by arteriography in nine patients (23%). Endoscopic or transhepatic biliary opacification was performed in patients with HC and GBC and was completed by a preoperative biliary drainage (eight internal and 18 external) in 26 patients (66%). The mean number of preoperative investigations per patient was 3.9.

Final diagnosis was confirmed by pathology after resection or by biopsy if palliative treatment was performed and included 20 HCs, 11 IHCs, and eight GBCs.

Operative findings

Laparoscopic examination was completed in all except one patient. This patient with HC, who had undergone previous upper abdominal surgery, had dense adhesions to the anterior abdominal wall hindering satisfactory examination, and exploration was performed by limited laparotomy. Findings at laparoscopy and laparotomy are outlined in Fig. 1. Fourteen patients (36%) had evidence of advanced disease on laparoscopy and 25 patients were eligible for laparotomy. One patient without advanced disease on laparoscopy underwent portal vein embolization before the planned laparotomy, but 4 weeks later ascites and an aspect of peritoneal carcinomatosis were diagnosed by CT scan and precluded laparotomy. The remaining 24 patients (63%) underwent laparotomy. At laparotomy, nine patients (37%) were found to have advanced disease precluding resection, and 15 (63%) underwent resection of the tumor. Finally, 23 patients had unresectable disease; laparoscopy thus correctly identified 14/23 patients (61%) who had unresectable disease.

The details of findings responsible for unresectability are summarized in Table 1. Laparoscopy correctly identified peritoneal metastases in all except one patient; thus, the accuracy of laparoscopy in detecting peritoneal metastases was 92%. The only patient in whom laparoscopy failed had localized tumor deposits in the pelvis. In identifying liver metastases, laparoscopy had an accuracy of 71% (five out of seven patients). One patient with a large IC in the right liver underwent right portal vein embolization to induce hypertrophy in the remnant liver after staging laparoscopy ruled out dissemination. However, at exploration 40 days later, he had metastases in the left lobe of the liver and regional lymph nodes. Although laparoscopy was not repeated prior to exploration, this was considered a failure of diagnostic laparoscopy (by intent-to-treat analysis). Laparoscopy also failed to detect liver metastases in the patient in whom dense adhesions required conversion to laparotomy for exploration. All patients with vascular invasion or metastases to distant lymph nodes were missed on laparoscopy. Vascular invasion was diagnosed during laparotomy in five patients. In two of these patients, vascular invasion was suspected during laparoscopy, but laparotomy was necessary to obtain a pathological diagnosis.

The yield and accuracy of laparoscopy were highest for GBC (62% yield and 83% accuracy), followed by IHC (36% yield and 67% accuracy) and HC (25% yield and 45% accuracy), as listed in Table 2.

Before laparoscopy, portal vein embolization was scheduled to prepare the resection in 10 patients. Among these patients, unresectable disease was diagnosed by laparoscopy in five; five patients had a preoperative portal vein embolization and three underwent liver resection.

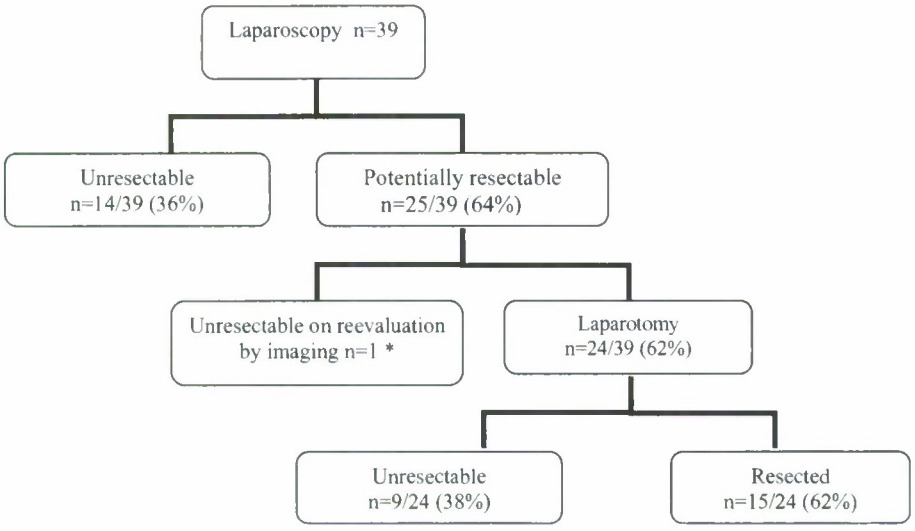

Fig. 1. Flowchart showing findings at laparoscopy and laparotomy. *The delay between staging laparoscopy and reevaluation by imaging after a portal vein embolization was 4 weeks.

Table 1. Factors precluding resection identified by laparoscopy or by laparotomy[a]

Factors precluding resection	Identified at laparoscopy	Identified only at laparotomy	Accuracy of laparoscopy (%)
Cirrhosis	1	0	1/1 (100)
Peritoneal metastases	11	1	11/12 (92)
Liver metastases	5	2	5/7 (71)
Adjacent organ infiltration	1	1	1/2 (50)
Advanced nodal spread	0	3	0/3 (0)
Vascular invasion	0	5	0/5 (0)

[a] Some patients had multiple factors responsible for unresectability

Table 2. Yield and accuracy of laparoscopy in detecting unresectable disease in individual cancers

Type of tumor	*n*	Overall yield (%)	Accuracy (%)
GBC	8	62 (5/8)	83 (5/6)
IHC	11	36 (4/11)	67 (4/6)
HC	20	25 (5/20)	45 (5/11)
Entire series	39	38 (14/39)	61 (14/23)

GBC, gallbladder carcinoma; IHC, intrahepatic cholangiocarcinoma; HC, hilar cholangiocarcinoma

Postoperative stay and complications

For the 15 patients undergoing only laparoscopy, the median postoperative stay was 4 days (range, 2–24). One patient with IC and advanced disease diagnosed by laparoscopy developed postoperative aspiration pneumonia resulting in a hospital stay of 24 days. For the nine patients with unresectable disease diagnosed at laparotomy, the median stay was 11 days (range, 7–23). There were no procedural complications attributable to laparoscopy.

Discussion

In the current study, the overall accuracy of laparoscopy in correctly identifying patients with unresectable disease was 61%. This result was obtained despite an extensive and homogeneous preoperative assessment including a mean of 3.9 imaging procedures per patient. Both yield and accuracy of laparoscopy varied markedly among the subgroups of biliary cancers. It was highest for GBC, followed by IHC and HC. Laparoscopy identified all but one case of peritoneal dissemination (92% accuracy), and it identified 71% of patients with liver metastases. The ability to identify unresectable disease due to lymph nodal and vascular invasion was more limited with laparoscopy.

A large number of patients with biliary cancers have advanced disease at presentation. Survival in patients who have incomplete tumor extirpation is identical to that in patients who do not undergo surgery and receive only palliative therapies [5, 13, 15]. Hence, the importance of avoiding a nontherapeutic laparotomy cannot be overemphasized. Despite improvements in imaging modalities, the incidence of nontherapeutic laparotomy in patients with proximal biliary cancers remains high, from 25 to 46% in the most recent series, and results in increased hospital stay and potential morbidity in addition to greater treatment expenses [9, 13, 18]. Staging laparoscopy has been proposed as an important tool to identify occult dissemination that can be missed on preoperative imaging and avoid unnecessary explorations.

The yield and accuracy of staging laparoscopy depend on the type of cancer. Gallbladder carcinoma has a propensity for peritoneal spread and liver metastases that can be easily identified by laparoscopy. In an analysis of 100 patients with biliary cancers, almost half of the GBC patients had advanced disease on laparoscopy [25]. Vascular invasion and lymph node metastases of HC, which represent the major cause of unresectability, are often missed during staging laparoscopy. In the study of the Memorial Sloan-Kettering Cancer Center, the overall yield for detecting unresectable disease in HB was significantly lower than that obtained for GBC. Therefore these authors suggested performing laparoscopy only in patients with

HC with a high risk of unresectable disease, such as T2 or T3 lesions [25]. There are few data in the literature on the role of laparoscopy in patients with IHC, a less common biliary cancer but with an increasing incidence. In our study, more than one-third of patients with IHC had advanced disease at laparoscopy and were spared an unnecessary laparotomy. Laparoscopy had an accuracy of 67% in identifying advanced disease. Staging laparoscopy should be integral in the management protocol of patients with IHC. Groups advocating aggressive surgery in cases of IHC have also changed their policy and started using laparoscopy to assess the resectability [18].

Laparoscopic ultrasound (LUS) has been proposed as a complementary investigation to obviate some of the limitations of laparoscopy and has added to the yield in patients with pancreatic and liver tumors [4, 6, 19, 21, 23]. In the current series, LUS was not routinely used and would not have been helpful in the diagnosis of liver metastases. Indeed, in two cases liver metastases were diagnosed by laparotomy performed because of adhesions in one case and 40 days after laparoscopy in the other. Also, it is difficult to identify vascular invasion and lymph nodal involvement on LUS. In the series of van Delden et al. [23], who were the first to study the use of LUS in proximal biliary cancers, nine of 31 patients (28%) had occult disease at laparoscopy and only one patient with unresectable disease was detected solely on the basis of LUS. Tumor adherence to major vascular structures and extensive biliary involvement by cancer are often difficult to determine radiographically. Accuracy may be further limited by the presence of biliary stents and secondary inflammation [25]. Furthermore, metastatic lymph nodes are difficult to diagnose based on ultrasound findings and mandate biopsy. Conversely, in a study from Edinburgh, UK, the yield of staging laparoscopy in HC was considerably increased by LUS, from 24 to 42%, by detecting local advanced disease, whereas accuracy in detecting liver metastases was not increased [6]. Also, the authors emphasized the long period (from 1992 to 2003) during which this study was conducted and advancements of preoperative imaging during this time, which could explain the considerable yield of LUS observed.

The strategy of preoperative external biliary drainage and portal vein embolization is increasingly being adopted in jaundiced patients who need major liver resection to reduce the risk of postoperative liver failure and improve surgical outcome [17]. The high incidence of occult advanced disease in potentially resectable patients highlights the need to perform laparoscopy before preoperative intervention for optimization is performed. Our study shows that early detection of dissemination by laparoscopy can avoid unnecessary invasive procedures and lead to immediate institution of palliative care.

Detection of advanced disease by laparoscopy not only helped in avoiding the pain and morbidity of an unnecessary laparotomy but also resulted in a shorter hospital stay. This is important for patients with unresectable biliary cancers, for whom the median survival is only a few months. Early discharge from the hospital improves quality of life and helps in an earlier institution of systemic chemotherapy [1, 11, 20]. Also, pathological malignancy is easier to confirm by harvesting an unsuspected liver metastases during laparoscopy than by obtaining tissue samples of HC by either transhepatic or endoscopic maneuvers [10, 16].

In summary, laparoscopy helped avoid unnecessary laparotomy in more than one-third of patients, resulting in significantly shorter hospital stay. Laparoscopy is accurate in detecting peritoneal and liver metastases but misses the majority of patients with vascular invasion and lymph nodal disease. Due to these limitations, laparoscopy is more useful in ruling out dissemination in GBC and IHC than in HC. We recommend the routine use of laparoscopy in all patients with potentially resectable GBC and IHC and selectively in patients with large HC, or when prior invasive procedures for optimization, such as portal vein embolization, are contemplated.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic ultrasound navigation in liver surgery: technical aspects and accuracy

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Abstract
The functional–anatomic structure of the liver according to Couinaud classification based on the intrahepatical course of the vascular structures is the basis of all modern liver surgery. Consequently, the use of intraoperative ultrasound is an undisputed requirement for every liver resection. Exact following of the planned resection plane can be realized only with the application of permanent online navigation based on intraoperative ultrasound during the dissection of the hepatical tissue. Now that the authors have established ultrasound navigated resection in open liver surgery using a navigated parenchymal dissecting instrument, they intend to transfer this technique from open to laparoscopic liver surgery. A special adapter was developed to connect an ultrasound-based navigation system to laparoscopic instruments. The authors present the first results in terms of technical aspects and feasibility.

Key words: Laparoscopic surgery — Laparoscopic ultrasound — Liver — Navigation

Despite recent advances in laparoscopic techniques and instrumentation, laparoscopic liver surgery still is limited to a select patient population. One major reason may be the lack of tactile sensation and orientation during dissection of the liver parenchyma. Laparoscopic fenestration of solitary giant liver cysts has been reported [4]. Laparoscopic resections are feasible and safe for selected patients with left-sided or right peripheral lesions requiring limited resection [2] (Table 1).

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Although laparoscopic resection of metastatic liver disease seems feasible, this approach still is debated [7]. The safe anterolateral segments according Couinaud classification are shown in Fig. 1. However, direct translation of the information received sonographically into the resection procedure can cause difficulties, especially with segment/sector ectomies. After the course of the vessels has been projected onto the liver capsule in accordance with the ultrasound picture, dissection of the hepatic tissue itself is performed currently without the support of pictures. As a result, there could be significant deviations in the planned resection plane (Fig. 2). Exact following of the planned resection plane can be realized only by application of a permanent online navigation based on intraoperative ultrasound during dissection of the hepatic tissue.

Now that we have established an ultrasound-navigated system for open liver surgery with online navigation of the dissection instrument, we will use this technique also in laparoscopic surgery to navigate under laparoscopic ultrasound control (e.g., during interventional ablation procedures or liver resections).

Materials and methods

The US-Guide 2000 is an independent navigation system compatible with all ultrasound machines. It is based on an electromagnetic tracking system with six degrees of freedom [5]. On the system monitor, the ultrasound B-picture, overlaid by the navigation data in real time received from the ultrasound and transferred into the navigation system, is displayed. The position finding necessary for the navigation is based on a calculation of distance and angle in accordance with the common satellite navigation. A newly developed adapter allows the navigation system to be combined with a laparoscopic ultrasound probe (B-K Medical 8566, Denmark, Fig. 3a and b). The computer is connected to a transmitter and two magnetic sensors. The weak magnetic field created by the transmitter has to cover the abdominal part in which the intervention is performed. At the same time, the sensors fixed to the head of the laparoscopic ultrasound probe, the interventional or dissection instrument, must remain within the magnetic field throughout the whole procedure. The navigation system

Table 1. Literature overview of laparoscopic liver surgery

Autbor	Patients (n)	Duration (min)	Conversion rate (%)	Complication rate (%)	Hospital duration (days)
Rau 1998 [10]	17	183.5	5.9	11.8	7.8
Cherqui 2000 [2]	30	214	6.6	20	9.6
Mouiel 2000 [9]	30	79	10	20	—
Fong 2000 [6]	11	248	55	40	9.2
Berends 2001 [1]	10	180	20	0	6
Tang 2002 [11]	11	190	9	9	11.3
Gigot 2002 [7]	37	—	13.5	22	7
Descottes 2003 [3]	87	—	10	5	5

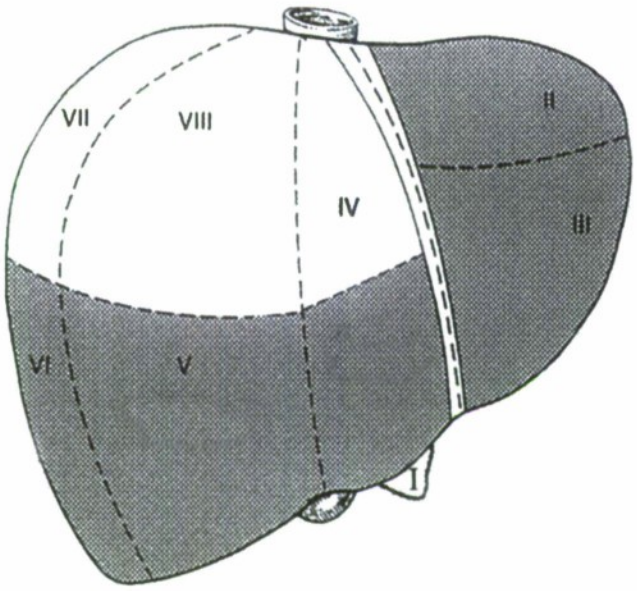

Fig. 1. Anterolateral segments II, III, IVb, V, and VI (shaded grey) according to Couinaud classification. Adapted from Gigot et al. [8].

recognizes the position and anterograde orientation of the needle in relation to the laparoscopic ultrasound head and target structure, then projects this virtually onto the ultrasound picture. Additional functions of the ultrasound machine (e.g., duplex sonography) are available during the intervention and can be used to recognize and avoid vessels.

First, the adapter is placed at the head of the laparoscopic ultrasound probe to connect the electromagnetic tracker to the adapter. The nearer the adapter can be placed to the tip of the instrument, the higher the accuracy of the system. For calibration with an ultrasound phantom, the distance between the adapter and the ultrasound probe must be determined and calibrated with the software of the navigation system. Then the other tracker is placed at a laparoscopic dissection instrument built for laser dissection and calibrated as mentioned earlier. In phantom testing and in a liver organ model, the virtual resection line then is overlaid to the laparoscopic ultrasound B-mode picture, offering the possibility of navigated ablation or resection. Second, the system is integrated in a liver organ model to detect disturbances attributable to trocar and camera instruments.

Results

For transmission of the ultrasound picture data, the ultrasound machine and the navigation system must be connected by an interface. For correct calculation and display of the course followed by the resection line, it is necessary to define the length of the hepatic dissection instrument (i.e., distance from the instrument tip to the sensor position). For the navigated resection, the US-Guide 2000 is positioned close to the area of intervention. The two magnetic sensors, connected by cable to the navigation system, are then attached to the laparoscopic ultrasound head with special adapters. The transformer adapter that takes on the transformer sensor is a small plastic mount connected to the ultrasound head. The transformer sensor is attached to it in the same manner as a connecting clamp. The ultrasound B-mode picture is then presented with the overlaid navigation data (Fig. 4a). We used metal troears up to 25 mm in size to bring the system into the abdominal cavity (Fig. 4b).

Laparoscopic navigation under ultrasound guidance is technically feasible in this model. Even when the tip of the ultrasound probe was angulated, no disturbances of the navigation system were obvious, due to the close approximation of the laparoscopic ultrasound head and electromagnetic sensor. Anatomic landmarks in liver tissue could be safely reached. No interaction of the electromagnetic tracking system and the laparoscopic equipment (e.g., trocar and laparoscopic camera) could be seen.

Conclusion

In this report, we describe the use of a laparoscopic navigation system with permanent sonographically guidance. Therefore, the exact following of a planned resection level can be transferred online to the liver organ. This improves the precision of laparoscopic liver dissection and may lead to an improvement in the quality of the operation. Laparoscopic navigation under ultrasound guidance offers a new technique and tool for the visceral surgeon. Especially in laparoscopic surgery, this method may improve orientation in interventions or resections in liver surgery. Our preliminary results show the feasibility of this technique in the field of laparoscopic surgery. To date, the size of the electromagnetic sensors are limiting the minimally invasive use of navigation because the sensors in our studies still measure 8 $\times$ 8 $\times$ 6 mm. Further studies investigating accuracy and reproducibility in the laparoscopic operation field are necessary for evaluation of this new technique.

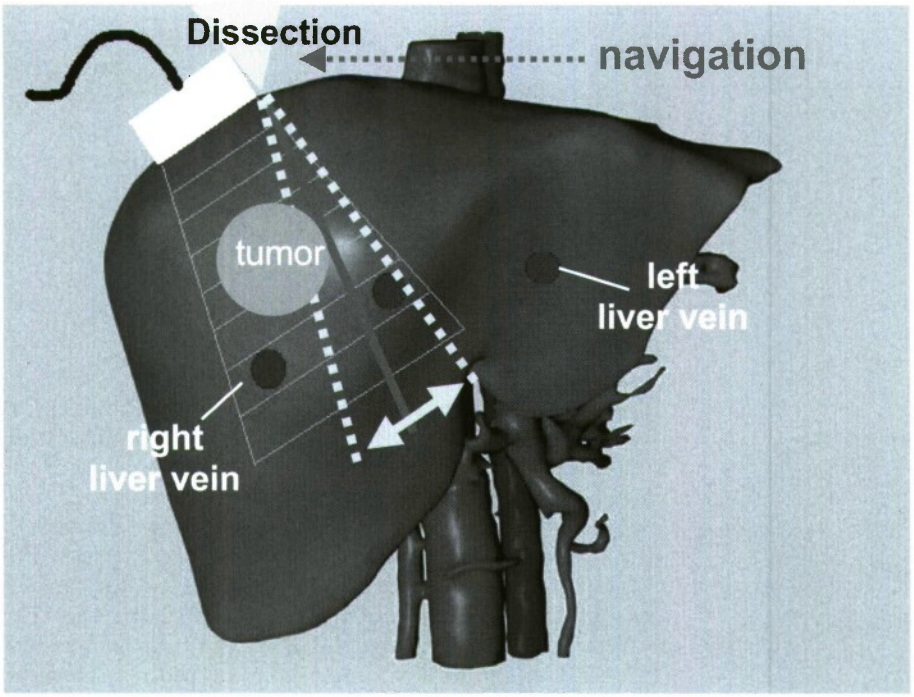

Fig. 2. Deviation of planned (*red line*) vs real (*yellow lines*) resection line without navigation.

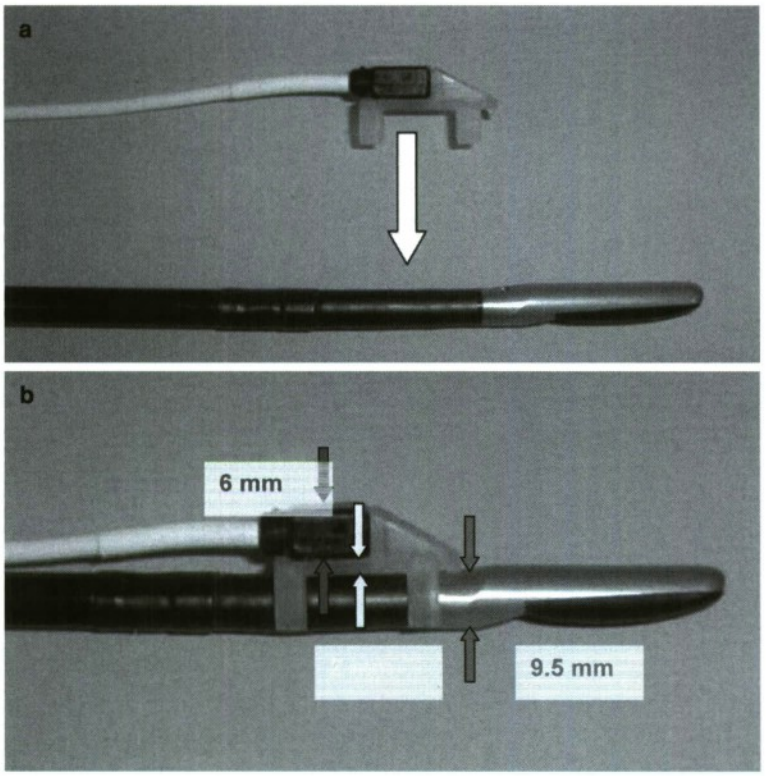

Fig. 3. **a** Adapter with mounted tracking sensor placed as near as possible to the tip of the laparoscopic ultrasound probe. **b** Adapter with mounted tracking sensor at the head of the laparoscopic ultrasound probe. The total diameter of the system is 17.5 mm.

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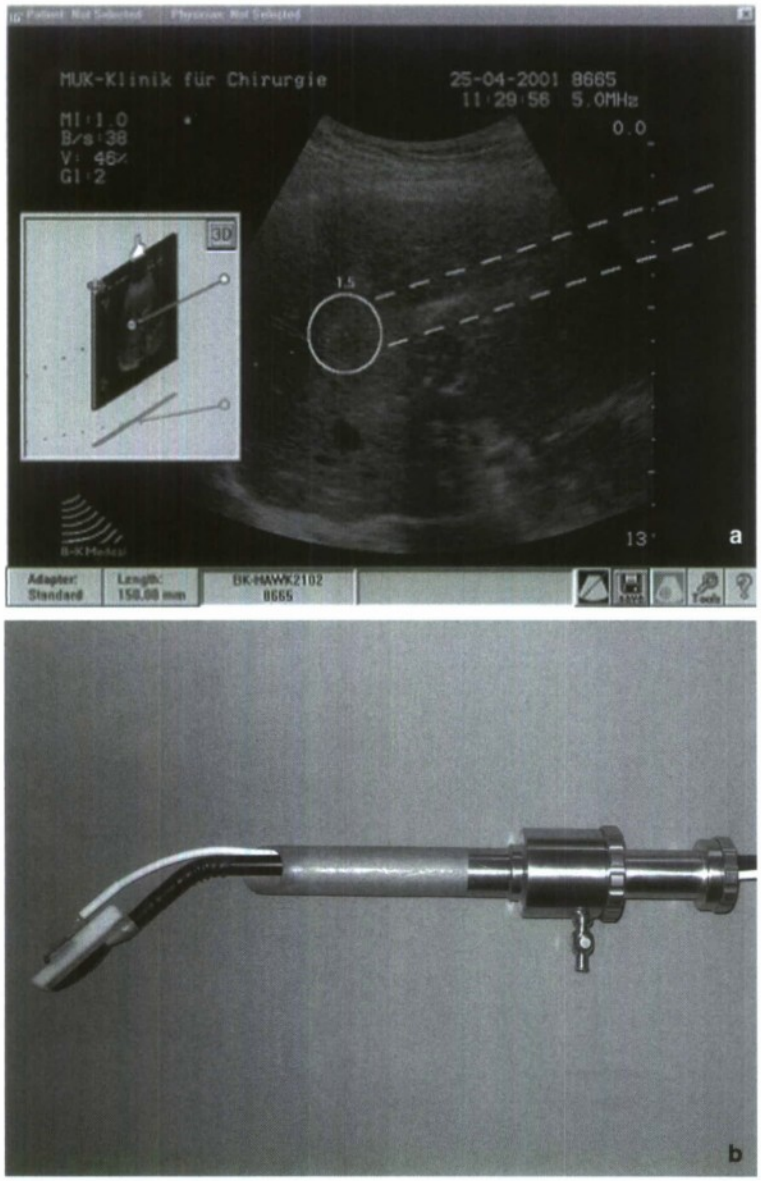

Fig. 4. **a** Ultrasound B-mode picture of the liver with the navigation line (*trajectory*) of the dissection instrument. The yellow circle indicates the point at which the dissection line intersects with the B-mode picture plane (out-of-plane function). **b** Laparoscopic ultrasound probe (B-K Medical 8566) connected to the navigation system through a 22 mm trocar in an experimental environment. Problems of sterilization are not yet solved.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Advantages of advanced laparoscopic systems

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Abstract
Background: Conventional laparoscopy offers great benefits to our patients, but suffers from major technical drawbacks. Advanced laparoscopic systems are being developed adressing some of these drawbacks.
Methods: We performed a training-box based study, performing laparoscopic tasks using conventional laparoscopy and advanced laparoscopic systems in order to assess the influence of these technical drawbacks in order to predict where the biggest advantages of newly developed surgical systems can be expected.
Results: The most significant technical drawbacks were two-dimensional vision, disturbed eye-hand target axis and (possibly to a lesser extent) the rigid instruments with a limited five degrees of freedom.
Conclusion: Major advances in advanced laparoscopy might only be expected using console-based robot-arm manipulated systems like the daVinci surgical system, or a combination of a high-quality 3-dimensional vision system, restoration of the eye-hand-target axis and the use of an advanced handheld instrument offering seven degrees of freedom such as the Radius surgical system.

Key words: Advanced laparoscopy — Degrees of freedom — Robot — Da Vinci — Fulcrum — Radius — Stereoscopy

Minimal invasive surgery is one of the great advances in medicine in recent decades, aiming at maximal reduction of surgical trauma. However, laparoscopic surgeons sacrifice dexterity to provide patients with less invasive surgery. The following are major drawbacks of laparoscopy:

1. Two-dimensional (2D) vision using a conventional monitor reduces perception of depth.
2. A disturbed eye–hand–target axis decreases ergonomics and dexterity.
3. The long, inflexible instruments used in laparoscopic surgery magnify the surgeon's natural hand tremor.
4. The rigid instruments with five degrees of freedom limit the surgeon's natural range of motion, decreasing dexterity.
5. Fixed abdominal entry points result in limited freedom of motion and movement of the tip of the instrument to the opposite direction of the outer part of the instrument, a technical drawback known as the fulcrum effect.
6. Camera instability increases fatigue.
7. Limited tactile feedback decreases dexterity.

These factors probably all contribute to the relatively long learning curve in laparoscopic surgery [15].

Advanced stereoscopic and instrument manipulating surgical systems are being developed in order to address some of the shortcomings related to conventional laparoscopy, potentially leading to faster and more accurate laparoscopy [6, 7]:

1. A variety of stereoscopic systems are being developed. Although stereoscopy rarely offers convincing depth perception [9], its use might improve laparoscopic performance [2, 8, 12, 16, 18].
2. The disturbed eye–hand–target axis is difficult to restore using conventional laparoscopic equipment. Although ergonomic monitor placement is crucial, the ideal situation of projecting the image exactly where the operation takes place is difficult to achieve without a console-based surgical system [1, 4].
3. Tremor can be diminished using a robot arm manipulated system with tremor filtration [11].
4. Both handheld and console-based surgical systems offer the full seven degrees of freedom, increasing dexterity [11, 17].
5. The fulcrum effect is difficult to address using conventional laparoscopic instruments. Although extensive training leads to faster automation to the fulcrum effect [3, 10], only robot arm manipulated

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systems can restore intuitive movement of the instrument's tip in the direction of the surgeon's hand, increasing dexterity.
6. Camera instability due to exhausting camera holding can be restored using a variety of mechanical or robot arm manipulated systems.
7. No commercially available surgical systems have been able to restore normal sensitivity in tactile feedback.

We performed a training box-based study, describing time consumption and accuracy in both inexperienced users and expert laparoscopic surgeons performing laparoscopic tasks using conventional laparoscopy, the Radius Surgical System (Tuebingen Scientific, Tuebingen, Germany), and the da Vinci Surgical System (Intuitive Surgical, Mountain View, CA, USA) in a variety of settings. The aim of the study was to assess the significance of the previously described technical drawbacks for laparoscopic surgery in order to predict where the major advantages of newly developed surgical systems can be expected.

Materials and methods

Participants

Ten inexperienced and 10 experienced volunteers were selected to perform laparoscopic tasks using various laparoscopic systems. The inexperienced group consisted of 10 volunteers without any previous laparoscopic experience. The experienced group consisted of 10 expert laparoscopic and thoracoscopic surgeons from the Departments of Surgery and Cardio-Thoracic Surgery of Maastricht University Hospital. All of them had extensive experience in laparoscopy or thoracoscopy, having performed more than 100 laparoscopic or thoracoscopic procedures.

Conventional laparoscopy

All conventional laparoscopic tasks were performed using a pelvic trainer with one 12 mm video port and two 12 mm trocar ports (Versaport, US Surgical Corporation, Norwalk, CT, USA). A 10 mm, 0° digital video camera (Endoeye, Olympus, Hamburg, Germany) was used, and the image was displayed on a 14-in. high-resolution 100 Hz monitor. Camera handling was done using a simple rigid standard. Manual laparoscopic drills were performed using disposable 5 mm laparoscopic instruments (Endo Clinch II, AutoSuture, Norwalk, CT, USA) and a 5 mm laparoscopic needle driver (Storz 26173SC laparoscopic needle driver, Karl Storz Endoskope, Tuttlingen, Germany).

Radius surgical system

All Radius-assisted laparoscopic tasks were performed in the same pelvic trainer using the same trocars described previously. The Radius handheld manipulator (Radius Surgical System) was used instead of conventional laparoscopic instruments. This laparoscopic instrument enables the surgeon to perform laparoscopic tasks offering the full seven degrees of freedom instead of the five degrees of freedom in conventional laparoscopy, potentially increasing dexterity and improving performance. Unfortunately, the tip of the Radius instrument was not suitable to grasp the beads used in task 1. Therefore, this task was not done using the Radius Surgical System.

da vinci surgical system

All da Vinci-assisted laparoscopic tasks were performed in the same pelvic trainer as described previously using a 12 mm video port and two 7 mm trocars. We used three arms of the four-armed da Vinci Surgical System. This robotic surgical system consists of a surgeon's console, patient side cart, Endowrist instruments, and InSite Vision System. The surgeon's console offers an ergonomic position to the surgeon, translating the surgeon's intuitive movements into precise, real-time movements of the instruments. The patient side cart offers four robot arms, executing the surgeon's commands while offering tremor filtration and movement downscaling if desired. The Endowrist instruments attached to the patient side cart offer the full seven degrees of freedom. The InSite Vision System provides high-quality stereoscopic stable vision, projecting the tips of the instruments where the fingertips of the surgeon are located.

Three arms of the four-armed da Vinci system were used. One arm handled the camera and the other two arms manipulated two da Vinci laparoscopic Dehakey forceps. The da Vinci tasks were performed using the da Vinci Surgical System in stereoscopic 3D InSite vision, in 2D InSite vision, and in a conventional monitor-viewed modus.

Tasks

Three laparoscopic tasks were devised to test dexterity, two-handed coordination, and suturing. Each participant was instructed about the main features of the endoscopic tasks to be performed and on how to use the surgical systems. The participants were allowed to manipulate each surgical system for 5 min to become familiar with the controls and setup. Questions were allowed before and during the tests, but no assistance was provided. The same order of tasks was performed for every participant, but the sequence of the use of the different surgical systems changed in order to prevent a learning curve from interfering with the results.

Task 1: pick up and drop

A comparable laparoscopic drill was used in other studies [5, 13, 14], in which a receptacle (40 mm opening and 10 mm high) containing five beads was used. The task was to pick up a bead from the receptacle with the right-handed instrument and transfer it halfway to a second receptacle. The bead had to be taken over with the left-handed instrument and dropped inside the second receptacle. Time was recorded from starting position with the instrument in focus but outside the initial receptacle to the fifth bead dropped into the final receptacle. Inaccuracy was defined as 10 points for every bead accidentally dropped outside the receptacle . The task was performed eight times —twice per suitable instrument. The tip of the Radius instrument was unfit for this task.

Task 2: cap the needle

This task was performed as described previously [5] using a 19-gauge × 1.5-in. aspiration needle with Luer Lock (Terumo Europe NV, Leuven, Belgium) and its cap. The task was to cap the needle after grasping both pieces from the floor of the training box, keeping both cap and needle above the box floor. Time was recorded from starting position with the instruments in focus but 5 cm from the needle and its cap to the moment when the needle and cap were securely coupled and held by one instrument. Inaccuracy was defined as 10 points for every cap or needle accidentally dropped or touching the box floor. The task was performed 10 times—twice per instrument.

Task 3: suturing and knot tying

This task has previously been described [5, 14, 19], and it consists of using a size 8 latex glove and a Vicryl 3–0 polyglactin suture with FS-1 24 mm 3/8 circular needle (Johnson & Johnson, New Brunswick, NJ, USA). The task was to pass the needle through two separated 5 mm dots on the glove and then tie a double knot. Time was recorded from

Table 1. Mean time consumption and inaccuracy scores in the total group (inexperienced, experienced subgroups)

	Task	Conventional	Radius	daVinci 3-D	daVinci 2-D	daVinci-M
Time	Task 1, first trial	171 (233,108)	—	85 (108,62)	96 (111,82)	140 (189,90)
	Task 1, second trial	121 (167,74)	—	65 (74,56)	92 (107,76)	118 (143,94)
	Task 2, first trial	138 (220,55)	100 (156,43)	40 (44,35)	64 (74,55)	105 (121,89)
	Task 2, second trial	103 (158,49)	62 (80,44)	55 (40,70)	64 (52,77)	109 (137,80)
	Task 3, first trial	332 (500,164)	304 (477,132)	122 (165,79)	158 (192,124)	182 (238,127)
	Task 3, second trial	323 (515,132)	240 (335,148)	87 (105,69)	155 (200,110)	186 (251,120)
Inaccuracy	Task 1, first trial	18 (28,7)	—	9 (13,4)	10 (16,3)	24 (44,4)
	Task 1, second trial	11 (17,5)	—	6 (6,5)	9 (16,2)	14 (26,2)
	Task 2, first trial	23 (37,9)	14 (20,8)	15 (10,20)	23 (21,24)	30 (26,34)
	Task 2, second trial	16 (27,4)	9 (9,8)	17 (12,22)	24 (19,28)	37 (37,36)
	Task 3, first trial	23 (44,2)	27 (41,13)	0 (0,0)	4 (7, 1)	7 (11, 2)
	Task 3, second trial	27 (46,7)	24 (45,2)	2 (3,0)	5 (9,0)	12 (24,0)

starting position with the instruments in focus but 5 cm away from the needle to the moment when the suture was securely tied. Inaccuracy was defined as 10 points per millimeter distance between the black dot and the needle entry through the glove. Twenty points was added if the knot was too loose or the suture broke. The task was performed 10 times—twice per setup.

Statistical analysis

Data were stored in an Excel XP database (Microsoft, Redmond, WA, USA) and analyzed using SPSS version 11.0.1 (SPSS, Chicago, IL, USA). Comparison of groups was done using Pearson's chi-square test. Comparison of two related samples was done using a nonparametric Wilcoxon signed rank test. A p value ≤ 0.05 was defined as statistically significant.

Results

Study population

The median age of the study population was 32 years (range, 21–52), 36 years in the experienced group (range, 32–52) and 23 years in the inexperienced group (range, 21–35). In total, 20 participants performed two tasks twice using five different setups. One task was performed twice using four setups, leading to a total of 560 tasks. Performing every task, time consumption, and accuracy were registered, leading to a total of 1,120 analyzable data points.

Time and accuracy

Time consumption was compared by performing different tasks using various instruments and setups. Inexperienced participants took substantially more time to complete a task than the experienced surgeons. Conventional surgery was most time-consuming, whereas the da Vinci system with stereoscopy was the fastest. Task 3 was far more time-consuming than tasks 1 and 2. The benefit of using advanced surgical systems seemed less for experienced users compared to inexperienced users.

Accuracy was compared using the different surgical systems. Higher numbers of failures and mistakes resulted in higher inaccuracy scores. Inexperienced participants had higher inaccuracy scores than expert surgeons. Conventional laparoscopy and the use of the da Vinci system with monitor-viewed vision resulted in the highest inaccuracy scores, whereas use of the da Vinci system with stereoscopic InSite vision resulted in the lowest inaccuracy scores and thus the best results. Table 1 shows mean time consumption and inaccuracy scores for the total group and for the inexperienced and experienced subgroups separately.

Comparing instruments

Using the Radius Surgical System, two tasks were performed twice each, describing time consumption, accuracy, and score. This resulted in 12 data samples. The other instruments were used to perform three tasks twice each, describing time, accuracy and score. This resulted in 18 data samples. Using a nonparametric Wilcoxon signed rank test, related samples could be compared in order to assess significant superiority of one setup or the other. Results are depicted in Table 2.

Discussion

Conventional laparoscopy suffers from seven technical drawbacks as described previously. This study was conducted in order to assess these drawbacks.

The role of 2D vision was assessed by comparing results of da Vinci in 2D InSite vision mode with da Vinci in stereoscopic InSite vision mode. The da Vinci system in 3D mode seemed faster and more accurate in all 12 data samples (Table 1). This difference was significant in five of 12 data samples (Table 2), suggesting high-definition stereoscopic vision does indeed lead to faster and better performance of laparoscopic tasks.

The role of the disturbed eye–hand–target axis was assessed by comparing the results of da Vinci in the 2D InSite vision mode with da Vinci in the monitor-viewed mode. Two-dimensional InSite vision seemed faster and more accurate in all 12 data samples (Table 1). This difference was significant in five of 12 data samples (Table 2), suggesting restoration of the disturbed eye–hand–target axis does improve performance of laparoscopic tasks.

Table 2. Number of significantly better results comparing first instrument versus second instrument (number of comparing data samples)

	Total group	Inexperienced	Experienced
Conventional vs Radius	0 vs 1 (8)	0 vs 2 (8)	0 vs 0 (8)
Conventional vs daVinci 3-D	0 vs 9 (12)	0 vs 10 (12)	0 vs 1 (12)
Conventional vs daVinci 2-D	0 vs 5 (12)	0 vs 8 (12)	1 vs 0 (12)
Conventional vs daVinci-M	1 vs 0 (12)	0 vs 2 (12)	2 vs 0 (12)
Radius vs daVinci 3-D	0 vs 5 (8)	0 vs 7 (8)	0 vs 2 (8)
Radius vs daVinci 2-D	1 vs 4 (8)	0 vs 5 (8)	1 vs 0 (8)
Radius vs daVinci-M	1 vs 1 (8)	1 vs 1 (8)	3 vs 0 (8)
daVinci 3-D vs daVinci 2-D	5 vs 0 (12)	3 vs 0 (12)	4 vs 0 (12)
daVinci 3-D vs daVinci-M	12 vs 0 (12)	10 vs 0 (12)	6 vs 0 (12)
daVinci 2-D vs daVinci-M	5 vs 0 (12)	4 vs 0 (12)	0 vs 0 (12)

The role of limited degrees of freedom in conventional laparoscopy was assessed by comparing conventional laparoscopy with the Radius Surgical System. Although the tip of the Radius instrument was not fit for task 1, the other two tasks seemed to be performed faster and more accurate using the Radius instrument in seven of eight data samples (Table 1). This suggests that offering seven degrees of freedom might improve laparoscopic performance.

The roles of tremor enhancement, fulcrum effect, and limited tactile feedback could not be assessed separately in this study. However, comparing the Radius system, which suffers from tremor enhancement, fulcrum effect, and limited tactile feedback, with the da Vinci system in monitor-viewed mode, no significant difference was present (Tables 1 and 2). This suggests these three drawbacks do not play an important role and might not require a technical solution.

The role of camera instability was not assessed in this study since camera holding was done by a rigid standard or robot arm.

Analysis of the experienced and inexperienced subgroups showed a more significant advantage of the use of advanced laparoscopic systems in the inexperienced group. This suggests that extensive training in laparoscopy may reduce the need for advanced stereoscopic or manipulating laparoscopic systems.

We conclude that the most significant improvements with regard to the previously mentioned technical drawbacks in conventional laparoscopy are high-definition 3D vision, restoration of the disturbed eye–hand–target axis, and (possibly to a lesser extent) the use of instruments offering the full seven degrees of freedom. Major improvements in laparoscopic surgery may only be expected from either a console-based surgical system, such as the da Vinci Surgical System, or a combination of a high-definition 3D vision system with ergonomic monitor placement (or a head-mounted display), with a handheld, seven degrees of freedom instrument, such as the Radius Surgical System.

Advanced laparoscopic surgery is in its infancy, and major improvements in the availability of specifically designed surgical systems are expected soon, offering great opportunities for the future. However, more research is needed in order to develop affordable and feasible instruments offering high-quality 3D vision, a restoration of the eye–hand–target axis, and seven degrees of freedom.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

The anatomical significance and techniques of laparoscopic rectal surgery

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Abstract
Background: Because there are difficulties associated with the technique of laparoscopic colorectal surgery, thorough knowledge of the anatomy is particularly important. We pay close attention to anatomical features during laparoscopic rectal surgery. In this study, we analyze the association of the anatomy with the operative procedure.
Methods: Laparoscopic rectal surgery was performed on 117 patients (66 men) with benign and malignant diseases in the rectum by the complete laparoscopy or hand-assisted technique. All operations were mainly performed by the first author. The association between anatomy and the operation was analyzed.
Results: The mean operative time was 144 min (range, 87–235). The hand-assisted technique was performed in two patients. Four patients required conversion to laparotomy due to the amount of fat in three patients and disruption of the Endo-stapler in one patient, for a conversion rate of 1.7%. Operative blood loss was small, averaging 126 ml (range, 50–350). No injury of the ureters, major bleeding in front of the sacrum, or other operation-related severe complications occurred during or after operation. In one case, dissecting disrupted the anterior left wall of the rectum.
Conclusion: By mastering the anatomical features of laparoscopic rectum surgery, operative mistakes and complications can be reduced. Particular attention must be paid to the anatomy of the obese patient undergoing laparoscopy. It is very convenient that the corresponding skills can be applied in the course of dissection and exposure.

Key words: Rectum — Surgical procedure — Laparoscopy — Anatomy

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Laparoscopic colon surgery was successfully applied by Fowler and Jacobs in 1990. Since then, the technique has developed rapidly, and the feasibility of laparoscopic colorectal surgery has been demonstrated.

Prospective and retrospective studies have shown the safety and feasibility of the operation. However, the operative range for the colorectum is extensive, not just cholystectomy, which is rather limited in some regions. The blood supply and adjacent tissues of the colorectum are complicated and often variable. The operation of the colorectum involves not only simple resection but also reconstruction of the intestinal tract. Moreover, it involves the radical problem of malignancy. These factors result in technical difficulties of laparoscopic colorectum surgery [3, 6, 10]. Therefore, a detailed understanding of the anatomy is very important. A total of 117 patients with benign and malignant diseases of the rectum were laparoscopically operated on by us since 2001. We gained detailed knowledge of the anatomical features and their association with the operative procedure.

Materials and methods

One hundred and seventeen patients with rectal diseases underwent laparoscopic surgery. All operations were mainly performed by the first author. There were 66 men and 51 women, with a median age of 50.4 years (range, 17–76). There were four rectal tubulovillous adenomas with severe atypical hyperplasia and three rectal tubulovillous adenomas with severe atypical hyperplasia and focal cancer certified by histologic examination. We used the GEN 300 ultrasonic knife (Johnson & Johnson) and Ligasure vessel sealing system (Valleylab). Hand-assisted kits were the hand-port (Smith & Nephew)and Lap Disc (Johnson & Johnson).

Results

The operative period ranged from 87 to 235 min, with an average of 144 min. The hand-assisted kits were used in two operations. Four patients were converted to open operation; thus, the conversion rate was 1.7%. Obesity

Fig. 1. The left ureter lies lateral to the ovarian vessel above the pelvic entrance.

Fig. 2. The left ureter runs across the end of the common iliac artery at the pelvic entrance.

resulted in three operative conversions, and one conversion was due to the breakdown of the laparoscopic Endo-stapler so that the lower rectum could not be transected.

Blood loss during the operation was minimal, with an average of 126 ml (range, 50–350). No injury of the ureter or major bleeding in front of the sacrum and other operation-related complications occurred during or after the operations. Only in one case did dissection disrupt the anterior left wall of the rectum.

An anastomatic leak occurred in one patient 5 days after operation, and it was treated by intermittent washing and continuous suction through a drainage tube. This patient with rectal cancer and liver metastasis (a 64-year-old male) had been treated by interventional therapy of the liver and general chemotherapy for more than 3 months. Then, he was transferred to surgery for operation.

One patient (a 76-year-old male) died due to major bleeding of a stress ulcer. The bleeding continued even though multiple treatments were performed. His family decided to stop treatment on day 8 after the operation. This patient had had blood hypertension disease for more than 20 years. He took enteric-coated aspirin for approximately 3 years, but it was stopped 1 week before the operation.

There were also two cases of pneumonia, one case of deep vein thrombosis in the lower limb, and one case of heart failure after operation. However, they were all cured by corresponding treatments.

Discussion

Laparoscopic colorectal surgery has become more standardized in the course of continuous practice. Ten of thousands of procedures have been performed and followed up for more than 10 years. The standardized operative procedure is sufficient to reach the surgical aim. Moreover, its minimally invasive advantages cannot be obtained by open operation [1, 2, 5, 8].

Laparoscopic colorectal surgery was first performed in 1993 in China [10, 11]. To date, it has been used in approximately 50 large hospitals, mainly on malignant tumors. Due to continuous improvements in the operative technique and the application of the ultrasonic knife and Ligasure vessel sealing system, inexperienced surgeons can make full use of the experience of others and skip the "learning curve" of laparoscopic colorectal surgery. The fact that there were no operative technique-related complications in our 117 patients further proves the clinical feasibility of this kind of operation.

Identifying the ureter is the first important step in laparoscopic rectal surgery. We conventionally expose the left ureter. First, the white filmy adhesion between the lateral leaf of the mesosigmoid and the peritoneum in the left iliac gutter is snipped. Then, the lower loosely connective tissue is further dissected. The testicular (ovarian) vessel passes lateral to the ureter. The left ureter is often near the root part of the mesosigmoid. The left and right ureters go across the end of the common iliac artery and the origin of lateral iliac artery, respectively, at the pelvic entrance. Its peristalsis can be seen while the ureter is poked by dissecting forceps (Figs. 1–3). After entering the pelvis, it first descends along the lateral wall and then turns anteromedially at the level of the sciatic thorn. In the male, the ureter reaches the fundus of the bladder posteroinferior to the deferent duct. In the female, the ureter runs anteriomedially in the base of the broad ligament, crossing the uterine artery beneath the artery 2 cm lateral to the uterine cervix and then reaches the bladder wall. Because the right ureter is more lateral, it does not need to be exposed. In most circumstances, the right ureter can be seen going down at the pelvic entrance through the peritoneum, especially in nonobese patients (Figs. 4 and 5).

The inferior mesenteric artery originates from the anterior wall of the lower part of the aorta at approximately the level of L3, 3 or 4 cm below the aortic bifurcation, and then running in a lower left direction. It divides into the left colic artery superiolateral, the sigmoid artery lateral, and superior rectal artery

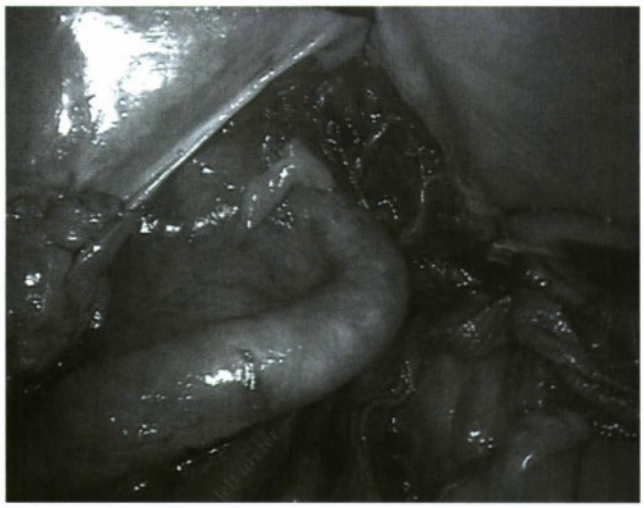

Fig. 3. The left external iliac artery which is variable presses over the ureter.

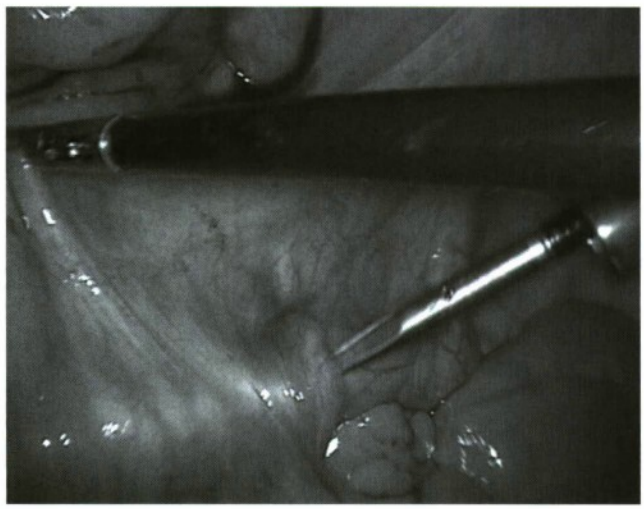

Fig. 4. The right ureter can be seen through the peritoneum.

Fig. 5. The right ureter can be seen through the peritoneum in another patient.

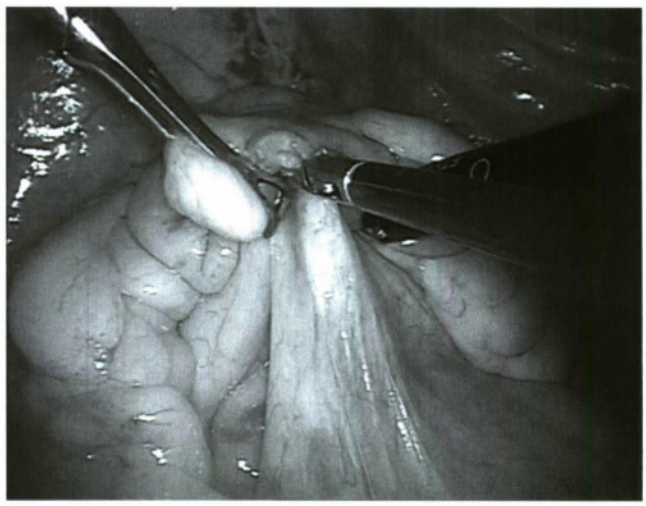

Fig. 6. The inferior mesenteric artery is drawn straight. The pedicle of the inferior mesenteric artery can be seen.

downward. When the assistant or the left hand of the operator elevates the upper part of the mesosigmoid using the grasper in the left superior direction, the inferior mesenteric artery will be drawn straight. Then, the pedicle of the inferior mesenteric artery can be generally seen. The root of the inferior mesenteric artery can easily be dissected at the base of the pedicle and then cut (Fig. 6).

The superior rectal artery enters the pelvic cavity through the mesosigmoid and descends left and anterior to the sacral promontory. It divides the left and right branches in the upper part of the rectum at the level of S3, and then runs down to the rectum posteriorly to laterally (Fig. 7). Although the mesorectum is cut with the ultrasonic knife, the branches in the mesorectum bleed easily, especially in patients who are older and those with blood hypertension, coronary heart disease, and arteriosclerosis whose vessels are hard and fragile. The cut end of the bleeding vessels can be clamped with the dissecting forceps to stop the bleeding by electric coagulation. If Ligasure is used, the chance that major bleeding will occur is largely reduced.

The middle rectal artery originates from the anterior branch of the internal iliac artery and enters into the lower part of the rectum through the rectal lateral ligament. It can be cut near the rectal wall with the ultrasonic knife or Ligasure.

In obese women, especially those who are short, the fat accumulation makes the mesorectum thick and the peritoneum at the anterior and lateral walls hangs loosely into the pelvic cavity. Therefore, the pelvic cavity in these patients becomes smaller and narrow so that exposure to the pelvic cavity is more difficult to obtain (Fig. 8). Performing the anus-preserving procedure in low rectal cancer is very difficult. Use of the hand-assisted procedure for keeping off the fat blockage or the immediate conversion to open operation must often be performed, and these do not represent failure of the operation.

After the peritoneal reflection before the rectum is incised, there are the bladder, the ampulla of the deferent duct, and the seminal vesicle in the upper part and the prostate in the lower part in this rectovesical septum in the male. In the female, the plane called the

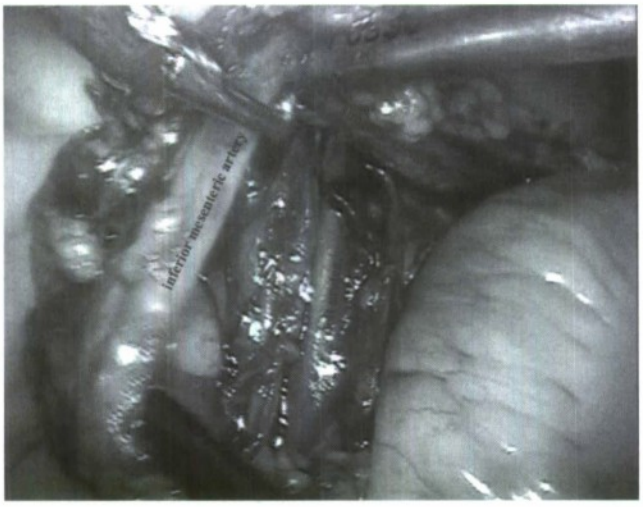

Fig. 7. The inferior mesenteric artery runs down into the superior rectal artery.

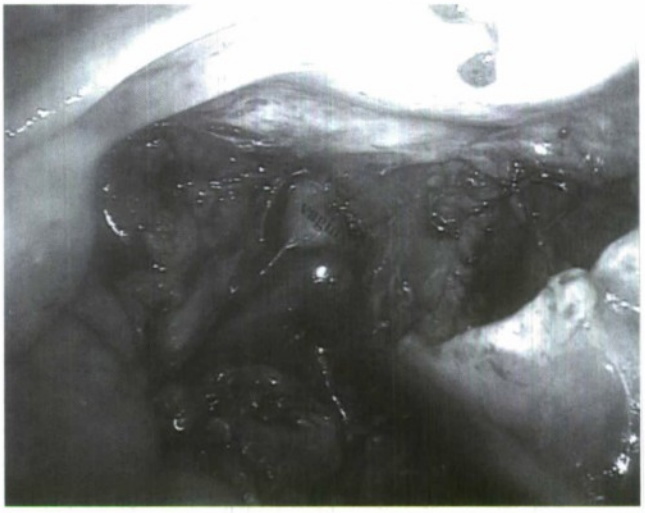

Fig. 9. The posterior wall of the vagina can be seen by the guiding method through the vagina.

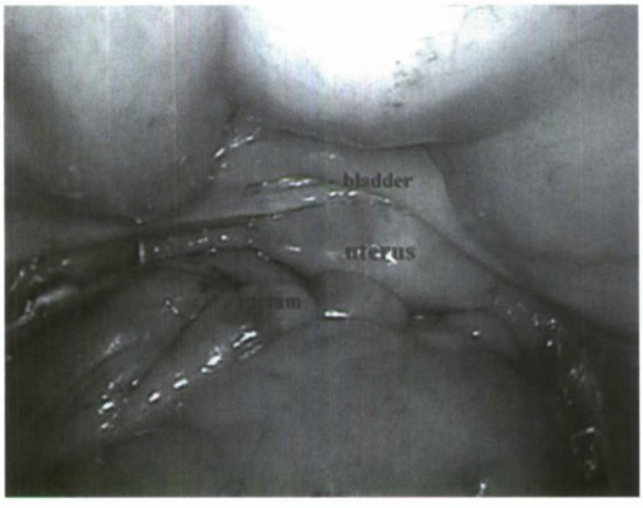

Fig. 8. In a short, obese woman, the mesorectum is thick, and the peritoneum of the pelvic cavity at the anterior and lateral walls hangs loosely into the pelvic cavity.

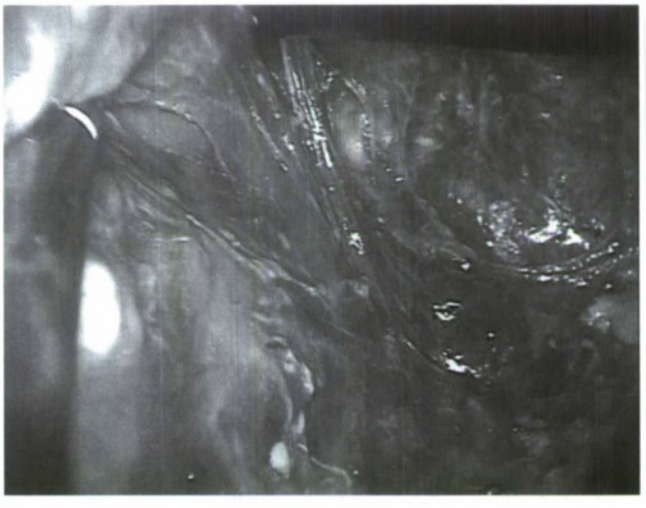

Fig. 10. The spacious and bright field of vision in front of the sacrum under laparoscopy.

rectovaginal septum is looser than the male's, so it is easily dissected. The guiding method through the anus or vagina can often achieve twice the results with half the effort (Fig. 9). The assistant should place one finger into the anus or vagina or both (bimanual examination). The primary operator touches the wall of the rectum or vagina with the head of the dissecting forceps, meeting the assistant's fingers in the anus or vagina, to seek the dissecting plane indirectly. The disruption of the left anterior wall of the rectum in one case by dissecting occurred due to the faulty assistant's guide at the perineum in the early stage of the operation.

While dissecting the presacral space, the spacious and bright field of vision under laparoscopy significantly improves the situation of the narrow and difficult to expose postrectal space in the conventional open operation. The blunt dissection by the operator's fingers is often needed in the conventional open operation, and it is sometimes performed in a semiblinded condition. The clear plane for dissecting under laparoscopy largely reduces the dangerous occurrence of major bleeding of the presacrum (Fig. 10). On the other hand, the two bundles of the hypogastric nerve plexus can be much more easily seen in laparoscopy than in the open operation, which is very helpful for preserving the autonomic nerve and the bladder, and thus preserving sexual function after the operation.

The superior hypogastric nerve plexus from the aortic plexus sends out a couple of hypogastric nerves at approximately the level of the sacral promontory, 3 cm below the aortic bifurcation, one on each side so that it is shaped like a "moustachio"(Fig. 11). The hypogastric nerve descends on either side between the internal iliac artery and the rectal inherent fascia and converges with the anterosuperior part of the pelvic nerve plexus lateral to the rectum beneath the peritoneal reflection. The hypogastric nerves often seem to be "put" in front of the sacrum after dissection under laparoscopy. If the

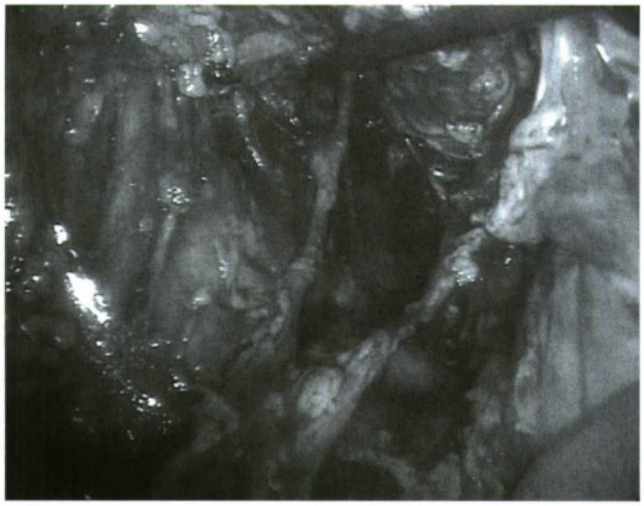

Fig. 11. A couple of hypogastric nerves, shaped like a "moustachio," seem to be "put" in front of the sacrum.

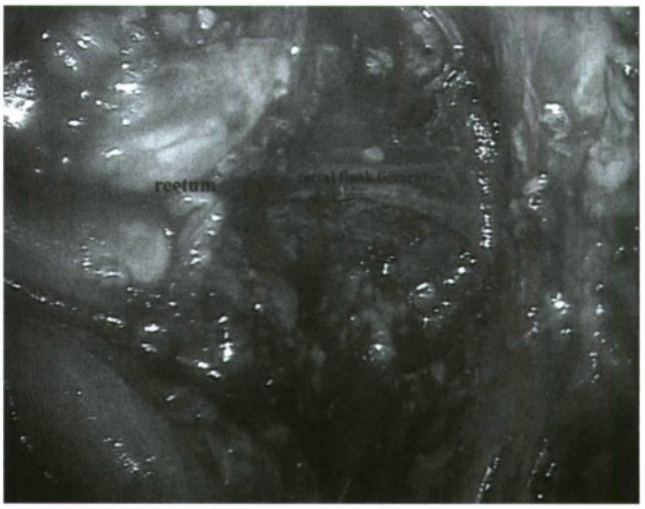

Fig. 12. The rectal lateral ligament containing the middle rectal artery and pelvic splanchnic plexus is clearly exposed.

distribution and course of the hypogastric nerve are clear, it usually is not injured, unless the tumor has invaded the rectal inherent fascia [4, 7]. In this condition, preservation of the autonomic nerve is no longer considered.

The tiny pelvic splanchnic plexus comes from the anterior foramen of S2–S4, crossing with the middle rectal artery at approximately the central part of the rectal lateral ligament. This plexus is difficult to dissect in any kind of operation (open or laparoscopic). In order to preserve this plexus, dissecting and cutting should be done near the rectal wall (Fig. 12) [7, 9].

Anatomy is the cornerstone of any surgical operation. A thorough knowledge of the anatomic features of laparoscopic rectal surgery can reduce operative mistakes and complications.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Impaired esophageal function in morbidly obese patients with gastroesophageal reflux disease: evaluation with multichannel intraluminal impedance

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Abstract

Background: Morbid obesity is associated with gastroesophageal reflux disease (GERD), and both have an independent association with motility disorders. Impaired esophageal function is thought to play a role in the development of dysphagia after fundoplication and bariatric procedures (especially restrictive procedures). The authors aimed to define both the physiology and the underlying pathophysiology of swallowing using a novel technique, multichannel intraluminal impedance (MII), which can accurately determine the clearance of a swallowed bolus through the esophagus, in combination with traditional manometry, which can measure peristalsis.

Methods: Simultaneous MII, manometry, and pH monitoring were performed for 10 asymptomatic subjects, 22 consecutive nonobese patients with GERD (GERD), and 22 consecutive morbidly obese patients with GERD (MO-GERD) who were under evaluation for antireflux and bariatric surgery at the University of Washington. In this study, MII was defined as abnormal if less than 80% of swallowed liquid boluses cleared the esophagus completely.

Results: All GERD and MO-GERD patients had abnormal pH monitoring. The manometric findings were similar for the GERD and MO-GERD patients. All the asymptomatic subjects had normal manometry and impedance test results. Abnormal manometry would have predicted that approximately 23% of GERD and MO-GERD patients had defective emptying. However, when measured with impedance, esophageal clearance was found to be defective in two times as many GERD and nearly three times as many MO-GERD patients.

Conclusions: In patients with GERD, impedance often detects impairments in esophageal motility not identified by manometry. Morbidly obese patients with GERD have a higher incidence of impaired esophageal motility than nonobese patients with GERD. This may have implications for bariatric procedures, especially those that are restrictive.

Key words: GERD — Esophageal impedance — Esophageal manometry — Esophageal motility — Morbid obesity

Gastroesophageal reflux disease (GERD) and morbid obesity are among the most common diseases in the United States. More than 30% of the U.S. population experiences regular symptoms or manifestations of GERD [4, 15]. More than 50% of U.S. adults are obese, and more than 5% are severely obese [13]. Surgical intervention plays prominently in the management of each disease. Fundoplication is an excellent alternative to antisecretory therapy for GERD. Currently, the only reliable and effective method of long-term weight loss for morbidly obese patients is bariatric surgery [7]. Moreover, GERD is commonly associated with obesity [16], occurring in as many as 50% to 70% of patients undergoing bariatric surgery [6, 14]. Thus, there are common considerations between antireflux and bariatric surgery.

Esophageal motility may be important in the etiology and pathophysiology of GERD. It potentially determines the type of antireflux procedure a patient may be able to tolerate without dysphagia. This is one reason why esophageal manometry is recommended before a restrictive antireflux procedure is performed [8]. Although most bariatric procedures also increase resistance to flow through the gastroesophageal junction, manometry is rarely performed preoperatively. Thus, our knowledge concerning the prevalence and nature of esophageal motility disorders in obese patients with GERD is limited.

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Manometry measures the presence and strength of peristalsis, and thus provides information about clearance only indirectly. Multichannel intraluminal impedance (MII) is a new technology that allows the transit and clearance of swallowed material within the esophageal lumen to be evaluated. It can therefore directly measure the effectiveness of esophageal transit and clearance.

In this study, we sought to determine the independent effects of GERD and obesity on esophageal function, as measured by manometry and impedance. The results may provide insights about the development of postoperative dysphagia after bariatric restrictive procedures, and may help tailor approaches and procedures to avoid this complication.

Methods

Between April 2002 and August 2004, we performed manometry, impedance, and 24-h pH monitoring for patients presenting with GERD for fundoplication or bariatric surgery, as well as for asymptomatic volunteers (with no GERD symptoms). Acid suppression therapy was stopped 5 to 7 days before testing. No patients were taking narcotics, anticholinergics, or promotility agents. Tests were performed in the morning after at least 8 h of fasting. Each participant also completed a standardized GERD symptom questionnaire.

Symptom questionnaire

Symptoms were rated by patients and subjects on both frequency and severity scales. The frequency scale had the following range of choices: 0 (never), 1 (once per month), 2 (once per week), 3 (once per day), and 4 (several times per day). Any frequency that fell between two numbers was upgraded to the higher number. The severity score was a visual analog scale from 0 to 10 as follows: 0 (never), 2 (mild), 5 (moderate), 8 (severe), and 10 (worst imaginable). We posed questions on 22 symptoms: 11 gastrointestinal symptoms (heartburn, regurgitation, abdominal pain, belching, dysphagia to liquids and solids, bloating, nausea, chest pain, odynophagia, globus) and 11 extraesophageal symptoms (coughing, hoarseness, wheezing, laryngitis, aspiration, choking, dyspnea, sore throat, asthma, bronchitis, pneumonia).

Study groups

Asymptomatic subjects

Volunteers were recruited using the Web advertising site for University of Washington research recruitment. The control group consisted of 10 volunteers who, when questioned, answered "0" for each of the 22 symptoms on the questionnaire. This portion of the study was approved separately by the University of Washington's Human Subjects review board (HSD-02-4684-D02).

GERD (nonobese) group (GERD)

The study enrolled 22 consecutive nonobese patients (body mass index [BMI] less than 35) referred to our esophageal function laboratory with symptomatic GERD under evaluation for an antireflux operation. We excluded patients with potential anatomic esophageal obstructions: peptic strictures, previous antireflux operations, or paraesophageal hernias. All these patients had abnormal distal esophageal (5 cm above the lower esophageal sphincter [LES]) acid exposure on 24-h pH monitoring (> 4%).

Morbidly obese patients with GERD (MO-GERD)

The study enrolled 22 consecutive morbidly obese patients with symptomatic GERD under evaluation for bariatric surgery at the University of Washington and referred to our esophageal function laboratory for esophageal motility and acid exposure evaluation. All these patients had a BMI (kg/cm^2) greater than 35. We excluded patients with potential anatomic esophageal obstructions: peptic strictures, previous antireflux operations, or paraesophageal hernias. All the patients had abnormal distal esophageal (5 cm above the LES) acid exposure on 24-h pH monitoring (> 4%).

Esophageal function testing

A specially designed solid state catheter with five manometric sensors and four pairs of impedance sensors separated by 5-cm intervals was used to assess esophageal pressures and impedance with the patient in the supine position (Sandhill Scientific Inc, Highlands Ranch, CO, USA). The LES was examined with the distal circumferential manometric sensor. A station pull-through measurement of the LES pressure (LESP) determined the length and proximal position of the sphincter. The catheter then was placed with impedance and manometry sensors 5, 10, 15, and 20 cm above the LES. The esophageal body was assessed over 10 episodes of deglutition with 5-ml aliquots of water, followed by 10 additional swallows of viscous material (Sandhill Scientific Inc).

Impedance definitions

A pair of impedance sensors detected the presence and exit of the bolus in a small segment of the esophagus at each of four levels. A bolus was considered to have entered a pair of impedance sensors when the esophageal impedance (in ohms) dropped 50% from its baseline. Exit of the bolus occurred if and when the impedance rose above this 50% drop. Data were analyzed using BioView analysis software (Sandhill Scientific Inc), and each tracing was personally reviewed by the investigators. For each swallow, complete (effective) bolus transit had occurred when the bolus entered the first pair of sensors and exited the second, third, and fourth pairs of sensors. The study was considered abnormal if complete bolus transit (CBT) occurred less than 80% of the time. Bolus transit time is the time in seconds from the entrance of the bolus in the proximal most channel (channel 1) to its exit in the distal most channel (channel 4). These definitions are accepted on the basis of multi-institutional trials [17].

Manometry definitions

Ineffective esophageal motility was defined to mean that more than 30% of swallows were either nonperistaltic or had distal esophageal amplitudes less than 30 mmHg. Nutcracker esophagus was defined as peristaltic contractions with average distal esophageal amplitudes exceeding 180 mmHg.

This study was approved by the University of Washington's Human Subject's Division review board (HSD- #02-2447-D 03).

Results

Symptoms

The GERD and MO-GERD groups reported similar symptoms. Heartburn was present daily for all patients. There was no difference in the median severity scores between the GERD (8; range, 5–10) and MO-GERD (8; range, 6–10) groups. At presentation, 8 GERD patients and 7 MO-GERD patients demonstrated dysphagia. The mean frequency and severity scores are shown in Table 1.

Table 1. Presenting symptom frequency and severity

	Heartburn frequency[a]	Heartburn severity[b]	Regurgitation frequency[a]	Regurgitation severity[b]	Dysphagia frequency[a]	Dysphagia severity[b]
Asymptomatic	0	0	0	0	0	0
GERD	3.4	7.6	2.2	5.6	2.2	4.8
MO-GERD	3.8	8	3.6	8.6	2.0	2.0

GERD, gastroesophageal reflux disease; MO-GERD, morbidly obese patients with GERD
[a] Frequency: 0 (never), 1 (once a month), 2 (once a week), 3 (once a day), 4 (several times per day)
[b] Severity: 0 (never), 10 (worse)

Table 2. 24-h pH monitoring

	DeMeester score[a]	Distal acid exposure[b]	Distal acid exposure supine %[b]	Distal acid Exposure upright %[b]	Proximal acid exposure %[c]
Asymptomatic	4.7 ± 3.9	2.2 ± 1.2	1.5 ± 1.8	0.9 ± 1	0
GERD	64.5 ± 49	16 ± 14	13 ± 13	16 ± 16	4.8 ± 4.7
MO-GERD	46.8 ± 33[d]	13 ± 10[e]	13 ± 8	11 ± 11	6 ± 7

Values expressed as mean ± standard deviation
[a] Normal < 14.7
[b] 5 cm above the LES
[c] 15 cm above the LES
[d] vs. Asymptomatic $p < 0.01$ vs GERD $p = 0.09$
[e] vs. Asymptomatic $p = 0.011$ vs GERD $p = 0.25$

24-h pH monitoring

Aeid exposure was normal for all asymptomatie subjeets and abnormal for all GERD and MO-GERD patients. There was no statistieal differenee in esophageal aeid exposure between the GERD and MO-GERD groups (Table 2).

Manometry

The median LESP was 20.2 mmHg (range, 12–33.9 mmHg) in the asymptomatic group; 13.2 mmHg (range, 4.2–53.4 mmHg) for the GERD patients, and 16.7 mmHg (range, 0–43 mmHg) for the MO-GERD patients. All the asymptomatie subjeets had normal peristalsis. Five patients in the GERD group had abnormal manometry: two had ineffeetive esophageal motility, two had nuteraeker esophagus, and one had a hypertensive LES (>50 mmHg). Five patients in the MO-GERD group had abnormal manometry: two had ineffective esophageal motility, two had nuteraeker esophagus, and one had diffuse esophageal spasm (Table 3).

Table 3. Manometry results

	LES pressure (mmHg)	Distal esophageal amplitude (mmHg)	Normal[a]
Asymptomatic	20.2 ± 7	70.7 ± 18.9	100%
GERD	13.2 ± 10	74.9 ±49.4	82%
MO-GERD	16.7 ± 11[b]	91.9 ± 46[c]	82%

Values expressed as mean ± standard deviation
[a] % of patients with normal peristalsis
[b] vs. asymptomatic $p = 0.45$ vs GERD $p = 0.88$
[c] vs. asymptomatic $p = 0.08$ vs GERD $p = 0.26$

Table 4. Impedance results

	CBT (%)	Bolus transit time (s)
Asymptomatic	98	7.0 ± 1.4
GERD	88	6.75 ± 1
MO-GERD	66[a]	6.87 ± 1.8[b]

CBT, complete bolus transit; GERD, gastroesophageal reflux disease; MO-GERD, morbidly obese patients with GERD
[a] vs. Asymptomatic $p < 0.01$ vs GERD $p = 0.01$
[b] vs. Asymptomatic $p = 0.85$ vs GERD $p = 0.47$

Impedance data

The asymptomatic subjeets had CBT for 98% of swallows. The GERD patients had CBT for 88% of swallows. Effeetive CBT was experieneed by 66% of the MO-GERD patients, a rate signifieantly lower than that observed for the asymptomatie subjects ($p < 0.01$) or the GERD patients ($p = 0.01$) (Table 4).

We then analyzed eaeh patient aeeording to whether he or she could be eonsidered to have normal bolus transit, defined as CBT for at least 80% of swallows. By this eriteria, 9 GERD (41%) and 13 MO-GERD (59%) patients had abnormal impedance (<80% CBT). All the patients that showed ineffeetive esophageal motility on manometry had abnormal impedance results. There were 7 GERD and 8 MO-GERD patients with abnormal impedanee despite normal manometry (Table 5).

For the swallows with CBT, there was no significant differenee in bolus transit time (from ehannel 1 to 4) for the three groups: asymptomatie subjeets, 7.0 s; GERD, 6.75 s; MO- GERD, 6.87 s.

Table 5. Patient motility results: impedance (MII) vs manometry

		GERD				MO-GERD	
		Manometry				Manometry	
		Normal	Abnormal			Normal	Abnormal
MII	Normal	10	3 2 nutcracker 1 hypertensive LES	MII	Normal	9	0
	Abnormal	7	2 2 IEM		Abnormal	8	5 2 IEM 2 nutcracker 1 esophageal spasm

GERD, gastroesophageal reflux disease; MO-GERD, morbidly obese patients with GERD; LES, lower esophageal sphincter; IEM, ineffective esophageal motility

Correlation between dysphagia and motility

To determine the relationship between dysphagia and esophageal motility in patients without an anatomic restriction, we analyzed the relationship between dysphagia and manometry/impedance. At presentation, 8 GERD patients and 7 MO-GERD patients demonstrated dysphagia. There was no correlation between dysphagia and the presence of abnormal esophageal motility in either group. Among the 8 GERD patients with dysphagia, 3 (38%) had abnormal manometry and 3 (38%) had abnormal impedance, whereas among the 14 patients without dysphagia, 2 (14%) had abnormal manometry and 8 (57%) had abnormal impedance.

Among the 7 MO-GERD patients with dysphagia, 1 (17%) had abnormal manometry and 4 (57%) had abnormal impedance, whereas among the 15 patients without dysphagia, 4 (27%) had abnormal manometry and 9 (60%) had abnormal impedance.

Discussion

This study confirmed previous reports [11] that patients with GERD have a relatively high prevalence of abnormal motor function, as defined by manometry. Using a new technique (impedance), we showed that for patients with GERD, these abnormalities (and others not detected with traditional manometry) lead to substantial impairments in esophageal clearance. In fact, impedance demonstrated that 41% of patients with GERD had defective bolus transit through the esophagus, and in that sense, impedance proved to be a more sensitive test than manometry. Finally, we were able to show, for the first time, that the defective motor function seen in patients with GERD is significantly worse when GERD is associated with morbid obesity.

Dysmotilty and GERD

The association between GERD and motility disorders is well described, because both ineffective esophageal motility [11] and hypermotility disorders [1] have been detailed. Indeed, in this investigation, we found both types of disorders in our patients with GERD. The role that this abnormal motor function plays in the pathogenesis of reflux disease still is unclear. On the other hand, considering that most antireflux operations increase the resistance to flow through the gastroesophageal junction, the test has been recommended because it identifies, albeit indirectly, patients in whom dysphagia may develop postoperatively. Several studies have shown, however, that abnormal motility, as documented by manometry, does not predict the development of dysphagia after Nissen fundoplication [2, 5]. One reason may be that manometry, by measuring only the character and strength of peristalsis, may not adequately define the sufficiency of esophageal motility.

In the search for a more reliable tool to assess esophageal function, esophageal impedance was developed and recently been validated [17]. Impedance is the measurement of electrical resistance. By attaching pairs of electrical sensors to a manometry catheter, impedance can detect the presence of gas, liquid, or mixed substances in the esophageal lumen. When these sensors are placed sequentially on a catheter that spans the esophagus, impedance can measure the clearance of a swallowed bolus through the esophagus and estimate the effectiveness of the esophagus to clear in a more direct fashion than manometry. Moreover, it can be combined with manometric sensors on the same catheter, providing a more comprehensive assessment of esophageal function.

We were pleasantly surprised to find that whereas manometry identified motility abnormalities in approximately one-fourth of GERD patients, impedance found that all these, as well as some additional patients in whom manometry results appeared normal, had defective bolus clearance. The fact that none of our asymptomatic subjects had any abnormalities detected in the transit or clearance of the bolus strongly suggests that the abnormalities we found are real. The ultimate significance of this relatively high prevalence of defective clearance in the pathogenesis of dysphagia or GERD as well as its potential impact on patients who undergo operations at the cardia remains to be determined.

Dysmotility and Obesity

A major finding of this study was that morbid obesity is an independent risk factor of impaired esophageal function for patients with GERD. The association of obesity and esophageal dysmotility has been described previously using manometry [9, 10, 12]. Our study confirmed the existence of manometric abnormalities in about 25% of patients with MO-GERD. However, unique to our study is the finding that more than half of these patients present with substantial abnormalities in the transit of a bolus through the esophagus, and that this abnormality is significantly worse in morbidly obese than in nonobese GERD patients. Whether GERD is aggravated by the morbid disease state, resulting in a greater incidence of esophageal motor dysfunction, or whether obesity has an independent impact on esophageal function is unclear. However, given the increase in obesity and the increase in gastric restrictive procedures, which increase resistance to flow through the gastroesophageal junction, it appears that this should be the focus of greater attention.

Currently, esophageal motility testing is not routinely performed before bariatric operations. This is surprising because motility testing is routinely recommended before antireflux surgery, and most bariatric operations impose an increased resistance to flow at least to the same extent as antireflux surgery. Although this restriction is important to the desired outcome of bariatric procedures (i.e., restriction of food intake), in some patients there can be a pathologic degree of impaired clearance. This is especially true for purely restrictive procedures such as the LapBand (BioEnterics/Inamed Corp., Santa Barbara, CA, USA) technique. Esophageal dilation and even pseudoachalasia after these procedures have been described [3]. The results of our study suggest that impaired esophageal clearance may, at least to some degree, play a role in the development of these complications. In fact, our data suggest that because the incidence of dysmotility is so high in these patients (nearly 60%), there may be a place for measuring esophageal function before bariatric surgery; at least for patients with GERD.

Conclusion

Complete esophageal motility testing with manometry and impedance shows a high incidence of esophageal motility abnormalities in patients with GERD. Many of the abnormalities are identified by impedance only. These motility impairments are even more severe in morbidly obese patients with GERD. Although more investigation is needed, these data suggest that patients with GERD, especially the obese, may be at risk for clinically significant impairments in esophageal clearance after restrictive operations of the cardia.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

The MISTELS program to measure technical skill in laparoscopic surgery

Evidence for reliability

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Abstract
Background: The McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) is a series of five tasks with an objective scoring system. The purpose of this study was to estimate the interrater and test–retest reliability of the MISTELS metrics and to assess their internal consistency.
Methods: To determine interrater reliability, two trained observers scored 10 subjects, either live or on tape. Test–retest reliability was assessed by having 12 subjects perform two tests, the second immediately following the first. Interrater and test–retest reliability were assessed using intraclass correlation coefficients. Internal consistency between tasks was estimated using Cronbach's alpha.
Results: The interrater and test–retest reliabilities for the total scores were both excellent at 0.998 [95% confidence interval (CI), 0.985–1.00] and 0.892 (95% CI, 0.665–0.968), respectively. Cronbach's alpha for the first assessment of the test–retest was 0.86.
Conclusions: The MISTELS metrics have excellent reliability, which exceeds the threshold level of 0.8 required for high-stakes evaluations. These findings support the use of MISTELS for evaluation in many different settings, including residency training programs.

Key words: Laparoscopic training — Simulation — Education — Evaluation — Reliability

The current method of evaluating technical skill in surgical trainees is a subjective assessment performed by practicing surgeons. This is relied on during the licensing process and in the selection of medical students for entry into surgical residency programs. Acquisition of skill has traditionally taken place almost exclusively in the operating room, where resources are limited. Recently, the widespread acceptance of minimally invasive techniques has required the development of new and complex technical skills. Important skills required in the practice of laparoscopic surgery, such as hand–eye coordination and three-dimensional visual spatial perception while viewing through a monocular viewing system, are easily reproduced in an inanimate system. In addition, inanimate systems allow practice with the same instruments used in the operating room but in a more relaxed setting without the time constraints present in the operating room. Various inanimate and virtual reality systems have been designed to facilitate improvement of laparoscopic techniques as well as evaluation of skill in trainees and surgeons [10–12]. We have previously described the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) program [4, 8]. It consists of a series of standardized tasks performed in a trainer box using a laparoscopic optical system and scored for speed and precision.

For an instrument of measure to become a useful tool in the selection and monitoring of trainees, it must show reproducibility of results when assessed by different testers (interrater reliability) and consistency of performance when the same trainee is evaluated on different occasions in similar conditions (test–retest reliability). It is also useful to have information about the internal consistency of a test in order to ensure that all of the components are measuring the same thing. The aim of the current study is to provide evidence for interrater and test–retest reliability and internal consis-

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tency of the MISTELS system. This would allow use of MISTELS in multiple institutions and for assessment of a trainee's progress over time.

Materials and methods

Subjects

Twelve volunteers from McGill University, including medical students, surgical residents, and attending surgeons, were tested. Each participant was required to view an instructional video demonstrating proper performance of each of the five tasks prior to being examined. Each participant performed the entire series of tasks twice on the same day. For interrater reliability, 10 subjects were scored by one of two observers during the live performance and videotaped. The second blinded observer then scored the performances on videotape using the same materials as the first observer. The materials were kept intact during the first measurement so as not to bias the second rater. For test–retest reliability, subjects were chosen on the basis that their performance had reached a plateau after prior practice, and each had achieved a total score of more than 230 when tested. Each of these volunteers was asked to perform the five MISTELS tasks twice on the same day. Twelve pairs of scores were used to assess test–retest reliability.

MISTELS

The MISTELS system has been previously described in detail [7]. Briefly, the simulator consists of a laparoscopic trainer box with two 12-mm trocars placed at convenient and standard working angles on either side of a zero-degree laparoscope. A large plastic clip and two alligator clips were used to suspend materials in standardized positions for the exercises. The laparoscope and camera (Storz endoskope; telecam) were mounted on a stand at a fixed focal length, thus allowing the examinee to work independently. The optical system consists of the laparoscope, camera, light source, and video monitor (19 in. Sony Trinitron). The video monitor was placed in line with the operator. Some subjects were tested with a gooseneck camera attached directly to a 21-in. television monitor or to a video-digitizing card inserted into the PCMCIA slot of a laptop computer allowing the image to be displayed on the screen.

Performance of each task is graded objectively, taking into account both precision and speed. The score for an individual task is calculated by subtracting the time required (seconds) from a preset cutoff time. A penalty score for inaccuracy is also deducted according to a predetermined system.

Tasks

Task 1: peg transfer

Using two graspers, the operator is required to lift each of six pegs from one board, transfer it to the other grasper, and then place it on the second board. The procedure is then reversed. Cutoff time is 300 sec.

Task 2: pattern cutting

The participant is required to cut a 4 cm predrawn circular pattern out of a 10 × 10 cm piece of double-ply suspended gauze. Cutoff time is 300 sec.

Task 3: placement of ligating loop (Endoloop)

A pretied slip knot (Surgitie, US Surgical Corporation, Norwalk, CT, USA) is placed on a circumferential line marked on a tubular foam appendage. Cutoff time is 180 sec.

Table 1. Internal consistency and test–retest reliability of the MISTELS program (n = 12)

	Test		Retest		
Task	Mean	SD	Mean	SD	ICC
1. Peg transfer	82.6	16.5	84.1	15.6	0.591
2. Pattern cutting	66.1	18.9	66.7	20.5	0.657
3. Endoloop	70.0	24.1	85.4	17.4	0.374
4. EC knot	78.4	34.9	80.2	34.7	0.806
5. IC knot	69.6	31.7	70.6	31.1	0.577
Total score	366.9	105.6	387.7	89.7	0.892
Cronbach's alpha	0.86		0.77		

EC, extracorporeal; IC, intracorporeal; ICC, intraclass correlation coefficient

Task 4: extracorporeal knot

A simple suture 120 cm in length is placed through two premarked points in a longitudinally slit Penrose drain. The suture is then tied with an extracorporeal technique using a knot pusher. The cutoff time is 420 sec.

Task 5: intracorporeal knot

This is similar to the previous task, except that the suture is 12 cm and an intracorporeal knot is used. The cutoff time is 600 sec.

Normalization

The score for each task was normalized by dividing the score obtained by a predetermined standard value that was derived from the maximum score achieved by a chief resident for that task (task 1 = 237, task 2 = 280, task 3 = 142, task 4 = 297, and task 5 = 520) and then multiplying by 100.

Statistical analysis

Internal consistency of the MISTELS system was estimated using Cronbach's alpha [3]. Cronbach's alpha was calculated for each of the four data sets corresponding to interrater (n = 10, rater 1 and rater 2) and test–retest (n = 12, test 1 and test 2). In addition, the impact of deleting each of the five MISTELS tasks on Cronbach's alpha was tested on the first test of the test–retest data set using SAS PROC CORR (SAS for Windows, SAS Institute, Cary, NC, USA).

Intraclass correlation coefficients (ICCs) were used to assess interrater and test–retest reliability of the MISTELS metrics. ICCs were calculated for each of the five tasks separately, as well as for the total score. Each ICC was performed using variance components from a two-way random effect model derived from SAS PROC GLM (SAS for Windows, SAS Institute). For interrater reliability, this model assumes that the raters are randomly selected from a larger population, and that each observer scores each participant. For test–retest reliability, it assumes that the two occasions of measurement represent a random sample of all measurement occasions, and that each participant is assessed at each occasion. We calculated 95% confidence intervals (CIs) according to Shrout and Fleiss [13] for each of the ICCs for the total scores.

Results

Cronbach's alpha for the first assessment of the test–retest was of 0.86 (Table 1), which suggests that the internal consistency of MISTELS is satisfactory [2].

Table 2. Correlation of each task with the total score and impact of deleting each of them separately on Cronbach's alpha—first test of the test–retest data set (n = 12)

Deleted task	Correlation with total	Cronbach's alpha
1. Peg transfer	0.81	0.83
2. Pattern cutting	0.73	0.84
3. Endoloop	0.74	0.82
4. EC knot	0.77	0.83
5. IC knot	0.62	0.86

EC, extracorporeal; IC, intracorporeal

Table 3. Internal consistency and interrater reliability of the MISTELS program (n = 10)

	Rater 1		Rater 2		
Task	Mean	SD	Mean	SD	ICC
1. Peg transfer	81.3	14.9	80.8	15.3	0.991
2. Pattern cutting	59.7	22.2	58.8	21.5	0.984
3. Endoloop	67.3	26.0	64.8	27.7	0.985
4. EC knot	68.1	37.7	67.8	37.4	0.999
5. IC knot	66.9	30.3	67.1	30.3	1.000
Total score	343.3	97.8	339.3	100.4	0.998
Cronbach's alpha	0.77		0.78		

EC, extracorporeal; IC, intracorporeal; ICC, intraclass correlation coefficient

Each task correlated highly with the total score (correlations, 0.62–0.81; Table 2), and internal consistency could not be improved with the elimination of any task (Table 2). Cronbach's alphas corresponding to interrater and retest data sets were all lower than the one obtained with the first assessment of the test–retest, but all remained acceptable (alpha = 0.77–0.78; Tables 1 and 3).

The ICCs for interrater reliability were all above 0.95 (Table 3), which indicates that more than 95% of the variance in scores can be attributed to a "true" difference between participants. The ICCs for test–retest reliability (Table 1) were all lower than those for interrater reliability. However, the ICCs for the total scores for interrater and test–retest were both excellent at 0.998 (95% CI, 0.985–1.00) and 0.892 (95% CI, 0.665–0.968), respectively. It should be noted that three of the 12 subjects who performed the test–retest obtained a score of zero in one of the tests for task 4 (extracorporeal knot) or task 5 (intracorporeal knot). Accordingly, the analysis was also performed excluding these three subjects, with even higher reliability (task 4: ICC = 0.88 vs 0.81; Task 5: ICC = 0.96 vs 0.58).

Discussion

There is an increasingly recognized need for tools to objectively measure technical skills. Various systems have been devised [10–12], which consist of structured tasks and objective grading systems. The MISTELS system has been devised in a similar fashion, with the intent to assist trainees in the acquisition of laparoscopic skills and to provide an objective way to measure those skills. For an instrument of measure to be used effectively, it must be shown to be valid and reliable [9].

Validity, as defined by the 1985 Standards for Educational and Psychological Testing, is "the appropriateness, meaningfulness, and usefulness of the specific inferences made from test scores" [1]. For a scale to be valid, it must measure what it intends to measure. There are various types of validity, including face, content, construct, and criterion validity [9]. Demonstrating validity is a complex undertaking, usually requiring a series of experiments. Prior to embarking on such an endeavor, it is necessary to show that the test is measuring something in a reproducible fashion. There is no point to painstakingly proving a system to be valid only to recognize later that it is not reliable. Reliability refers to the consistency, stability, and precision of test scores [14]. It is an indication of the extent to which measurements of individuals in different circumstances or by different observers yield similar results. The necessity to establish evidence for reliability arises from measurement error, which is a characteristic of all instruments of measure.

Types of measurement error can be grouped into three general categories: those associated with the observer (different observers using different methods or the same observer using different methods), the test (variability in the materials used for the test), and the subject (different performances by the subject on different occasions caused by fatigue, distraction, or other reasons). In the MISTELS system, differences in scoring technique between observers could occur in the measurement of time and/or precision. Both of these procedures have been standardized, and little variation is expected between observers. The ICC for interrater reliability for the total score was 0.998 (95% CI, 0.985–1.00), which confirms our expectation of low variability among observers.

Measurement of test–retest reliability is less straightforward because the MISTELS system is also conceived as an instructional tool. We have previously shown that practice in the simulator improves performance in the simulator [5, 6, 8]. Specifically, we have shown that scores increase significantly after a single repetition, and that the improvement is significantly greater in the less experienced group. To evaluate test–retest reliability, the subject must repeat the test, and the results can be biased toward the null when a less experienced subject improves significantly. To counterbalance this bias, we chose subjects who had attained a minimum total score of 230. MISTELS was designed as a coherent system for the training and evaluation of a set of laparoscopic skills. There may be some individuals who are better at certain tasks than others, but the overall performance carries the most practical significance. The cutoff criterion allowed us to include junior-level trainees, such as medical students and junior residents. We believe that if any bias would result from the inclusion of inexperienced subjects, it would be in the direction of low reliability due to the effect of practice on performance. We found that despite this

inclusion, the test–retest reliability for the total is excellent, with an ICC of 0.892 (95% CI, 0.665–0.968).

Conclusion

The MISTELS metries meet the standards of reliability for high-stakes examinations. The data for interrater and test–retest reliability support the use of the MISTELS system in any institution seeking to improve and measure technical skills in trainees and praetieing surgeons.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic subtotal splenectomy in hereditary spherocytosis

To preserve the upper or the lower pole of the spleen?

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Abstract
Background: Clinical manifestations of hereditary spherocytosis can be controlled by splenectomy. The use of this procedure has been restricted due to concerns regarding exposure of patients to a lifelong risk of overwhelming infections. Subtotal splenectomy, which removes 85–90% of the enlarged spleen, is a logical alternative. In the first cases performed by laparoscopy we have chosen to preserve the upper pole. However, this technique showed some disadvantages, especially concerning the correct intraoperative evaluation of the splenic remnant volume. Therefore, we developed a new variant of the procedure by preserving the lower pole of the spleen.
Methods: Based on the authors' experience in laparoscopy (176 laparoscopic splenectomies), 10 laparoscopic subtotal splenectomies were performed in patients with hereditary microspherocytosis, preserving either the upper or the lower splenic pole.
Results: Patient age ranged between 5 and 35 years. The mean volume of the remnant spleen was 41.4 cm^3. There were no complications, and no transfusions were needed. Follow-up for 1–30 months was available.
Conclusion: Subtotal splenectomy appears to control hemolysis while maintaining splenic function. The laparoscopic approach is safe and effective and should be considered the procedure of choice in hereditary microspherocytosis. Laparoscopic subtotal splenectomy presents an advantage over open subtotal splenectomy, resulting in decreased blood loss, shorter hospital stay, no conversions, fewer operative and postoperative complications, and excellent remission rates. On the basis of our experience, the preservation of the lower pole of the spleen seems to be a first-line option for the optimal evaluation of the residual splenic mass.

Key words: Subtotal splenectomy — Partial splenectomy — Subtotal laparoscopic splenectomy — Hereditary spherocytosis — Laparoscopic splenectomy

Hereditary spherocytosis (HS) is the most common inherited hemolytic anemia in which a primary deficiency in an erythrocyte membrane skeleton protein leads to surface area loss. Erythrocytes with decreased surface area and impaired deformability are trapped in the splenic pulp and phagocytized [19]. The result is chronic hemolysis and an increased propensity for gallstone formation.

The clinical severity of HS varies from symptom-free carrier to severe hemolysis. Patients with HS should be graded by their severity of disease (bascline hemoglobin, reticulocyte count, and jaundice level of activity). This predicts the clinical course and the need for splenectomy [4].

Splenectomy is very effective in reducing hemolysis, leading to a significant prolongation of the red cell life span. The clinical manifestations and complications (anemia and gallstones) are much reduced in severe HS and abolished in milder cases, but at the price of an increased risk of life-threatening sepsis, usually caused by pneumococcal species. This risk is age related, being highest in the youngest children and within the first years after surgery.

Current guidelines recommend pre-splenectomy vaccination against pneumococcus, haemophilus, and meningococcus together with long-term (lifelong)

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postoperative penicillin prophylaxis. These measures do not completely eliminate the risk beeause of the serotypes that are not represented in vaeeines, penieillin-resistant pneumococeal strains, and issues relating to lifelong eomplianee. Reeent studies have raised additional eoncerns regarding long-term complications after splenectomy, sueh as atheroselerotie events and pulmonary hypertension [2, 19].

Overwhelming postsplenectomy infections (OPSI) are primarily caused by *Streptococcus pneumoniae*, *Neisseriae meningitides*, or *Haemophilus influenzae*. Despite appropriate antibioties and intensive therapeutie intervention, the overall mortality in published studies for established cases of OPSI varies from 50 to 70%. Of those patients who die, > 50% die within the first 48 h of hospital admission. In those patients who survive, other sequelae include gangrene leading to amputations, deafness associated with meningitis, or mastoid osteomyelitis and aortic insufficieney seeondary to endocarditis [5].

Open subtotal splenectomy has been proven to be a therapeutic alternative in HS. In order to add the advantages of minimally invasive surgery, we began to perform this procedure by laparoscopy. Based on the authors' experience in laparoseopie surgery (176 laparoscopie splenectomies) and after performing five open subtotal spleneetomies with good hematologieal outcomes, we performed laparoscopic subtotal splenectomy in 10 patients. In open surgery, subtotal spleneetomy was performed preserving either the upper [11] or the lower pole of the spleen [2, 16, 18]. In the first eases [22] performed by laparoscopy, we chose to preserve the upper pole. However, this technique showed some disadvantages, espeeially eoneerning the eorreet intraopcrative evaluation of the splenic remnant volume. Therefore, we developed a new variant of the procedure by preserving the lower pole of the spleen.

Patients and methods

Patients

Between June 2002 and January 2005, 10 consecutive patients underwent laparoscopic subtotal splenectomy. The patients were six children (four girls and two boys; age range, 5–12 years; mean age, 7.5 years) and four young adults (age range, 19–35 years). The patients' characteristics are detailed in Table 1. The body mass index ranged between 17 and 31. Tbe diagnosis was based on clinical features (variable degree of anemia, jaundice, and splenomegaly) and laboratory findings (spherocytes, raised red cell hemoglobin concentration, and an increase in reticulocytes). Spleen size and volume were determined using ultrasounds. Spleen volume ranged between 243 and 760 cm^3 (mean, 429 cm^3). When small accessory spleens were detected they were preserved. The indication for surgery was severe anemia with recurrent need for transfusions, and surgery was performed after clinical monitoring of a number of variables (the degree of anemia, the impact of chronic fatigue on life quality, and the presence of gallstones). After discussions with tbe parents or the patients and after explaining the potential benefits and risks, subtotal laparoscopic splenectomy was performed. The procedure was feasible in all patients, and at the time of the intervention none required final total splenectomy. The mean duration of follow-up for tbe 10 patients was 13.1 months (range, 1–30).

Surgical technique

The objective of the surgical procedure was to remove approximately 85% of the splenic tissue while preserving either the upper or the lower pole of the spleen. Based on the authors' experience and standard approach in laparoscopic splenectomy, the upper pole of the spleen was preserved in the first seven procedures according to the recommendations of Petroianu et al. [13]. In the last three cases, the lower pole of the spleen was preserved based on our experience in open surgery (five open subtotal splenectomies). Under general anesthesia, the patient was placed in the right lateral decubitus position. Four trocars were used, two 12 mm ports (one for the laparoscope and the other for the hemostatic instruments) and two 5 mm ports for retractors. Trocar position was similarly utilized with any laparoscopic splenectomy. A 30° laparoscope was inserted into the abdominal eavity and a limited diagnostic laparoscopy was performed in order to detect accessory spleens (an accessory spleen was observed in one case and was preserved).

Subtotal laparoscopic splenectomy preserving the upper pole

Initially, the splenocolic and phrenosplenic ligaments were partially incised using a harmonic scalpel, and the branches of tbe gastroepiploic vessels to the lower pole were divided (Fig. 1A). The splenic hilum was carefully dissected, preserving the pancreatic tail intact. The branches of the splenic artery and vein were divided using Ligasure Atlas Sealer/Divider (Tyco Healthcare, Boulder, CO, USA). The last one or two short gastric vessels were preserved by observing the size of the future splenic remnant, which provided a clear line of demarcation on the spleen surface. Standard monopolar electrocautery was used to transect tbe spleen, ensuring that a 5 mm rim of devascularized splenic tissue remained in situ. Monopolar electrocautery was used in favor of the Ligasure or the harmonic shears in order to visualize splenic remnant vascularization. After tbat, tbe Ligasure Atlas Sealer/Divider provided excellent hemostatic control. A TachoComb (Nycomed GmbH, Linz, Austria) was used to complete haemostasis. The splenic fragment was placed in an endobag for removal. The most lateral 12 mm port site was used to extract the morcellated tissue, or the specimen was extracted via a Pfannenstiel incision. Two drains were placed at the end of the procedure. The postoperative courses were uneventful, and all patients were discharged within 1 week after surgery.

Subtotal laparoscopic splenectomy preserving the lower pole

This technique is similar to that used in the open approach (Fig. 1B). After dividing the branches of the splenic hilum and the short gastric vessels using Ligasure Atlas Sealer/Divider, a small fragment of the lower pole was preserved. The vascularization was based on the ascending branch of the left gastroepiploic artery. The advantage of this technique was better visualization of the remnant size.

Results

The mean surgery time was 95 min. The mean operative bleeding was < 70 ml. No intraoperative or postoperative blood transfusions were required. In six eases, the specimen was extraeted using an endobag after moreellation. In these cases, weight of the speeimen was caleulated using the following formula: intaet weight (g) = morcellated weight (g) × 1.34 + 45 [23]. In four eases, the specimen was extraeted via a Pfannenstiel ineision. The mean weight of the reseeted speeimen was 600 g.

Table 1. Demographic data of patients and values of hemoglobin and reticuloeytes before and after surgery

Patient No.	Age at surgery (yr)	Transfusions before surgery	Spleen volumetry before/after surgery (cm^3)	Hemoglobin value (g/dl)		Reticulocyte value, post-splenectomy (%)	Postsurgical follow-up (mo)
				Pre-splenectomy	Post-splenectomy		
1	16	Yes	664/71	8.4	11	16.2	32
2	19	Yes	760/79	7.7	11	12.7	31
3	5	Yes	336/35	8.6	10.7	18.5	20
4	35	Yes	603/80	8	10.2	11.3	19
5	7	Yes	307/21	7.5	9.4	8.7	13
6	5	Yes	373/32	8	10.6	6.3	13
7	8	Yes	317/29	8.9	11.8	19.6	12
8	12	Yes	278/21	7.4	10.4	8.7	4
9	22	Yes	408/26	8.9	12.1	9.8	4
10	10	Yes	243/20	7.6	9.5	6.3	3

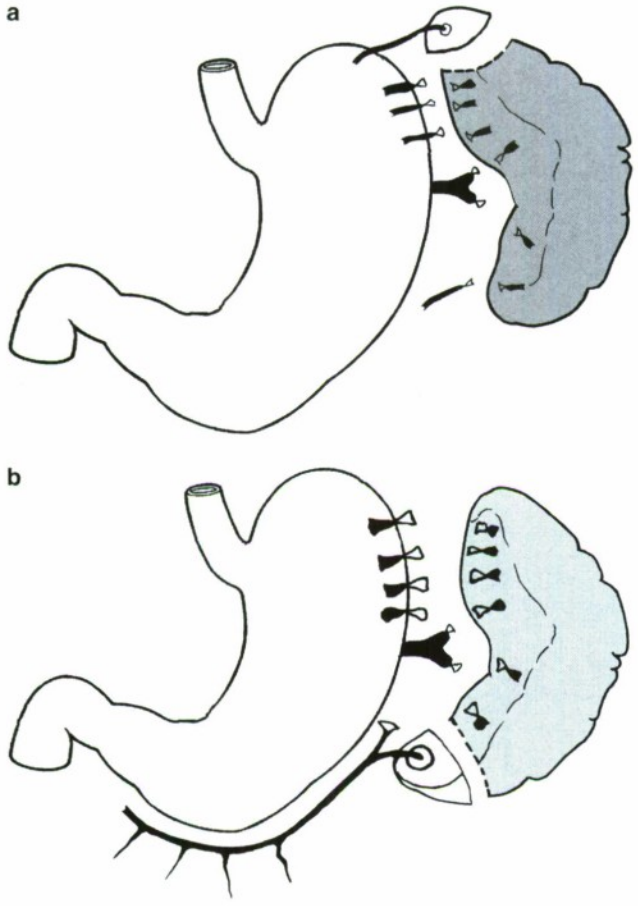

Fig. 1. (**A**) Surgical technique used for laparoscopic subtotal splenectomy: the remnant upper pole of the spleen with its vascular supply (a short gastric vessel). (**B**) Surgical technique used for laparoscopic subtotal splenectomy: the remnant lower pole of the spleen with its vascular supply (a pedicle arising from the left gastroepiploic vessels).

In all patients, the hemoglobin values were increased and the reticulocyte number was decreased following subtotal splenectomy (Table 1), as a direct consequence of an increase in the life span of red blood cells. During a follow-up period that ranged from 1 to 30 months, none of the patients required blood transfusions to maintain adequate hemoglobin levels. In all patients, a Doppler ultrasound performed after surgery showed the vascularization of the splenic remnant. Comparison of the spleen volumetry before and after surgery showed that the splenic remnant represented 15% of the initial volume of the spleen. Following Stoehr et al. [18], we assessed the phagocytic activity of the remnant spleen by scintigraphy with 99-technetium, which showed radionuclide uptake in the splenic area. Also, the percentage of pitted erythrocytes was < 2%. Howell–Jolly bodies appeared transiently after surgery in six of 10 patients. One patient required splenic remnant removal 11 months after the initial surgery due to persistent mild hemolytic anemia. In this case, due to the adhesions of the splenic remnant, conversion to open surgery was necessary.

Discussion

Indications for surgical treatment

Splenectomy should be performed in children with severe transfusion-dependent HS. The clinical manifestations of HS include anemia, chronic jaundice, and cholelithiasis. Total splenectomy that abrogates hemolysis is the most attractive treatment option, but this exposes the patient to a life-long risk of potentially lethal infections. Splenectomy leads to a significant prolongation of the red cell life span (although this is not necessarily extended to a normal life span). By eliminating the need for regular blood transfusions in severe cases, this surgical procedure also eliminates the associated risks of blood-borne viral infections and iron overload [20]. In addition, the impact on the patient's quality of life is significant, with a major improvement in the patient's physical and professional abilities after surgery.

Unfortunately, spleen removal leads to many inconveniences because the spleen represents approximately 25% of the lymphatic tissue and is the major repository of mononuclear phagocytic cells. As a result, it performs an efficient filtration function for the bloodstream [14]. OPSI is a well-defined clinical condition resulting from the inability of the splenectomized host to combat infections with encapsulated bacteria. Because of this lethal complication, a number of alternatives to splenectomy have been studied, including autotransplantation of the removed spleen and partial splenectomy [1, 6, 14]. Partial

splenectomy is preferable to splenic autotransplantation because it is associated with higher antibody titers after immunization, better pneumococcal splenic uptake, and improved survival rates.

Subtotal splenectomy provides a potentially effective alternative to total splenectomy in patients with HS. It is likely that contact between antigens and lymphoid cells as well as maturation of the pre-B cells can proceed in the remnant spleen.

In the study by Bader-Meunier et al. [2], approximately 15% of the enlarged spleen was preserved in order to decrease the sequestration of red blood cells as much as possible while at the same time maintaining an adequate amount of remnant spleen to preserve its phagocytic function.

Key points in the surgical technique

Open subtotal splenectomy has been suggested as a feasible alternative for severe forms of HS [2, 16, 18]. The potential benefits of this method were first proposed by a group of French surgeons, who published between 1993 and 2001 a study based on 40 cases. Since then, the technique has been applied by others, and additional studies have shown that this method provides good results [16]. It has also recently been hypothesized that a more radical approach to open resection could permanently decrease recurrent hemolysis and at the same time conserve a remnant spleen of 10 cm^3 [18]. Seshadri et al. [17] performed a partial laparoscopic splenectomy for a 2 cm splenic cyst. In the current study, after five open subtotal splenectomies were performed with good hematological outcomes, the potential benefits of the laparoscopic approach were analyzed because laparoscopic splenectomy is currently considered the best approach in patients without splenomegaly [22].

The development of partial splenectomy is based on the knowledge of the splenic vascular pattern [13, 21]. This surgical approach is feasible because of the unique anatomical features of this organ, which is divided into a variable number of almost independent vascular territories. Splenic vessels, including branches of the main splenic pedicle, short gastric vessels, and left gastroepiploic vessels, are divided outside the spleen before entering the splenic hilum as terminal vessels. There are three types of anastomoses between the individual branches of the splenic artery: hilar, intraparenchymatous, and subcapsular [3, 7, 8]. The intraparenchymatous anastomoses do not maintain the viability of the externally devascularized regions of the spleen, a fact that makes it possible to obtain a safe hemostasis of the splenic remnant. Subtotal splenectomy can be performed after primary ligation of the main pedicle of the splenic artery and vein, preserving either a short gastric artery [10] or a branch of the left gastroepiploic artery [20].

In order to establish the best therapeutic option, it is essential to determine the amount of splenic parenchyma that needs to be removed to effectively reduce red blood cell destruction. In addition, it is important to evaluate the minimal amount of residual parenchyma necessary for maintaining adequate phagocytic function [2, 19, 20]. Previous studies have shown that this goal can be achieved by preserving approximately 15% of the enlarged spleen. This is the key point of the surgical procedure.

In the current study, the technique described by Tchernia et al. [2, 19, 20] was used during open surgery to preserve the ascending branch of the left gastroepiploic artery. This solution was initially difficult to apply in the laparoscopic approach because in this case the procedure is conducted after manipulation of the lower splenic pole. As a result, Petroianu's technique was initially used as a part of the laparoscopic approach. This technique has been used successfully in a large number of operations to preserve the splenogastric vessels, which are considered to be enough for the upper splenic pole [9, 11, 12, 15].

In the current study, the lower splenic pole was preserved in the last three patients with good results. In the first procedures, according to the recommendation of Bader-Meunier et al. [2], approximately 15% of the enlarged spleen was preserved, a target that was more difficult to achieve using the laparoscopic approach than with open surgery. In the first procedures the main difficulty was to approximate 15% of the enlarged spleen. The evaluation of the splenic remnant volume was quite difficult in the cases with preservation of the upper pole of the spleen. Therefore, in the last cases we chose to preserve the lower pole of the spleen. This technique allowed us a better mobilization of the splenic remnant and a more accurate evaluation of the volume. The length of the remnant ranged between 3.5 and 6 cm, depending on the initial size of the spleen, and was measured using a 10-cm flexible band. Based on the 10 cases in this study and recent publications [18], it appears that a smaller remnant spleen (a remnant volume between 5 and 10%) is sufficient to preserve the splenic immune and phagocytic functions. Laparoscopic subtotal splenectomy combines the advantages of minimally invasive surgery with the maintenance of phagocytic function of the splenic remnant.

Hematologic results

The hemoglobin values increased and the reticulocyte count decreased in the first several days after surgery. This was the result of increased bone marrow production, evidenced by 20% reticulocytes.

Studies published between 1993 and 2001 [2, 19, 20] based on 40 cases that were followed for 14 years after surgery showed that the mean increase in hemoglobin value after partial splenectomy was 3 g/dl, whereas the decrease in the number of reticulocytes averaged approximately 300×10^9/L [2]. This occurred as a direct result of an increase in the red blood cell life span, with an average increase of 6.5 ± 1 days—a result far from normal.

Long-term postsurgical follow-up results show that beneficial clinical effects are sustained over a long period. However, in one study, one patient experienced complications that led to a secondary total splenectomy [2]. A male patient who underwent surgery at the age of 5 years

and maintained a hemolytic state after surgery required a secondary splenectomy (clinical symptoms included recurrence of jaundice, chronic fatigue, and mild anemia). Laparoscopic surgery was attempted, but it was necessary to convert to open surgery due to phrenosplenic adhesions. Other complications that also require secondary splenectomy include bleeding and torsion of vascular pedicles.

Several studies found that secondary splenectomy was required in 10% of patients at 5 years and in 33% at 10 years [2, 20]. The size of the remnant spleen increased in all cases. The growth was assessed by ultrasound and CT scan. Significant regrowth of the splenic remnant was noted during the first year after surgery, sometimes four and a half times its postoperative size [18], which did not correlate with the measured hemoglobin values or reticulocyte counts [2]. Although the current study is based on a small series of patients and the follow-up is short, our aim was to present a new approach in patients with HS. Of course, long-term results are needed in order to prove that the effects are sustained over a long period.

The outcome of patients with HS with total splenectomy was compared to that of patients with subtotal splenectomy [20] performed by open surgery. The results showed that subtotal splenectomy appears to be the first-line treatment option for patients with HS [2]. Regarding the phagocytic activity of the remnant, the percentage of pitted cells after partial splenectomy was similar to that seen in normal individuals, whereas after total splenectomy their numbers were markedly increased [20].

Conclusions

Subtotal splenectomy has been shown to provide a persistent decrease in hemolytic rate while preserving the integrity of splenic phagocytic function. Subtotal splenectomy should be considered preferable in two situations. First, in children younger than 5 years of age who need regular transfusions, subtotal splencetomy decreases the risk of both severe sepsis and transfusion-related viral infections. Second, subtotal splenectomy should be considered for cases in which mild or moderate anemia is present and the patient has chronic discomfort, significant splenic enlargement, or biliary lithiasis but does not require transfusions or requires them only sporadically. Laparoscopic subtotal splenectomy presents an advantage over open subtotal splenectomy, resulting in decreased blood loss, shorter hospital stay, no conversions, fewer operative and postoperative complications, and excellent remission rates. On the basis of our experience, the preservation of the lower pole of the spleen seems to be a first-line option for the optimal evaluation of the residual splenic mass. The laparoscopic approach is safe and effective, with encouraging short-term results, but a much longer follow-up (up to 20 years) is needed to be certain that the beneficial effects will be sustained.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic cholecystectomy using a newly developed laparoscope manipulator for 10 patients with cholelithiasis

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Abstract
Background: Laparoscopic surgery has continued to gain popularity in almost all fields of abdominal surgery, and robotic systems have been introduced in general surgery. Naviot is a new remote-controlled laparoscope manipulator system controlled by the operator's hand. This study assessed its introduction into clinical practice.
Methods: A group of 10 consecutive patients with cholelithiasis underwent laparoscopic cholecystectomy assisted by the Naviot system (Naviot group). Another group of 41 patients who underwent laparoscopic cholecystectomy with a conventional human camera holder (human camera group) were selected for a comparison of their operative results with those of the Naviot group.
Results: The operative time of 89.3 ± 27.1 min for the Naviot group was significantly longer than that of 74.8 ± 28.1 min for the human camera group ($p < 0.05$). However, when the setup time for the Naviot system was excluded, the operative time was not significantly different from that for the human camera group. Other operative results showed no significant difference between the two groups.
Conclusion: The authors believe that the new Naviot system is feasible for clinical use, and that it enables surgeons to perform solo gastrointestinal surgery.

Key words: Laparoscopic cholecystectomy — Laparoscopic manipulator — Naviot

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Laparoscopic surgery has continued to gain popularity in almost all fields of abdominal surgery. Laparoscopic cholecystectomy currently is the main standard treatment for patients with cholelithiasis and polyp of the gallbladder.

In conventional laparoscopic surgery, a human assistant controls the laparoscopic image by directing the laparoscope on the operative field as instructed by the surgeon. The task requires ongoing active communication between the surgeon and the assistant, and confusion or physical space conflicts may arise. Because the surgeon must focus on directing the assistant, he or she is distracted from performing the operation. Human camera images may be suboptimal due to lack of control because of tremor, off-center drift, or loss of horizontal orientation. Therefore, frequent correction is required. Also, inadvertent contact with tissue may result in the need to clean the lens frequently. These problems tend to diminish the concentration of the surgeon and impede the flow of the operation [5].

To alleviate such problems attributable to a human camera assistant, robotic camera systems such as AESOP (Computer Motion, Inc., Goleta, CA, USA) or EndoAssist (Armstrong Healthcare Ltd., Loudwater, United Kingdom) [1, 9] have been developed. Studies conducted to compare the differences between human and robotic control of the laparoscope have shown the robotic system to be superior [1–3, 7].

We recently developed a new robotic laparoscope manipulator that can follow a surgeon's wishes without obstructing his manipulation of the instruments [4, 8]. Anticipating that the manipulator would enable us to overcome such difficulties, we used it during a laparoscopic cholecystectomy of patients with cholelithiasis.

Table 1. The operative data of the Naviot and human camera groups

	Naviot (n = 10)	Human-camera (n = 41)	p value
Gender (M/F)	3/7	17/24	NS
Age (y.o)	61.1 ± 14.8	56.9 ± 12.6	NS
Operative time (min)	89.3 ± 27.1	74.8 ± 28.1	<0.05
Blood loss (g)	7.1 ± 13.5	15.1 ± 52.4	NS
Conversion to laparotomy	0	1	NS
Postopertive Hospital stay (day)	5.7 ± 13.5	8.1 ± 2.2	NS
Frequency of analgegia for pain	0.5 ± 0.7	0.8 ± 0.7	NS

Patients and methods

Patients

From October 2002 to March 2003 at Fukuoka City Hospital, 10 consecutive patients (3 men and 7 women with a mean age of 61.1 ± 14.8 years) with cholelithiasis underwent laparoscopic cholecystectomy assisted by the new Naviot system (Hitachi Ltd., Tokyo, Japan) (Naviot group) (Table 1). The details of the new system were carefully explained to all the patients, and their informed consent was obtained.

Another group of 41 patients who underwent laparoscopic cholecystectomy with a conventional human camera holder at Fukuoka City Hospital from May 2002 to October 2002 (human camera group) were selected for a comparison of their operative results with those of the Naviot group.

The new system: NAVIOT

The Naviot system is a robotic laparoscope manipulator that consists of a special laparoscope with an optical zoom, a flexible arm, an actuator, a five-bar linkage mechanism, and a hand controller with two buttons (Fig. 1). The flexible arm has three joints, and the actuator contains a motor that enables the arm to move. A five-bar linkage mechanism links the actuator and the arm. A specific laparoscope (only about 15 cm long) and half of the conventional laparoscope (with an optical zoom lens) are moved with the arm. The movement range is 45° in horizontal directions and 25° in vertical directions. The zoom can provide 6.0 magnifications. A hand controller consisting of two buttons (one for moving and the other for zooming) is attached to the holding part of a laparoscopic forceps (Fig. 2A). By pressing these buttons, the operator can control the zoom lens and move the laparoscope in eight directions. This new system enables the operator to move the operation field more quickly to the site he or she wants to see. The mark of the moving direction and the zooming are superimposed on the video image. Thus, the operator can always identify the movement of the laparoscope.

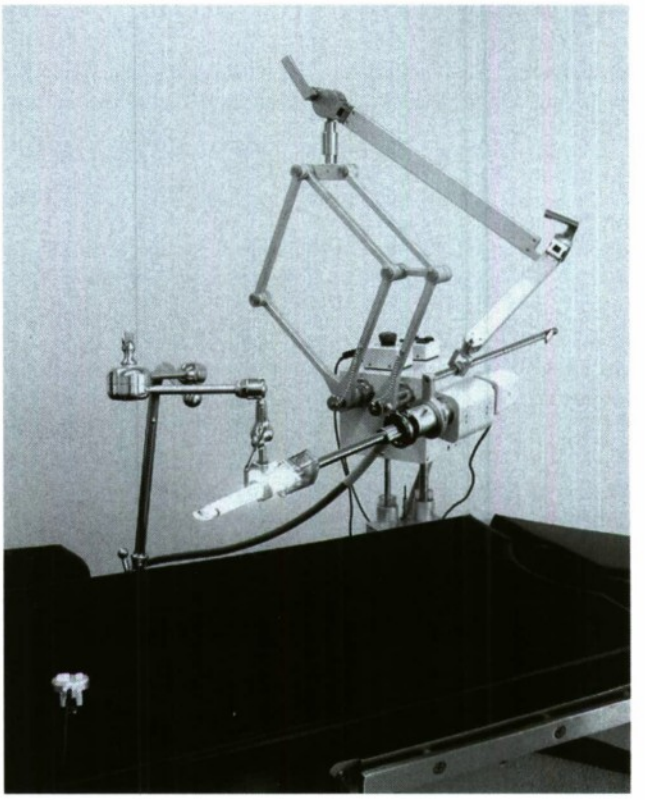

Fig. 1. Outlook of the Naviot system.

Operative procedure

All operations, including those using a conventional human camera holder, were performed by one individual operator familiar with endoscopic surgery and one or two assistants. The operations with Naviot were performed as follows. First, the actuator and the five-bar linkage mechanism were set up on the right side of the patient opposite the operator so as not to prevent forceps movement by the operator. The flexible arm was covered with a sterilized plastic bag, then connected to the five-bar linkage mechanism.

A skin incision about 12 mm long was made on the upper side of the patient's umbilicus. The laparoscope was inserted through a trocar applied to the incision. Then the laparoscope was connected to the flexible arm, and the arm was fixed. With the use of a 5 mm trocar in the upper midline for the right hand of the operator and two 2 mm trocars in the right upper quadrants for the left hands of the operator and the assistant, the cholecystectomy was performed. The controller of the Naviot was put on the 2 mm forceps close to the grip of the operator's left hand, and the operator controlled the direction or zoom of the laparoscope by pushing the buttons with the left forefinger (Fig. 2B). The trocars were inserted, and the surgical procedures, such as clipping the cystic artery and duct and separating the gallbladder from the liver bed, were the same as in an operation with a conventional human camera holder.

Clinical analysis

Each patient's medical record was reviewed for the following information: age; sex; dates of admission, surgery, and discharge; surgical procedure; operative time; intraoperative blood loss; intraoperative and postoperative complications; and postoperative clinical course. The operative time was recorded in terms of minutes from incision to closure. The patient's postoperative physiologic state was evaluated as the frequency of analgesia (pentazocine) used during the 48 h after surgery, the duration of fever (>38°C), the day liquid food was initiated, and the duration of the postoperative hospital stay.

During the operation, we measured the movement range of the laparoscope (in both vertical and horizontal directions), the movement velocity, and the zoom magnification. We also measured the operating time, which was divided into three phases: (A) the time from skin incision to insertion of the laparoscope, (B) the time from insertion of the laparoscope to fixation of the arm, and (C) the time from fixation of the arm to the end of the operation.

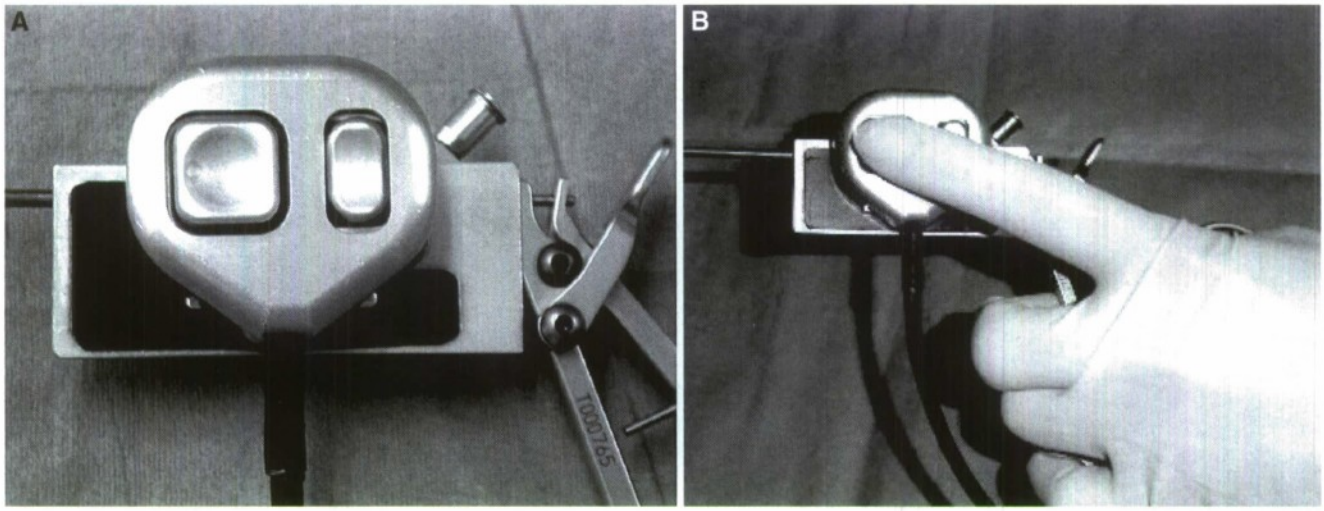

Fig. 2. **A** The controller of Naviot. **B** The operator controlled the direction or zoom of the laparoscope by pushing the buttons with the left forefinger.

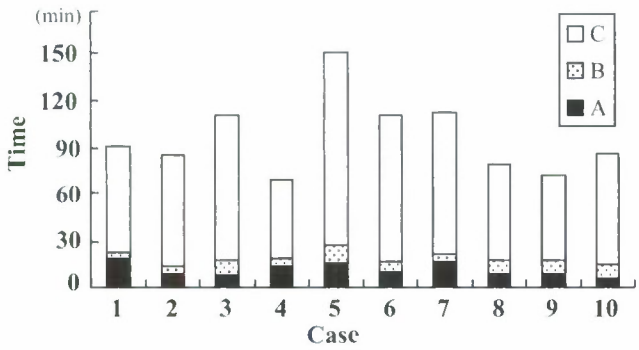

Fig. 3. The mean of the setup time and operative time for each patient including (A) the time from skin incision to insertion of the laparoscope, (B) the time from insertion of the laparoscope to fixation of the arm, and (C) the time from fixation of the arm to the end of the operation.

Statistical analysis

The Naviot group and the human camera holder group were compared for significant differences in age, sex, intraoperative and postoperative complications, length of hospitalization, operative time, intraoperative blood loss, and postoperative physiologic state. Data are represented as the mean ± standard deviation. The Mann–Whitney U test was used to calculate statistical significance ($p < 0.05$).

Results

Operative procedures

Between October 2002 and March 2003, 10 patients underwent laparoscopic cholecystectomy with the Naviot system at Fukuoka City Hospital. Each patient's mean setup and operative times for phases A, B, and C are shown as Fig. 3.

At this writing, no major complications related to the Naviot system have been encountered in any procedures. The patient in case 5 with a severe history of cholecystitis had severe adhesion around the gallbladder. Because sufficient vision, even with the highest zooming, could not be obtained due to the long distance between the camera and the gallbladder, we changed the camera of the Naviot system to the human-held camera for safe performance of the operation. After this case, we used the new camera of the Naviot system with improved zooming. A conversion lens was added to the camera between the zooming lens and the charged-coupled devices (CCD), which enabled us to obtain a clear vision of the object, which existed in the deeper place. In the first four cases, the controller of the Naviot system, which was fastened to the 2 mm forceps with the clip close to the grip of the operator's left hand, easily slipped down during the operation. To remedy this problem, the controller was fixed at a comfortable position on the 2 mm forceps by driving screws after case 4 (Fig. 3).

The operative time of 89.3 ± 27.1 min in the Naviot group was significantly longer for laparoscopic surgery than the 74.8 ± 28.1 min for the human camera group ($p < 0.05$). However, when the setup time (time of B) for the Naviot system was excluded, there was no significant difference in operative time between the Naviot group and the human camera group. There also was no significant difference in estimated blood loss between the Naviot group (7.1 ± 13.5 g) and the human camera group (15.1 ± 52.4 g).

Postoperative physiologic state

There were no significant differences in the frequency of analgesia (pentazocine 15 mg) administered for postoperative abdominal pain during the 24 h after surgery, the duration of postoperative fever, the start of liquid food, or the duration of postoperative hospital stay between the two groups (Table 1).

Discussion

A new remote-controlled laparoscope manipulator system (Naviot) was introduced for 10 cases of laparoscopic cholecystectomy, and all the procedures were performed safely and efficiently.

The search to find an alternative to a human camera holder for both economy and efficiency first led to the development of mechanical manipulators such as Omnitract, Bookwalter, Boonpong holder, and the like [6]. With these manipulators, the operator must release instruments and interrupt the procedure to make operating field adjustments. Robotic systems designed to avoid this weakness have been introduced in general surgery. A series of 20 patients undergoing laparoscopic cholecystectomy using a self-guiding robot has been reported by Omote et al. [7], who found no significant difference in operating time between their series and historical controls. Aiono et al. [1] reported that the EndoAssist robotic camera holder performed effectively and reduced operating time, as compared with a human camera holder, during laparoscopic cholecystectomy.

With the Naviot system, the operator can move the laparoscope in eight directions smoothly, and can obtain a fine visual field to his or her satisfaction. The hand control adopted as the man–machine interface with this system is superior to voice control in terms of intuitive and delicate control of the laparoscope [4]. What is more, the operator also can move the laparoscopic forceps simultaneously because the hand controller is attached to the holding part of the forceps. Using this system, we were able to perform the laparoscopic cholecystectomy more efficiently.

A zoom lens control also can provide a fine view at some distance from the target. Furthermore, a better view of the surgical field was obtained after improvement of the zooming function. The optical zoom with the laparoscope also is very beneficial. The operator does not need to insert the laparoscope deeply to see the operative field. This means that there is less risk of injuring the organs in the abdominal cavity. A wide workspace also can be made in the abdominal cavity because the laparoscope is 15 cm in the length, which is half that of the conventional laparoscope. Because the tip of this short laparoscope does not protrude from the trocar in the peritoneal cavity, accidental collision with tissue can be avoided in the operation. Additionally, the zoom lens used with the laparoscope is specially made not to collect moisture. Because the operator does not need to pull the laparoscope out to clean the lens so often during the operation, time is saved.

We divided the total operation time into three phases: A, B, and C. Preparation of the system occurred in phase B. Although the overall operative time for the Naviot group was longer than for the human camera group, the net operative time (overall operative time – setup time [B]) was not significantly longer. Furthermore, the setup time for the Naviot system could be shorter with acquisition of more experience. There was no significant difference in the postoperative physiologic state (frequency of analgesia, duration of postoperative fever, start of liquid food, and duration of postoperative hospital stay) between the two groups. Accordingly, use of the Naviot system for laparoscopic cholecystectomy can be comparable with the human-held camera.

In the first four cases, we had some trouble with insufficient zooming of the camera and frequent slipping of the hand controller from the forceps. We resolved these problems by adding a conversion lens between the zooming lens and the CCD in the camera, and by fixing the controller on the forceps with driving screws. After these improvements, we could obtain a better surgical view, and could be released from the irritation of pushing the wrong buttons and of refixing the controller on the forceps with interruption of surgery.

Conclusion

We managed 10 cases of laparoscopic cholecystectomy using the Naviot, a remote-controlled laparoscopic manipulator system. Using the Naviot, we accomplished all the procedures safely and efficiently. We believe this new system is feasible for clinical use. It enables surgeons to perform "solo surgery" in the field of gastrointestinal surgery.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Modified needlescopic video-assisted thoracic surgery for primary spontaneous pneumothorax

The long-term effects of apical pleurectomy versus pleural abrasion

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Abstract
Background: The objective of this study was to evaluate the feasibility and safety of modified needlescopic video-assisted thoracic surgery (VATS) for treating primary spontaneous pneumothorax. The efficacy between apical pleurectomy and pleural abrasion through this technique was also compared.
Methods: Between 2001 and 2003, 65 patients with primary spontaneous pneumothorax underwent modified needlescopic VATS procedures. The blebs were resected with endoscopic linear staplers. Pleurodesis was achieved by apical pleurectomy before September 2002 ($n = 30$) and by pleural abrasion for the remainder of the study period ($n = 35$).
Results: Mean operation time was 103 min in the pleurectomy group and 78 min in the abrasion group ($p = 0.001$). Complications developed in four patients (6.2%): prolonged air leaks in three patients and wound infection in one patient. The mean postoperative hospital stay was 3.8 ± 1.8 days. The two groups had comparable doses of requested analgesics, complication rates, postoperative chest tube and hospital stays, and postoperative pulmonary function test. Ipsilateral recurrence did not occur in any of the pleurectomy group patients after a mean follow-up of 31 months, but it occurred in three patients (8.6%) in the abrasion group after a mean follow-up of 19 months.
Conclusions: Modified needlescopic VATS provides a feasible and safe procedure for treating primary spontaneous pneumothorax. In terms of efficacy, apical pleurectomy is more effective in preventing ipsilateral recurrence than pleural abrasion.

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Key words: Needlescope — Video-assisted thoracic surgery — Spontaneous pneumothorax — Pleurectomy — Pleural abrasion

Optimal surgical management of primary spontaneous pneumothorax has been a matter of debate, especially regarding the type of surgical approach and the method of pleurodesis [2, 8]. Recent advances in video-assisted thoracic surgery (VATS) that combine bullectomy with pleural abrasion or apical pleurectomy provide a feasible alternative for treatment of recurrent primary spontaneous pneumothorax and have been chosen as the preferred management by many physicians [11, 17]. However, after conventional VATS, postoperative chest pain has not been completely alleviated [3, 13], and healing of the surgical wounds of conventional VATS has not been cosmetically excellent.

Needlescopic equipment and instruments have been applied to thoracic procedures. Initial reports suggested that needlescopic VATS was feasible in treating primary spontaneous pneumothorax and resulted in better cosmesis and less postoperative pain [4, 9, 18]. However, the number of patients in these studies is small, and the long-term effectiveness of this new technique remains unknown. Because of the inferior vision of the needlescope and inadequate strength of the instruments, pleurodesis is usually not performed or it is accomplished by pleural abrasion [4, 9, 18]. Therefore, the recurrence rate of needlescopic VATS could be higher compared to that of conventional VATS.

In previous studies, apical pleurectomy performed by open thoracotomy or conventional VATS was shown to be feasible and resulted in a very low incidence of recurrence [1, 15]. However, apical pleurectomy has not been performed using the needlescopic VATS technique.

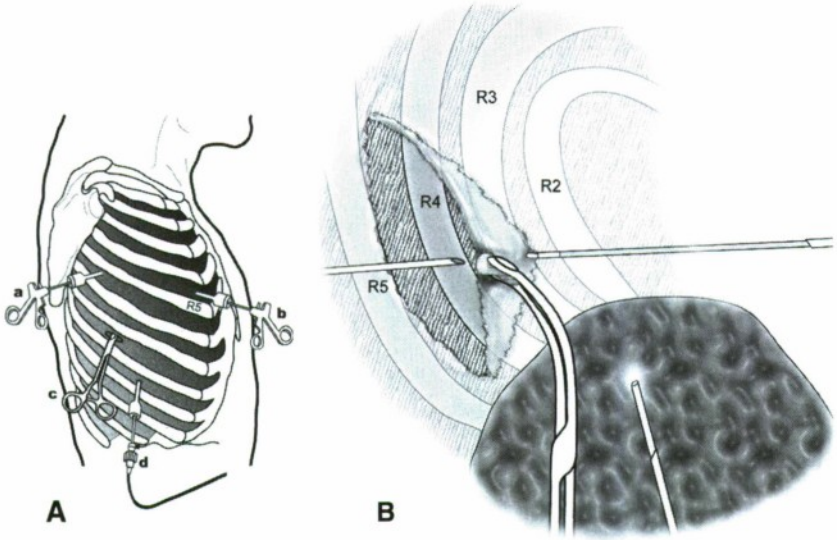

Fig. 1. Operative technique of apical pleurectomy via modified needlescopic video-assisted thoracic surgery. **(A)** Allocation of the skin incisions for chest tube wound and mini-ports: a and b, 3-mm superior mini-ports for mini-endograspers; c, 12-mm chest tube wound for conventional or 10-mm thoracoscopic instruments; and d, 3-mm inferior mini-port for needlescope. **(B)** Under the vision of the needlescope, a mini-endograsper was used to lift the parietal pleura while it was bluntly stripped off the inner chest wall by inserting the curved dissector with a pledget through the chest tube wound (R5, the fifth rib).

In this study, the technique and experience of modified needlescopic VATS for the treatment of primary spontaneous pneumothorax are reported. Also, the long-term effects and pulmonary functional results of pleural abrasion and apical pleurectomy through this minimally invasive approach are compared.

Materials and methods

From June 2001 to October 2003, consecutive patients undergoing a modified needlescopic VATS procedure for the treatment of spontaneous pneumothorax were retrospectively identified through a review of records at the Far Eastern Memorial Hospital, Taipei County, Taiwan. The indications for operation included ipsilateral recurrence, continuous air leaks for more than 72 h, and contralateral recurrence. Patients older than 55 years of age or with preexisting pulmonary diseases were excluded from this study to avoid patients with secondary pneumothorax. In addition, patients who underwent a conventional VATS technique or had previous VATS procedures on the involved side were also excluded from the analyses.

Operative techniques of modified needlescopic VATS

The operation techniques for modified needlescopic VATS have been described previously [4]. In brief, under general anesthesia using intubation with a double-lumen endotracheal tube, patients were placed in a lateral decubitus position and the ipsilateral lung was deflated. Two sets of independent videothoracoscopic equipment and monitors (Karl Storz, Tuttlingen, Germany), one for needlescopic videothoracoscopy and the other for 10-mm videothoracoscopy, were used simultaneously and placed near the patient's head. The needlescopic procedures were modified by using the 10 mm videothoracoscopy for most of the surgical steps. A needlescope was indicated only when we needed to use the chest tube wound to insert the endoscopic stapler, to extract the specimen, or to perform apical pleurectomy or pleural abrasion.

A 10-mm 30° telescope (Karl Storz) was first inserted through the previous chest tube wound to examine the pleural cavity. If the chest tube wound was not available, a 12 mm port was made at the sixth or seventh intercostal space. Three small skin punctures were made, and mini-ports were inserted for needlescopic instruments (3 mm instruments, Olympus, Tokyo). The inferior mini-port for the needlescope was located at the seventh or eighth intercostal space of the middle axillary line, one intercostal space lower than the level of the chest tube wound, to avoid a mirror image during surgical procedures. The two superior mini-ports were located at the fourth and fifth intercostal space of the anterior and posterior axillary lines, respectively. Initially, the 10 mm telescope and two mini-endograspers were used to identify the blebs. When a bleb was identified, it was fixed by mini-endograsper at one of the superior mini-ports. A 3 mm 30° needlescope was introduced at the inferior mini-port to visualize the bleb. The 10-mm telescope was then withdrawn, and a 45 mm endoscopic linear stapler was introduced to resect the bleb. If no air leakage was identified, apical stapling was routinely performed at the most suspicious area. The surgical specimen was retrieved from the chest tube wound. The 10 mm telescope was inserted again to check the stapling line. Electrocautery was used when bleeding from the stapling line was noted.

Apical pleurectomy or pleural abrasion was performed under the vision of needlescope. Between June 2001 and September 2002, pleurodesis was performed by apical pleurectomy. Between October 2002 and October 2003, pleural abrasion was performed because of its shorter operation time and easier operative technique. Informed consent was obtained from each patient after thorough explanation of the procedures.

For apical pleurectomy, a 3-mm 30° needlescope was introduced through the inferior mini-port. The inferior border of the pleural strip was marked by mini-endohook electrocautery at the upper margin of the fifth or sixth rib, depending on the location of the blebs. The mini-endograspers from the superior mini-ports were used to lift and steady the pleura while it was bluntly stripped off the inner chest wall by inserting the curved dissector with a pledget through the chest tube wound (Fig. 1). The dissection was made in an apical direction. The longitudinal limit of the resection ran along the sympathetic trunk posteriorly and the internal mammary artery anteriorly to the height of the left subclavian artery on the left side or the brachiocephalic trunk on the right side.

Pleural abrasion was also performed under the vision of needlescope. The upper half of the parietal surface was abraded by inserting the curved dissector with a diathermy scratch pad through the chest tube wound. We used the 10 mm videothoracoscope intermittently to ascertain that the upper half of the pleural surface was thoroughly and evenly rubbed.

After the operation, normal saline solution was instilled, and the 10-mm videothoracoscope was introduced to check for air leaks and bleeding. A chest tube was placed in the apex through the chest tube wound. The punctures sites of the 3 mm port were closed with a 4–0 nylon suture. The wounds were then secured with adhesive tape (Steri-Strips). The surgical specimens were routinely sent for pathological examination.

Postoperative care

The patients were extubated in the operating theater and observed for 1 or 2 h in the recovery room. The tube was connected to a low-pressure suction system of approximately −10 to −20 cm H_2O. Postoperative analgesics included routine oral nonsteroid analgesics and

Table 1. Clinical characteristics of patients treated by needlescopic apical pleurectomy or pleural abrasion

	Apical pleurectomy (n = 30)	Pleural abrasion (n = 35)	p value
Age (yr)[a]	27.5 ± 11.0	24.2 ± 7.0	0.165
Gender (male)	27 (90%)	33 (94%)	0.655
Smoker	11 (37%)	13 (37%)	1.000
Side involved (left)	13 (43%)	22 (63%)	0.140
Surgical indications			0.391[b]
Ipsilateral recurrence	17 (57%)	17 (49%)	
Persistent air leaks	10 (33%)	14 (40%)	
Contralateral recurrence	3 (10%)	4 (11%)	
Bleb number			0.391[b]
No bleb	4 (13%)	4 (11%)	
One or two blebs	17 (57%)	23 (66%)	
Multiple blebs (≥3 blebs)	9 (30%)	8 (23%)	
Blood loss[a]	94.1 ± 23.9	85.0 ± 35.1	0.236
Surgery duration (min)[a]	102.5 ± 31.5	77.5 ± 28.3	0.001

[a] Mean ± standard deviation
[b] Analyzed by Pearson chi-square test

acetaminophen. Intramuscular meperidine hydrochloride (Demerol, 50 mg/ampule) was administered every 4–6 h according to the patient's request if the pain became intolerable or could not be relieved by oral analgesics. The tube was removed when the lung was fully expanded and no air leaks could be noted in a 24-h period. Patients were discharged 1 day after the removal of the drainage tube if no complications occurred.

Postoperative pulmonary function

Postoperative pulmonary function tests were performed for patients able to attend a hospital outpatient appointment at least 6 months after surgery. Forced vital capacity (FVC) and forced expiratory volume in 1 s ($FEV_{1.0}$) were measured using a Microspiro HI-298 spirometer (Chest Corporation, Tokyo) with the patients seated.

Data collection and analyses

The clinical data, operative findings, operation time, duration of postoperative chest drainage, length of hospital stay, and complications were collected from the medical records. The requested doses of meperidine were collected from the nursing records. Patients were followed up by clinical visits for at least 12 months and by telephone conversation thereafter. Continuous variables such as age or weight were expressed as mean ± standard deviation and analyzed by the two-sample t-test. Categorical variables such as gender or smoking status were presented by frequency (%) and were analyzed by Fisher's exact test or by Pearson's chi-square test. The rates of freedom from recurrence were estimated using the Kaplan–Meier method. The log-rank test was used to analyze differences in recurrence. Statistical analyses were performed using SPSS 10.0 software. A p value of less than 0.05 was considered significant.

Results

Sixty-five patients who had undergone a needlescopic VATS procedure for primary spontaneous pneumothorax were identified at our institution. The mean age was 25.5 years (range, 16–52; 60 males and five females); 24 patients (37%) were smokers. The indications for operation were ipsilateral recurrence in 34 (52.3%), persistent air leaks in 24 (36.9%), and contralateral recurrence in seven (10.8%). Needlescopic VATS was unilateral in all cases. Blebs or bullae were identified in 57 patients (87.7%), and multiple blebs (≥3 blebs) were visualized in 17 of these patients (26.2%). The most common site for blebs was the upper lobe (51 patients, 78.5%).

The operative findings and management are summarized in Table 1. The two groups of patients had comparable clinical characteristics in terms of age, sex, smoking status, surgical indication, bleb number, and estimated blood loss. The mean operation time was 103 min in the pleurectomy group and 78 min in the abrasion group (p = 0.001). The results of treatment are summarized in Table 2. Intramuscular meperidine was requested by 58% of the patients, mainly on postoperative day 1; the mean accumulated dosage of injection was comparable for both groups. No operative deaths and no major complications were reported. Three patients (4.7%) had air leaks lasting longer than 5 days; one patient had infection of the chest tube wound. These patients were managed conservatively. The complication rate for both groups was comparable. The mean postoperative hospital stay was 3.9 days (range, 2–10) in the pleurectomy group and 3.8 days (range, 2–12) in the abrasion group.

The patients underwent a postoperative follow-up ranging from 12 to 39 months, with a median follow-up of 25.4 months. Patients in the pleurectomy group had a significantly longer mean follow-up than the abrasion group (31.2 vs 19.4 months). Ipsilateral recurrence of pneumothorax occurred in three patients (8.6%) treated by pleural abrasion but in none of the patients treated by apical pleurectomy. The recurrences occurred 4, 6, and 24 months after the operation, respectively. The rates of freedom from recurrence after the operation for both groups were determined using the Kaplan–Meyer method and are plotted in Fig. 2 and compared by the log-rank test. Patients who underwent apical pleurectomy had a significantly lower rate of ipsilateral recurrence (p = 0.024). When the operative findings were reviewed, no leaking site could be identified in one patient, and multiple small blebs were noted in two other patients. Two of three recurrent patients underwent a reoperation by conventional VATS. Missed blebs were identified in the vicinity of the previous staple line. No

Table 2. Results of patients treated by needlescopic apical pleurectomy or pleural abrasion

	Apical pleurectomy (n = 30)	Pleural abrasion (n = 35)	p value
Meperidine hydrochloride (mg)[a]	56 ± 56	51 ± 69	0.746
Postoperative chest tube duration (d)[a]	3.2 ± 1.6	3.1 ± 1.1	0.812
Postoperative hospital stay (d)[a]	3.9 ± 1.7	3.8 ± 1.5	0.860
Complications			
Air leaks > 5 d	2 (6.7%)	1 (2.9%)	0.591
Wound infection	0 (0%)	1 (2.9%)	1.000
Follow-up (mo)[a]	31.2 ± 5.3	19.4 ± 3.2	<0.001
Recurrence	0 (0%)	3 (8.6%)	0.243
Pulmonary function test[b]			
FVC (%)[c]	86.3 ± 9.8	88.5 ± 11.8	0.574
$FEV_{1.0}$ (%)[c]	94.9 ± 11.2	99.0 ± 13.9	0.378

FVC, forced vital capacity; $FEV_{1.0}$, forced expiratory volume in 1 s
[a] Mean ± standard deviation
[b] Fifteen patients in the pleurectomy group and 25 patients in the abrasion group were available for pulmonary function test.
[c] Represented as percentage of predicted value

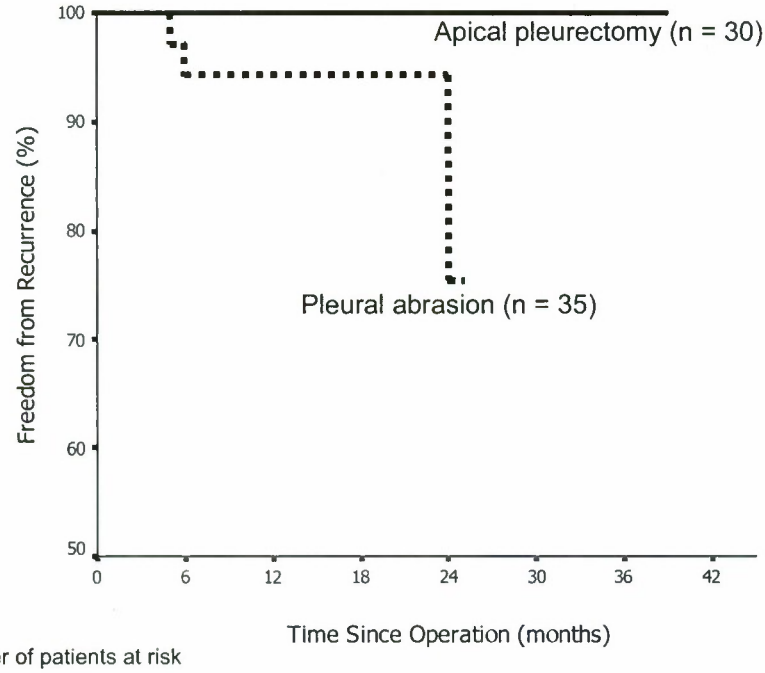

Fig. 2. Freedom from recurrent pneumothorax in each group after modified needlescopic video-assisted thoracic surgery (p = 0.024 by log-rank test). The number of patients at risk for each 6-month period is indicated under the corresponding time.

obvious adhesions were noted in the whole pleural cavity, even in the areas of previous pleural abrasion. The blebs were excised, and pleurodesis was accomplished by apical pleurectomy. The remaining patient was treated by chest tube insertion.

Discussion

This study demonstrates that modified needlescopic VATS is a feasible and safe procedure for treating primary spontaneous pneumothorax. The results also show that apical pleurectomy is more effective than pleural abrasion in obtaining pleural symphysis and freedom from recurrence without increased pain, complications, or comorbidities.

Needlescopic surgery generally refers to procedures that use instruments with an external diameter ≤ 3 mm [6, 10]. Although needlescopic surgery represents the next logical step in the evolution of VATS, there are technical limitations associated with the needlescopic instruments [12, 18]. Scopes with a small needle size provide poor visibility. Furthermore, the mini-instruments are inconvenient for grasping the bulky lung parenchyma and performing pleurodesis because of their small jaws and inadequate strength.

For patients with spontaneous pneumothorax, an incision of at least 10–12 mm for a chest tube was usually present before the operation or indicated after the operation. This incision made it possible for us to use a 10-mm thoracoscope for most of the surgical steps. In addition, the endoscopic linear stapler for pulmonary

resection and the curved ring forceps or dissector for pleural abrasion and pleurectomy can be introduced through this wound. Taking advantage of this wound, modified needlescopic VATS can be safely and easily performed with no compromise of the surgical procedures [4].

Although modified needlescopic VATS is feasible and safe, our experience showed that needlescopic bullectomy and pleural abrasion carry a higher rate of recurrence (8.6%) compared to the same procedures performed by conventional VATS [11, 17]. The early postoperative recurrences of pneumothorax are generally thought to be due to overlooked existing pulmonary blebs. It is possible that needlescopic VATS leads to a higher risk of missing blebs than conventional VATS. In this situation, a strong and adequate pleural adhesion is indicated to prevent recurrence of the pneumothorax. Our long-term recurrence rate is 0 in the pleurectomy group, indicating that apical pleurectomy can provide reliable and durable pleural symphysis to prevent further recurrence, even using needlescopic procedures.

Since the introduction of surgical intervention for spontaneous pneumothorax, pleurectomy has been a reliable method for pleurodesis. The procedure has a very low incidence of recurrence, ranging from 0 to 1%, by open thoracotomy, transaxillary minithoracotomy, or VATS [1, 15]. British Thoracic Society guidelines suggest that pleural abrasion is associated with a higher rate of recurrence than pleurectomy [8]. Compared to pleurectomy, pleural abrasion is a procedure that has problems associated with standardization of the material used as well as the force and time needed for abrasion. Postoperatively, we usually found that the parietal pleura were unevenly abraded. In the two patients who underwent reoperation after recurrence, only scanty adhesions were noted in the pleural cavity. In contrast, parietal pleurectomy created a dense and even inflammatory surface between the pleura and the chest wall [6]. Several authors have since described pleurectomy as the most secure procedure to obtain permanent pleurodesis [6, 14]. Since the disease is almost always located at the apex of the lung, we believe that in young people a limited apical pleurectomy combined with local excision of the diseased lung is sufficient for definitive control of recurrences. In addition, if lung blebs are found and resected in the middle or lower lobes, pleurectomy can also be extended to a lower level.

Although dense pleurodesis may limit the expansion of the lungs, there is no evidence that apical pleurectomy significantly affects pulmonary function. Previous studies showed that the mean vital capacity of patients with previously documented pneumothorax who did not have surgery was 87 or 88% of the normal predicted values [5, 16]. By comparison, our data showed that the vital capacity following either pleural abrasion or apical pleurectomy did not alter significantly. In addition, FVC and $FEV_{1.0}$ were comparable for both groups of patients.

The intensity of postoperative pain caused by apical pleurectomy or pleural abrasion was also evaluated by comparing the requested doses of meperidine. Our data showed that the incidence and mean doses of meperidine injection were comparable for both groups. This suggests that apical pleurectomy may not induce stronger pain than pleural abrasion.

Some researchers do not favor pleurectomy as a routine pleurodesis procedure due to the following pitfalls. The surgery is more technically demanding, and the operation time is significantly longer. Thus, the cost associated with the operation is higher. In addition, apical pleurectomy makes further operations more difficult. In our experience, the operation time can be significantly shortened after the learning curve, and the expense of difficult further operations can be compensated by the decrease in short-term recurrence.

We acknowledge that this is a retrospective study and the comparison was based on a historical control. However, our results suggest that needlescopic VATS is feasible and safe, and it may provide satisfactory results if apical pleurectomy is used. Further prospective research that includes randomized design is needed to rigorously test the effects of this treatment.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Systematic evaluation of different approaches for minimizing hemodynamic changes during pneumoperitoneum

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Abstraet

Background: Capnoperitoneum (CP) eompromises hemodynamic funetion during laparoseopy. Three therapeutic eoneepts were evaluated with an aim to minimize the hemodynamie reaetion to CP: First, a eontrolled increase of intrathoraeic blood volume (ITBV) by intravenous fluids; second, partially reduced sympathetic activity by the β_1-bloeker esmolol; and third, a decrease in mean arterial pressure (MAP) by the vasodilator sodium nitroprusside.

Methods: For this study, 43 pigs were assigned to treatment with fluid and sodium nitroprusside (group A) or with esmolol (group B). In both groups, the pigs were assigned to head-up, head-down, or supine position, resulting in three different subgroups. Invasive hemodynamie monitoring was established ineluding left heart eatheter and cardiac oxygen lung water determination (COLD) measurements. Measurements were documented before CP with the animals in supine position, after induction of a 14-mmHg CP with the animals in each body position, after a 10% reduction in MAP by vasodilation, and after an increase in ITBV of about 30% by infusion of 6% hydroxyethylstareh solution.

Results: Increasing ITBV improved hemodynamic function in all body positions during CP. Esmolol redueed eardiae output and myoeardial contraetility. Sodium nitroprusside did not improve hemodynamic function in any body position.

Conclusions: Optimizing volume load is effective for minimizing hemodynamie ehanges during CP in the head-up and in head-down positions. In general, β_1-bloekers cannot be reeommended beeause they might additionally eompromise myoeardial eontraetility and suppress eompensatory reaetion of the sympathetie nerve system. Vasodilation has not improved hemodynamie parameters during CP.

Key words: Fluid Management — Hemodynamic — Laparoseopy — Pathophysiology — Penumoperitoneum — Therapy

Capnoperitoneum (CP) during laparoseopie surgery eauses speeifie hemodynamic ehanges. Furthermore, eardiae funetion during laparoseopy might be additionally impaired in patients with preexisting cardiovaseular diseases. With knowledge of the physiologic background and the therapeutic approaches available to minimize hemodynamie ehanges, the number of patients excluded from laparoseopie surgery can be reduced to a minimum.

During CP, a decrease in eardiae stroke volume and eardiae output often has been deseribed as well as an inerease in mean arterial pressure or heart rate [2, 6, 9, 11, 17, 24]. These changes are eaused by an increase in the intraabdominal pressure (IAP), which is supposed to reduee venous blood return to the heart [4, 7, 18–20] followed by a decrease in intrathoracie blood volume (ITBV) or left ventrieular end diastolie volume (LVEDV) [5, 14, 16, 25]. Either ITBV or LVEDV is useful for assessing eardiac preload. Cardiae preload determines cardiae funetion aeeording to the Frank–Starling mechanism. A lower eardiae preload results in less filling of the ventrieles, with a eonseeutively deereased cardiac stroke volume. The reduetion in stroke

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volume is recognized by receptors in the carotid sinus, increasing sympathetic nerve activity. Thus, mean arterial pressure or heart rate is increased during CP.

Experimental and clinical studies have suggested that hemodynamic function during laparoscopy might be improved by increasing intravascular volume or medication with esmolol or nitroglycerine [3, 10, 13], but these different therapeutic strategies have never been evaluated systematic. Thus, according to the physiologic causality, different therapeutic approaches were compared. In this animal trial, an increase in intrathoracic blood volume by infusion therapy, a reduction in mean arterial pressure or heart rate by β_1-blockers, or vasodilation by sodium nitroprusside was induced during CP. Because body position is well known to influence hemodynamic function during CP, the animals were divided into different groups to represent head-up, head-down, and supine positions.

Materials and methods

The hemodynamic reactions of 43 pigs with a body weight of 30 ± 2.6 kg were observed during CP with an IAP of 14 mmHg. The pigs were assigned randomly to treatment with fluid and sodium nitroprusside (group A) or with esmolol (group B). In both groups, the animals were divided according to three different body positions: 30° head-up, 30° head-down, and supine. Cardiovascular monitoring included measurement of parameters to assess cardiac preload, cardiac afterload, and myocardial contractility. The study was approved by the animal welfare committee of the city of Berlin, Germany (Reg.Nr. 0026/00).

Anesthetic regimen

The day before the experiment, the pigs were allowed to drink water ad libitum. The animals were premedicated with a 400-mg intramuscular metomidate (hypnodil). With the animals in supine position general anesthesia was induced with etomidate 6 mg, fentanyl dihydrogencitrat 0.1 mg, and cisatracurium 10 mg. Anesthesia was maintained by ventilation with 1% to 2% isofluran and by intermittent injections with cisatracurium and fentanyl. Blood gases were analyzed during every measurement as well as end-tidal carbon dioxide (CO_2). The frequency of mechanical ventilation was adjusted to end-tidal CO_2 to maintain normocapnia. No hyperventilation was necessary during the measurements. The animals received 0.2 ml/min/kg of electrolyte solution. To avoid blood clotting around the vascular catheters, a bolus with 5,000 I.U. heparin followed by a continuous rate of 1,000 I.U. per hour was given intravenously. After all the measurements, the animals were killed by intravenous injection of T61 (0.3 ml/kg).

Monitoring

After induction of general anesthesia, a central venous catheter was placed in the superior cava vein to measure central venous pressure (CVP). Heart rate was counted by electrocardiogram (ECG). A 4-F oximetry-thermodye-dilution catheter (Pulsion Medical Systems Inc, Munich, Germany) was placed in the descending aorta to measure mean arterial pressure MAP. The catheters were connected to the cardiac oxygenation lung water determination (COLD) monitoring system (PULSION COLD Z-021; Pulsion Medical Systems Inc). The ITBV which mainly influences cardiac preload was calculated by the monitoring system as well as cardiac output (CO) and cardiac stroke volume. Systemic vascular resistance (SVR) was calculated as $SVR = (MAP - CVP) \times 79.9 / CO$. Myocardial contractility, independent of load conditions and heart rate, is best described by myocardial contractility (Emax) [21, 22], and was measured via left heart conductance catheter (SPC 572 Millar Mikro-Tip catheter; Krauth Medical Cardiovascular, Hamburg, Germany). The catheter consists of two pressure sensors placed in the left ventricle and the ascending aorta via carotid arteriotomy. Volumes were calculated by 12 electrodes using the technique of conductance. Emax is characterized as the slope of the straight line that represents the relation between intraventricular pressure and volume at the end of the systole after different loaded cardiac cycles. The pressure–volume relation was modified using transient vena caval and descending aortic occlusion to imitate acute changes of cardiac pre- and afterload.

Measurements

Before all measurements, the animals received 1,000 ml of 0.9% NaCl solution intravenously to avoid hypovolemia. After placement of all the catheters and an adaptation of 20 min, baseline values were recorded. The animals were assigned randomly to be placed in supine, 30° head-up, or 30° head-down position. In group A, a CP of 14 mmHg was established and kept by an insufflator (Thermoflator, Storz, Germany) via a port in the right abdomen. Values during CP were recorded after another adaptation of 15 min. The following measurement of hemodynamic parameters was conducted after a 10% decrease in MAP by continuous infusion with the vasodilatator sodium nitroprusside. The vasodilation was stopped after the measurement. The CP was released, and the animals were placed back in supine position.

After 30 min of adaptation, ITBV was increased by 30% up to a maximum infusion of 1.5 l 6% hydroxyethyl starch solution. The animals were again placed in their previous position combined with a CP of 14 mmHg. Measurements were repeated after another adaptation of 15 min. In group B, a bolus with 1mg/kg of the ultrashort effective β_1-blocker esmolol was given intravenously after the baseline measurements just before CP was established. Esmolol medication was adjusted to a rate of 200 µg/kg/min related to the half-life period. Values during CP were recorded after another adaptation of 15 min.

Statistical analysis

The hypothesis was that increasing intravascular volume during CP improves the hemodynamic function. The main end point regarding hemodynamic function was stroke volume. The number of animals was restricted to a maximum of nine animals per group by the animal welfare committee. Eight animals were excluded from the study because of hemodynamic decompensation ($n = 5$), bleeding ($n = 2$), or embolic complication ($n = 2$) in the intial phase of the experiment. Because completion of eight animals per group was not possible with the remaining animals, the trial was closed with seven animals per group except for eight animals in group A (head-down).

Periodically calculated parameters are given as the mean of three measurements. Values are presented as median and 5 to 95 percentile. The Wilcoxon test was used to assess differences between the measurements. The relative differences between the baseline values and the measurements were compared between the three body positions using the Kruskal–Wallis-test. Differences between group A and B are presented as box and whisker plots, and were compared using the Mann–Whitney-*U* test (Figs. 1–5). All *p* values less than 0.05 were considered significant. For statistical analysis, the SPSS 11.0 (Chicago, Illinois, USA) software was used.

Results

Baseline measurements were not different between the three body positions. In the supine position, CP was well tolerated (Table 1), whereas CP in the head-down position caused some negative effects. Intrathoracic blood volume and stroke volume decreased, whereas systemic vascular resistance increased (Table 2). The negative

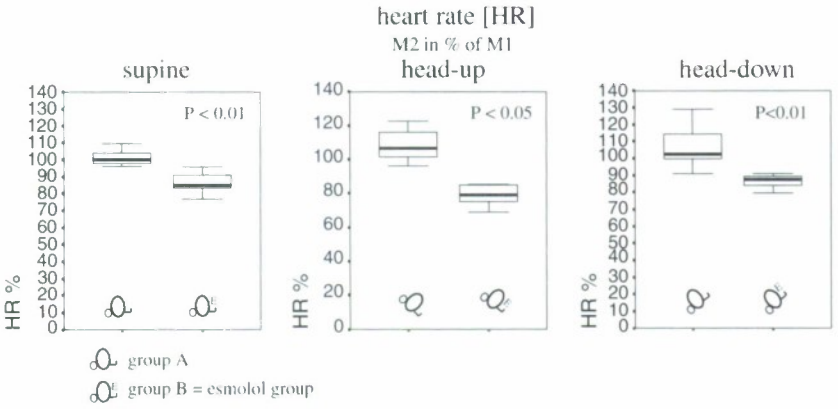

Fig. 1. Differences between groups A and B with regard to changes in heart rate during capnoperitoneum, as compared with baseline values.

Table 1. Hemodynamic changes during capnoperitoneum (CP) in group A supine position, median (5–95 percentile)

	baseline M1	CP M2	CP + nipruss M3	CP + fluids M4
HR per min	101 (73–127)	97 (73–139)	87 (72–135)	91 (73–104)
CO (l/min)	4 (2.8–5.7)	4 (2.8–4.9)	3.2 (2.4–3.9)[a]	5 (4.3–6.4)[a]
SV (ml)	49 (36–65)	48 (27–58)	38 (25–51)[a]	63 (58–78)[a]
ITBV (ml)	557 (485–670)	575 (477–597)	491 (411–534)[a]	718 (612–811)[a]
SVR (dyn/s/cm^{-5})	1370 (926–1876)	1537 (1,078–1,602)	1388 (1,047–1,710)	999 (742–1162)[a]
MAP (mmHg)	78 (67–109)	78 (65–99)	62 (54–72)[a]	84 (78–107)[a]
Emax mm Hg per ml	3.9 (2.9–4.4)	3.6 (2.7–4.3)	3.8 (2.6–4)	3.2 (2.7–4)

nipruss, nitroprusside; HR, heart rate; CO, cardiac output; SV, stroke volume; ITBV, intrathoracic blood volume; SVR, systemic vascular resistance; MAP, mean arterial pressure; Emax, myocardial contractility; Hg, mercury; M, measurement
[a] $p < 0.05$ compared with M2, Wilcoxontest

Table 2. Hemodynamic changes during capnoperitoneum (CP) in group A head-down position, median (5–95 percentile)

	baseline M1	CP M2	CP + nipruss M3	CP + fluids M4
HR per min	90 (83–115)	95 (78–119)	111 (73–126)	105 (85–168)
CO (l/min)	4.2 (3.9–5.6)	3.9 (3.3–5.8)	3.5 (2.9–5.4)[a]	5.2 (4.4–9.3)[a]
SV (ml)	56 (48–73)	49 (37–69)[b]	43 (31–51)[a]	61 (58–67)[a]
ITBV (ml)	624 (597–906)	584 (519–833)[b]	520 (470–747)[a]	756 (721–945)[a]
SVR (dyn/s/cm^{-5})	1034 (788–1,259)	1199 (936–1,572)[b]	1045 (791–1455)	774 (608–1,010)[a]
MAP (mmHg)	69 (51–78)	77 (61–88)	62 (45–70)[a]	81 (73–96)
Emax mm Hg per ml	4 (3.1–4.3)	4.1 (3.2–4.6)	4.5 (3.1–4.8)	4.2 (3–5.4)

nipruss, nitroprusside; HR, heart rate; CO, cardiac output; SV, stroke volume; ITBV, intrathoracic blood volume; SVR, systemic vascular resistance, MAP, mean arterial pressure; Emax, myocardial contractility; Hg, mercury; M, measurement
[a] $p < 0.05$ compared with M2, Wilcoxontest
[b] $p < 0.05$ compared with M1, Wilcoxontest

influences were more pronounced during CP in the head-up position (Table 3).

During CP in the head-down position, intrathoracie blood volume was redueed about 7%, with a eonsecutive decrease in stroke volume of about 13%, whereas systemie vaseular resistanee increased about 16%. In spite of the redueed stroke volume in combination with an unchanged heart rate, eardiac output remained unchanged as compared with base line measurements (Table 2).

During CP in the head-up position, intrathoraeie blood volume was decreased by 16% and stroke volume by 29%. Systemie vaseular resistance inereased by 12%, and MAP slightly decreased by 6%. Cardiac output also was redueed by 23% (Table 3). The following parameters were different between the body positions during CP: intrathoracic blood volume ($p < 0.01$), MAP ($p < 0.05$), stroke volume ($p < 0.05$), and eardiac output ($p < 0.05$). All these parameters were significantly improved by an inerease in intrathoracie blood volume during CP in all body positions beeause MAP inereased to normal ranges and stroke volume as well as eardiae output were elevated. With the better hemodynamie function, systemie vaseular resistance decreased (CP + fluids in Tables 1–3).

The reduction in MAP during CP by infusion of sodium nitroprusside did not improve hemodynamic parameters independently of the body position. Mean arterial pressure was deereased without differenees be-

Table 3. Hemodynamic changes during capnoperitoneum (CP) in group A head-up position, median (5–95 percentile)

	baseline M1	CP M2	CP + nipruss M3	CP + fluids M4
HR per min	95 (56–110)	99 (76–131)	95 (86–151)	107 (82–144)
CO (l/min)	4.7 (3.4–5.5)	3.6 (2.7–4.4)[a]	2.9 (2.5–3.9)	6.1 (5.2–7.3)[b]
SV ml	55 (45–69)	39 (30–59)[a]	33 (23–44)	55 (34–86)[b]
ITBV ml	630 (542–843)	527 (439–769)[a]	497 (397–685)	755 (669–937)[b]
SVR(dyn/s/cm^{-5})	1135 (944–1454)	1274 (1,042–1,762)[a]	1324 (983–1,690)	1053 (912–1,173)[b]
MAP (mmHg)	71 (60–85)	67 (55–76)[a]	58 (47–69)[b]	96 (80–101)[b]
Emax mm Hg per ml	3.9 (2.8–4.8)	3.6 (2.9–4.6)	3.2 (2.6–4.7)[b]	3.5 (3–4.3)

nipruss, nitroprusside; HR, heart rate; CO, cardiac output; SV, stroke volume; ITBV, intrathoracic blood volume; SVR, systemic vascular resistance; MAP, mean arterial pressure; Emax, myocardial contractility; Hg, mercury; M, measurement

[a] $p < 0.05$ compared with M1, Wilcoxontest

[b] $p < 0.05$ compared with M2, Wilcoxontest

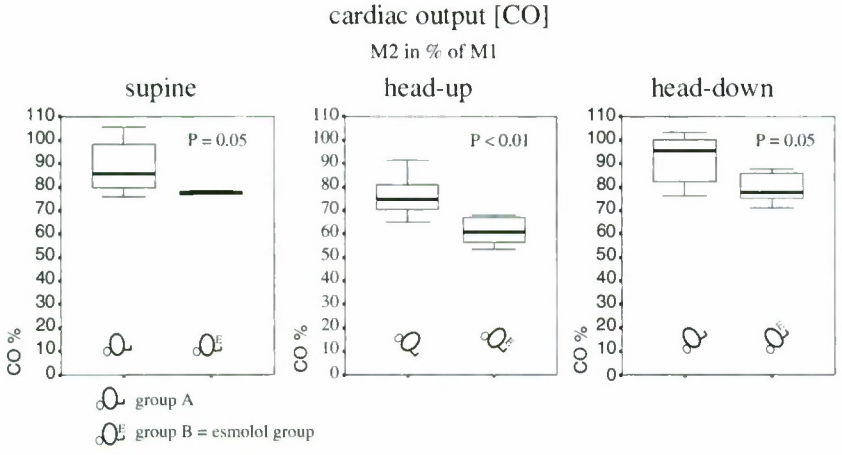

Fig. 2. Differences between groups A and B with regard to changes in cardiac output during capnoperitoneum, as compared with baseline values.

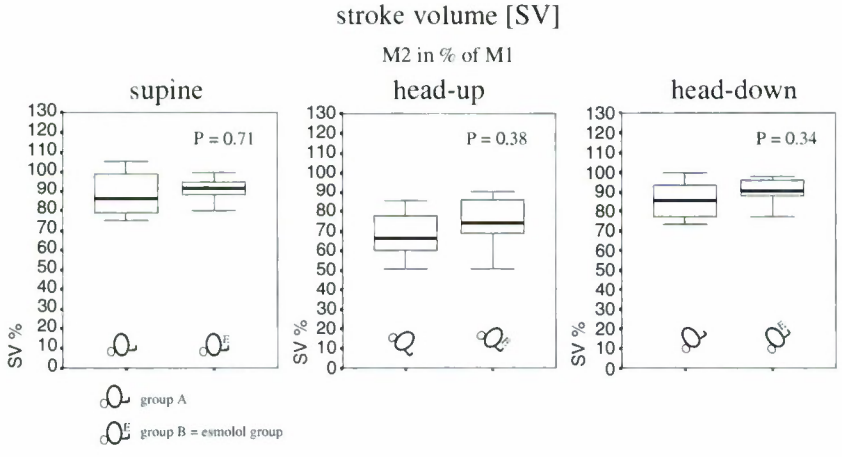

Fig. 3. Differenees between groups A and B with regard to changes in stroke volume during capnoperitoneum, as compared with baseline values.

tween the body positions ($p = 0.17$). Vasodilation induced a reduction in intrathoracic blood volume during CP in the supine and in head-down positions, as compared with CP alone. The increased reduction in intrathoracic blood volume caused a greater fall in stroke volume and cardiac output in these positions. Changes in intrathoracic blood volume, systemic vascular resistance, or cardiac output did not occur in the head-up position (CP + nitroprusside in Table 1–3).

The medication with the β_1-blocker esmolol had negative effects on hemodynamic parameters during CP in all body positions because heart rate (Fig. 1) and consecutively cardiac output (Fig. 2) decreased, whereas stroke volume (Fig. 3) and mean arterial pressure (Fig. 4) remained unchanged. Emax was compromised during CP in the head-up and in head-down positions (Fig. 5). With the decrease in cardiac output, systemic vascular resistance increased in the head-up position (Fig. 6).

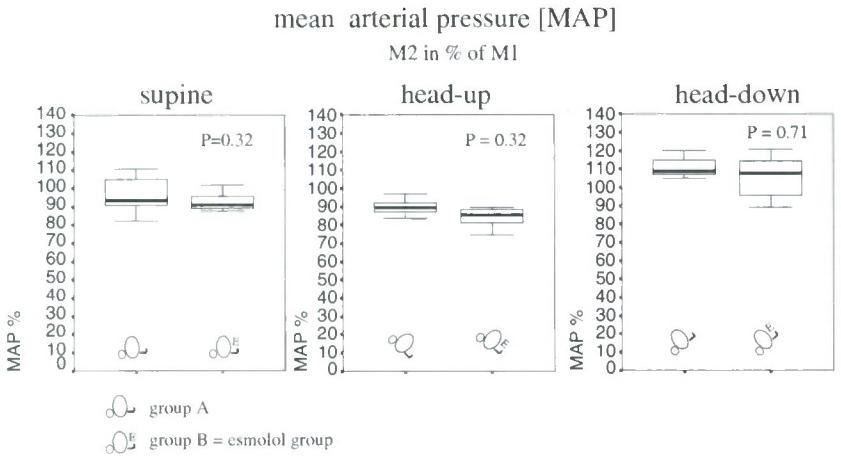

Fig. 4. Differences between groups A and B with regard to changes in mean arterial pressure during capnoperitoneum, as compared with baseline values.

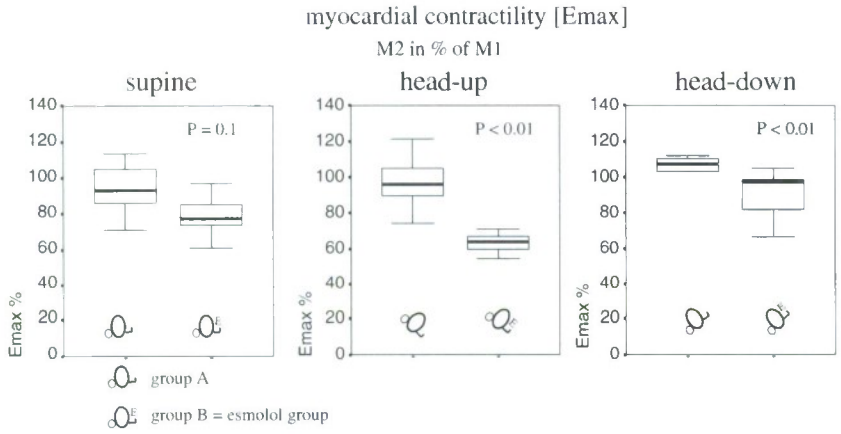

Fig. 5. Differences between groups A and B with regard to changes in myocardial contractility during capnoperitoneum, as compared with baseline values.

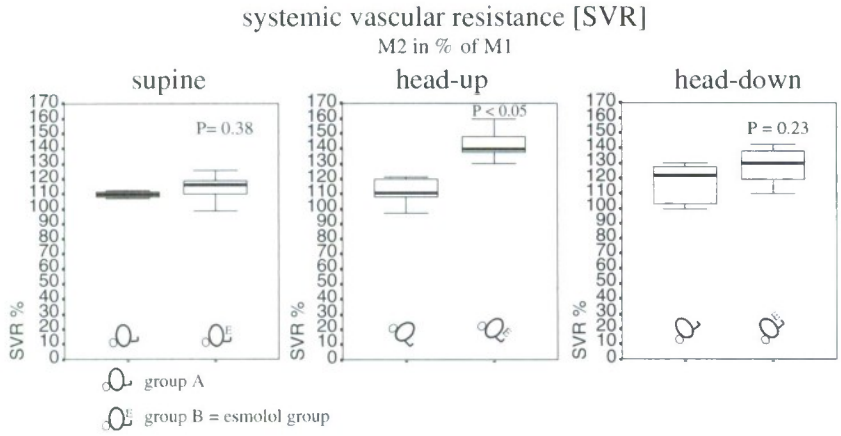

Fig. 6. Differences between groups A and B with regard to changes in systemic vascular resistance during capnoperitoneum as compared with baseline values.

Discussion

Increasing intrathoracic blood volume

Intrathoracic blood volume decreased during CP in the head-up and in head-down positions. An increase in intrathoracic blood volume by infusion of colloidal fluids improved hemodynamic function in all the body positions. This therapeutic approach was suitable for counteracting the decrease in stroke volume during CP caused by a compromised venous blood return and consecutively reduced intrathoracic blood volume. These mechanisms seem to be the most predominant determining factors of hemodynamic function during laparoscopic procedures. Thus, sympathetic reactions such as an increase in MAP or heart rate above normal values were avoided and stroke volume as well as cardiac output were improved. An earlier experimental study from our group showed that all the following conditions during laparoscopy independently influence

cardiac output and stroke volume: the increase in intravascular volume, the body position, and the IAP [10].

In the current trial, the hemodynamic system was negatively influenced only in the head-up and in head-down positions, but not in the supine position. However, during almost all laparoscopic procedures, head-up or head-down positioning is necessary to optimize the intraperitoneal view, so the exact combination of IAP and body position is of major importance regarding hemodynamic changes. Therefore, the interpretation of different hemodynamic data during laparoscopy must always consider body position, amount of IAP, and presumed vascular volume load.

Although 1 l saline solutions were infused preoperatively, animal hypovolemia during the measurements without an additionally increased preload cannot be excluded because normal ranges of intravascular volumes in pigs are not defined. Nevertheless, such a slight hypovolemia may very well reflect the clinical preoperative volume status in patients after preoperative fasting in combination with bowel-cleaning procedures.

The positive effect of increased venous blood return during laparoscopic surgery in the head-up position also was described in a clinical observational study. These authors of the study used intermittent pneumatic compression devices of the lower extremities to improve venous blood return by calf muscle compression. Usually, these devices, are used for prophylaxis of deep vein thrombosis. With the use of these devices venous blood return and cardiac index increased significantly during CP in the head-up position [1]. Increasing intravascular volume by infusing of 500 ml of hydroxyethyl starch increased cardiac output in another nonrandomized clinical trial during gynecologic laparoscopy in the case of presumed decreased volume preload [23].

Reducing sympathetic nerve activity

Medication with esmolol during CP decreased cardiac output in all body positions, as compared with CP alone. Because stroke volume remained unchanged, two effects of esmolol contributed to that reduction: the decrease in heart rate and myocardial contractility. Only in the head-up position, did systemic vascular resistance increase. If the sympathetic reaction during CP is considered to compensate for some negative hemodynamic effects such as the fall in stroke volume, esmolol might additionally compromise the hemodynamic system by locking this compensatory effect. However, the effects of esmolol during CP were interpreted differently in a blinded randomized clinical trial. Perioperative medication with esmolol reduced both heart rate and MAP during laparoscopic cholecystectomy in the head-up position. With the decrease in MAP, both the adrenaline and the antidiuretic hormone release were increased in the esmolol group [13]. Although the authors interpreted the fall in MAP and heart rate as improvement in the hemodynamic function they could not exclude, the possibility that esmolol compromises an increased sympathetic activity during CP. Medication with clonidine during CP may have effects comparable with those of esmolol. During laparoscopic cholecystectomy in head-up position, the catecholamine release decreased after medication with clonidine whereas both vasopressin and cortisol levels remained unchanged. Hemodynamic parameters were presumed to be improved because MAP, heart rate, and systemic vascular resistance were decreased. Cardiac output was not changed in the clonidine group during CP, but decreased after release of CP [8]. Clonidine also was effective in reducing MAP and heart rate during laparoscopic cholecystectomy in the head-up position in another clinical trial, but no data were given regarding stroke volume or cardiac output [15]. Again, the possibility cannot be excluded that both esmolol as well as clonidine compromise physiologic reaction to compensate for hemodynamic changes of CP.

Effect of vasodilation during CP

An increased MAP also was reduced during laparoscopic surgery by the administration of nitroglycerine to patients at cardiac risk of American Society of Anesthesiology (ASA) 3 and 4. Simultaneously with the fall in MAP, the systemic vascular resistance and the cardiac index were significantly improved in the aforementioned clinical study. These patients were monitored by invasive measurement using the pulmonary artery catheter [3]. In the current animal study, the hemodynamic parameters were not improved by vasodilation, perhaps because MAP was relatively low and did not increase during CP. Thus, the trial did not reflect the clinical situation of patients with a high MAP during CP. In healthy patients vasodilation during CP might additionally compromise venous blood return because of peripheral pooling. This effect was shown in the current study because intrathoracic blood volume was more decreased during CP in the head-down and supine positions after medication with sodium nitroprusside, as compared with CP alone.

Conclusions

Intraoperative normovolemia and fluid management seem to be most important for minimizing the hemodynamic side effects of CP. However, with standard hemodynamic monitoring, it is difficult to assess intravascular volume status [12]. On the basis of experimental data, no recommendation can be given about the amount of volume that might be necessary to avoid the negative hemodynamic effects of CP. However, invasive monitoring is not required for healthy patients undergoing laparoscopic surgery because they usually tolerate CP without major problems. Medication with β_1-blockers or vasodilators may compromise the compensatory effects of CP, but also may be helpful for patients with severe cardiac comorbidity. For these patients, invasive monitoring should be considered. Further research investigating the influence of CP on cardiovas-

cular changes and the effects of β_1 blockade, vasodilation, or volume loading must be performed using animal models of chronic heart failure to simulate the clinical situation of elderly multimorbid patients undergoing laparoscopic surgery.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Linear stapling of the short gastric vessels reduces blood loss and splenectomy at oesophageal and gastric surgery

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Abstract
Background: Increased operative blood loss, blood transfusion and nontherapeutic splenectomy negatively influence postoperative morbidity and mortality following esophageal or gastric resection. A critical point at which blood loss and iatrogenic splenic injury occurs is at the time of division of the short gastric vessels. We examined the efficacy of using a laparoscopic linear cutting stapler (developed for minimal access surgery) to divide with the short gastric vessels at open surgery.
Methods: Fifty-six patients were included. In 28 consecutive patients the linear stapler was used when dividing the short gastric vessels. These were compared to 28 matched controls (short gastric vessels were divided between hemostats and ligated). In the two patient groups, patient age, body mass index, and preoperative hemoglobin levels were similar.
Results: Operation time, splenectomy rates, blood transfusion, and mean transfusion volume were all significantly reduced in the group where the stapler was used.
Conclusions: Use of a linear cutting stapler reduced operation time, blood product use, and incidental splenectomy in patients undergoing radical open esophageal and gastric surgery.

Key words: Spleen conservation — Short gastric vessels — Transfusion requirements

Resection of the stomach or esophagus for malignant disease is associated with significant postoperative morbidity and mortality. It has been suggested that performing extended lymphadenectomy may contribute to this [6], but at gastrectomy D2 dissection remains the standard of care (>20% of patients with "early" gastric cancer have involved nodes) [3]. Similarly for types II (cardia) and III (subcardia) cancers of the esophagogastric junction, regional nodal dissection (celiac axis, splenic hilum and upper pancreas) is required [5]. The significant factors associated with perioperative complications are intra-operative blood loss, blood transfusion, splenectomy, and prolonged operation time rather than the extent of nodal dissection [1, 3, 5, 8, 9]. Extended nodal dissection in itself contributes to operation time and blood loss, but so too does inadvertent splenic injury. As the latter is theoretically avoidable, there is potential for reducing perioperative morbidity by avoiding incidental splenectomy. In our own experience, a critical point at which splenic injury occurs is when the short gastric vessels are divided. The principal difficulty when dividing the vasa brevia is the limited access created by the overhanging costal margin and diaphragm, especially in obese patients and in those with an acute subcostal angle.

With the advent of minimally invasive surgery, technology has been developed to overcome the difficulties due to limited access. We have previously described a technique to divide the short gastric vessels at gastric and esophageal surgery using a linear vascular cutting stapler developed for laparoscopic surgery [7]. We assessed whether use of the linear vascular cutting stapler could facilitate division of the short gastric vessels at conventional gastrectomy/esophagectomy and reduce operation time, blood loss, and the need for splenectomy.

Methods

Patients

Fifty-six patients are included in this report. In 28 consecutive patients the linear stapler was used when dividing the short gastric vessels, and these are matched to the previous 28 consecutive patients who underwent identical operations (the short gastric vessels were divided by the conventional technique between hemostats). In the two patient groups, patient age, body mass index, and preoperative haemoglobin levels were not significantly different (data not shown). The distribu-

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Table 1. Transfusion and splenectomy rates broken down by operation type

	Linear stapler used				Linear stapler not used			
Procedure	*n*	Splenectomy	Number of patients transfused	Units transfused (mean ± SEM)	*n*	Splenectomy	Number of patients transfused	Units transfused (mean ± SEM)
Transhiatal	13	0	3	0.5 ± 0.3	13	1	10	2.2 ± 0.5
Three-stage	8	0	4	1.1 ± 0.4	8	1	7	3.0 ± 0.6
Gastrectomy	7	0	2	0.7 ± 0.5	7	2	5	3.0 ± 0.9
Total	28	0[a]	9[a]	0.8 ± 0.6[a]	28	4	22	2.4 ± 0.7

[a] Significant versus group where stapler was not used ($p < 0.05$)

tion of procedures performed was as shown in Table 1. Data recorded included anesthesia time, transfusion requirements, incidental splenectomy rate (no therapeutic splenectomies were performed), and the rate of postoperative respiratory sepsis (defined as positive sputum culture or chest x-ray changes consistent with pneumonia).

Operative Technique

All patients who underwent gastrectomy had standard D2 dissection, while those with type II (cardia) and III (subcardia) cancers of the esophago-gastric junction underwent nodal dissection of the celiac axis, splenic hilum, and upper pancreas. In those patients where the linear stapler was used, the operative technique was altered slightly. Following detachment of the greater omentum from colonic and parietal attachments, the operator's left hand was placed on the greater curve of the stomach, with the gastrosplenic omentum sandwiched between the index and middle fingers. This allowed placement of the linear stapler (Endo-GIA; Autosuture, U.S. Surgical, Norwalk, CT) across the gastrosplenic ligament as previously described [7]. Two to three applications were usually sufficient.

Results

The male:female ratio was 1.15:1. The mean age was 67 years (range 43–86 years). There was one perioperative (30-day) mortality in each group (no difference between groups).

In the group where the conventional technique was used to divide the short gastrics, there were four incidental splenectomies (14.3%). This was reduced to zero in the group in which the stapler was used ($p < 0.05$, paired-sample *t*-test). The number of patients transfused in the nonstapled group was significantly higher (22 of 28) than in the stapled group (nine of 28) ($p < 0.05$, paired-sample *t*-test). The total number of units transfused was also significantly higher (2.4 ± 0.7 units versus 0.8 ± 0.6 units, $p < 0.05$, ANOVA, Tukey post hoc) (Table 1).

Anesthesia time was also shorter in the stapled versus the nonstapled group (174 ± 42 versus 228 ± 48 min, $p < 0.05$). The incidence of postoperative respiratory sepsis was also significantly lower in the stapled group (5 versus 12, $p < 0.05$, paired-sample *t*-test).

Discussion

Prolonged operating time, excessive blood loss, and splenectomy contribute to the morbidity associated with gastroesophageal surgery [3, 5, 9]. A recent analysis of more than 12,000 gastrectomies for gastric carcinoma demonstrated significantly poorer outcomes in patients who had nontherapeutic splenectomy [8]. In our experience, injury to the spleen occurred most frequently when ligating and dividing the short gastric vessels. Anatomically, the intimate relationship between the gastric fundus and the cephalad portion of the spleen contributes, while the friable and vascular nature of the spleen itself is also a factor. In the 28 cases where the short gastric vessels were dealt with by standard ligation and division, four nontherapeutic splenectomies were performed. Patient factors are unlikely to have played a role, as individual body mass indices were similar in both groups. When the vasa brevia were divided by stapling, the need for splenectomy was obviated in all cases.

With the advent of minimally invasive surgery, stapling devices were developed specifically to overcome limited access. Our premise was that such a device would have significant application at open surgery. The longer instrument shaft length allowed for ease of placement, while the overlapping rows of staples effectively sealed vessels. Operation time was significantly shorter as compared to the conventional approach. Another factor that is undoubtedly involved in the reduction of operation time is the lesser number of splenectomies performed. The lower incidence of respiratory morbidity in the stapled group was an interesting and unexpected finding. Presumably shorter operating time and lower incidence of transfusion contributed to this.

We found the technique particularly helpful in the obese and those with a narrow substernal angle. In these, patients gastroesophageal surgery is technically more demanding, as the vasa brevia to the upper pole of the spleen are obscured by overhanging of the costal margin, and also because of the difficulty in identifying the vessels through the fat of the gastrosplenic omentum and where intraoperative blood loss and transfusion requirements are traditionally greater [8].

Hemorrhage either from the vasa brevia themselves or from iatrogenic splenic injury (occurring at the time of division) is difficult to control, adds significantly to the operating time, and may increase perioperative blood product requirements as demonstrated by the results. Although perioperative allogeneic blood transfusion does not affect long-term survival after esophagogastrectomy for carcinoma, it does have a significant association with short-term survival in a

group whose overall survival is often limited after resection [2].

The current cost of the stapler in Ireland is €270. This rises to €560 when two refills are used. This is considerably more expensive than the use of hemostats and ties. However, we feel that this additional cost could be offset by operating-room time saved, blood products saved, and reduced bed days used as a result of a lower rate of respiratory complications.

One might suggest that the patients in the control group used for comparison were historical and therefore open to criticism. However, they were procedure matched and taken consecutively from those patients who had surgery performed immediately before the introduction of the stapling device. There were no differences in demographics, body mass index, or perioperative mortality between the groups. Therefore, although the comparison is not a randomized one, it is legitimate as a representative control group was used. As incidental splenectomy confers no oncological benefit [9] but does result in long-term immune compromise [2, 4, 8], it is reasonable to suggest that the use of the linear stapler may influence patient outcome.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Zoom endoscopic monitoring of small bowel allograft rejection

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Abstract
Background: The small bowel has been suecessfully transplanted in patients with irreversible intestinal failure. This report aims to deseribe endoseopie monitoring of small bowel rejection.
Methods: A magnifieation endoseope (zoom endoseope) was used in this study. In the first part of the study (Oetober 1998 to Mareh 2000, 271 endoseopy sessions), the specifie endoscopic findings that eorrelated with rejection were determined. An analysis then was performed on data from the second period (Mareh 2001 to November 2002, 499 sessions) to evaluate the zoom endoseope's aeeuracy in monitoring rejeetion.
Results: Specifie endoscopie findings of rejeetion found in the first period ineluded baekground erythema, villous congestion, blunted villous tip, and shortened villous height. When the rejeetion was suceessfully treated, endoscopie appearanee returned to normal. On the basis of these findings, five endoseopie criteria (villous shortening, villous blunting, baekground erythema, villous congestion, and mueosal friability) were used to seore endoscopic sessions in the second period. Endoscopie diagnosis of rejection was eompared with histology. Adult patients showed a sensitivity of 45%, a specifieity of 98%, a positive predictive value of 82%, and a negative predietive value of 88%. In pediatrie patients, these values were, respectively, 61%, 84%, 57%, and 86%. On 59 distinct oeeasions (30 in period 1 and 29 in period 2) in which the results were endoscopy negative yet biopsy positive (mild) for rejeetion, we eleeted not to treat these rejections on the basis of elinieal evaluation, and 58 (98%) resolved without further therapy.
Conclusions: With the use of magnification, endoscopy is a useful tool for monitoring acute rejeetion in the small bowel allograft.

Key words: Small bowel allograft rejeetion — Small bowel transplantation — Zoom endoscopic monitoring

With reeent improvements in surgical techniques and immunosuppressive regimens, small bowel transplantation has beeome a desirable and potentially life-saving alternative for patients with short gut syndrome or other problems eausing intestinal failure. Worldwide experienee with this proeedure has grown relatively fast beeause elinieal outeomes after intestinal transplantation have been improving over time [1, 5, 7, 17, 21]. However, the teehnology and clinical protoeols for monitoring graft funetion and treating acute rejection still are in the early stages of evolution. In contrast to known serum markers routinely used for monitoring liver or kidney transplant reeipients, serum makers for bowel graft rejection still are under investigation [1, 5, 7, 17, 21, 22]. Therefore, frequent biopsies of the small bowel graft are eritieal for detecting the presence of acute cellular rejection. Early detection of rejeetion also is extremely important beeause rapid progression to severe rejeetion ean oeeur without proper treatment, and advaneed stages of rejection are associated with poorer outeomes [11, 14]. Whereas random mucosal biopsy provides detailed information about a very small area, the endoscopie view can provide information about large areas. Endoseopy provides the quickest method for assessing the overall health of graft mucosa and is essential in obtaining speeimens for histologic evaluation [6, 9, 13, 26]. Unfortunately, surveillanee with standard endoscopy has not been sufficiently eapable of monitoring rejection [8, 29–31]. Standard endoseopy is just not powerful enough to provide an aeeurate view of the mild changes that oeeur in the early phase of small bowel rejeetion.

The use of magnifieation endoscopy has been reported for evaluation of Barrett's esophagus and celiac disease [25, 28]. Subsequently, in 1999, we published the

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first case report featuring magnification with a zoom video endoscope (ZVE) for evaluation of intestinal graft mucosa [16]. In this initial experience, the ZVE enabled us to visualize the villi and crypt areas directly in almost microscopic detail, thereby providing a more accurate overall assessment of graft mucosa health than with a standard endoscope. In addition, the ZVE enabled us to take a biopsy from the most representative area of the graft. We describe our experience using zoom endoscopy to monitor patients for small bowel rejection.

Patients and methods

We used zoom endoscopes (Pentax EC-3830LZ, EG 3430Z; Pentax Precision Instrument, Inc, Orangeburg, NY; and Olympus GIFQ160Z; Olympus America, Inc, Melville, NY, USA) for this study. Pentax equipment was used during the first period of the study, and Olympus equipment was used during the second period (see below). The reason for the change in equipment was solely administrative. With either zoom endoscope, the operator has the capability to change the image on a standard 14-in. video monitor from the standard endoscopic view (magnification ×12.5) to a highly magnified view (magnification ×105). This versatility is clearly seen in Fig. 1A through D, which shows normal through near maximum ZVE views of normal small intestinal mucosa. The degree of magnification available with this scope allows the endoscopist to visualize both the entire length of villi and the surrounding crypt area. Normal villous architecture seen on ZVE was similarly found in the histologic specimen taken at the same time (Fig. 1E and F).

During the first period of the study, a total of 271 endoscopic sessions involving 16 intestinal transplant recipients were evaluated over a 17-month period (October 1998 to March 2000). As a pilot study, we retrospectively analyzed our experience using the zoom endoscope to perform surveillance for rejection among these 16 patients. For each patient, the endoscopic procedure was performed through a surgically created ileostomy. The endoscope was advanced at least 5 cm from the ostomy outlet to avoid changes related to the ostomy site. In most cases, ZVE surveillance was performed 10 to 20 cm from the ostomy.

All procedures were performed at the patient's bedside without sedation. To correlate the visual impression of the villi and crypts under high magnification with the histology of the small bowel mucosa, the endoscopist obtained biopsies through the working channel of the endoscope during each endoscopic session. All endoscopies were performed by a single endoscopist (T.K.) during this period.

The demographics of the patients during the two study periods are summarized in Table 1. The transplantations were performed as previously described [17]. All the patients during the first period received daclizumab (Zenapax; Roche Laboratories, Nutley, NJ, USA) for induction immunosuppression along with standard doses of tacrolimus and corticosteroids for maintenance. Steroid bolus injection (1 g of methylprednisolone) and/or cycle (200 mg of methylprednisolone per day followed by a tapered schedule of 160 mg, 120 mg, 80 mg, 40 mg, and 20 mg per day for a total of 5 days) or OKT3 (Muromonab-CD3; Ortho Biotech Inc., Raritan, NJ, USA) was used to treat rejection. Sirolimus (Rapamycin; Wyeth Ayerst Research, Philadelphia, PA, USA) was added in most cases to the baseline immunosuppressive regimen after treatment of refractory rejection (usually recurrent rejection after the use of OKT3).

During the second period of the study (March 2001 to November 2002), we evaluated the capability of the zoom endoscope to provide surveillance for small bowel rejection. Specifically, a scoring system to identify rejection was defined from the results of the pilot study in the first period. A total of five criteria were chosen for endoscopic scoring of bowel rejection. Four of these criteria were based on the mucosal imaging results of the first period: shortening of the villous length, blunting of the villous tip, erythema at the background of the mucosa, and villous congestion. A fifth criterion, mucosal friability, representing the intestinal tissue's sensitivity to the actual use of the ZVE equipment (not its visualized imagery), was selected because our experience showed that it also provided a strong diagnostic sign for acute bowel rejection.

In keeping with the international criteria established for scoring individual histologic components of acute rejection in both kidney and liver transplantation [4, 27], a scoring system of 0 to 3 (0, normal; 1, mildly abnormal; 2, moderately abnormal; 3, severely abnormal) was chosen for each of the five endoscopic criteria, with a higher score denoting worse appearance. An overall ZVE small bowel rejection score was defined as the sum of the five individual component scores. Thus, a total ZVE score of 0 to 15 was possible. Scoring guidelines for each criterion are summarized in Table 2.

Next, the total score was categorized to define a ZVE grading scheme as follows: a total score of 0 was normal (grade 0), 1 to 5 was indeterminate for rejection (grade 1), 6 to 10 was mild (grade 2), 11 to 14 implied moderate rejection (grade 3), and 15 implied severe rejection (grade 4). Finally, for each sample, the ZVE grade of rejection was compared with the histologic grade of rejection: 0 (no rejection), 1 (indeterminate for rejection), 2 (mild rejection), 3 (moderate rejection), and 4 (severe rejection). Because we do not treat histologic grade 1 rejection, histologic grades 0 and 1 were considered negative for rejection. It must be noted that according to the recently revised histologic criteria of the Eighth International Small Bowel Transplant Symposium held in September, 2003 in Miami, Florida, code grade 1 denotes mild rejection (previously grade 2), and the code IND denotes an indeterminate grade (previously grade 1) [23]. However, because we were using the previous grading scale throughout the study, we are reporting the results as such in this article.

The planned schedule for performing endoscopies (along with histologic surveillance) during both periods of the study was as follows: once every 2 to 4 days during the first 2 weeks after transplantation, once weekly during the next 3 to 8 weeks after transplantation, and once a month during months 3 to 6 (or until stoma closure). During the course of any rejection episode, endoscopies were performed for the patient every 2 to 4 days.

The ZVE evaluations were performed by a total of four endoscopists (T.K., S.N., and G.S. for adults; T.K., G.S., and N.M. for children). Each endoscopist had a large experience in transplant endoscopy, and each had experience using the ZVE before the beginning of the second study period. Each biopsy was taken from the most representative area of the graft.

The ZVE evaluation and score were recorded at the time of endoscopy before histologic evaluation. The biopsy tissue was embedded in formalin, then processed and stained in a standard hematoxylin-eosin stain. Each biopsy was read by a single, expert pathologist (P.R.), who was blinded to the endoscopic score while reading the biopsy. Data were obtained from the following 47 patients who received intestinal transplants at the University of Miami and agreed to participate during the second period of the study: 26 adults (median age, 33 years; range, 20–59 years) and 21 children (median age, 6 years; range, 0.8–15 years). Because of technical limitations with the use of zoom endoscopy on very small intestines, the recipients of transplants from donors younger than 2 years were not included in the study.

A total of 499 ZVE sessions involved the 47 patients (308 in adults and 191 in children). For 20 patients (15 adults and 5 children), an induction protocol with Alemtuzumab (Campath-1H, ILEX Oncology, Inc., San Antonio, TX, USA) was used [34, 35]. The remaining 27 patients received the same immunosuppression protocol as those in the first period.

Institutional review board approval was obtained for this study along with written consent from each subject who chose to participate. Tests of association were performed using the (uncorrected) Pearson chi-squared test. A p value less than 0.05 was considered to indicate a statistically significant finding.

Results

Period 1

Figure 2 illustrates crypt erythema seen during the course of mild acute rejection. The space between villi has expanded and appears erythematous (Fig. 2B and C). In the standard, unmagnified endoscopic view, it is not clear whether this same area appears normal or displays minimal to mild mucosal erythema (Fig. 2A).

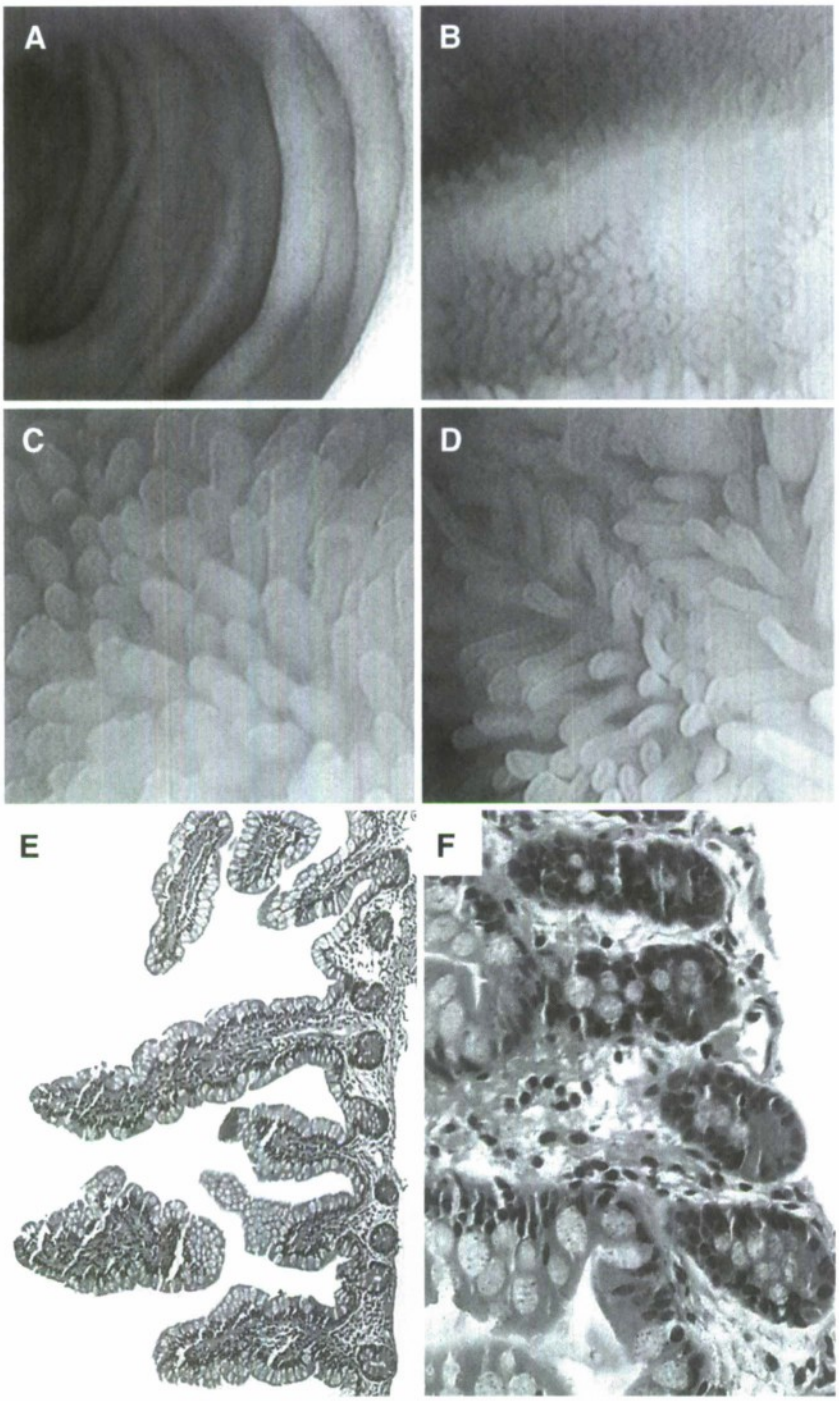

Fig. 1. Zoom videoendoscopic view of normal small bowel graft mucosa (standard [**A**], moderate [**B**], and maximum [**C, D**] magnification), along with corresponding histology taken at the same time (**E, F**), showing a well-preserved villous architecture with sparse cellularity present in the lamina propria. (hematoxylin-eosin; E magnification ×100, F magnification ×400)

Villi were relatively preserved at this mild rejection stage. Histologic examination of the mucosal biopsies taken at the same time confirmed the morphologic changes visualized by ZVE. Typically, the pathology demonstrated the presence of a mild lymphocytic infiltrate in the lamina propria, the presence of activated lymphocytes, and scattered single cell apoptosis (Fig. 2D and E). Villi may have been mildly edematous, but were otherwise morphologically normal.

As rejection progressed to a moderate grade, the blunting and shortening of villi became more obvious and were accompanied by a mild to moderate degree of erythema (Fig. 3A and B). Some of the villi in Fig. 3A and B appear considerably shorter and irregular in length, as compared with the villi of the mild rejection case seen in Fig. 2A to C. Such distinctions were not possible with standard magnification. Pathologic examination of mucosal biopsies taken simultaneously during ZVE demonstrated that the cellular infiltrate in the lamina propria had markedly increased, and the villi had become even more blunted (Fig. 3C and D). Crypt injury was increasingly prominent, with multiple clusters of apoptotic cells and crypt abscesses.

Table 1. Patient demographics

	Period 1 (n = 16)	Period 2 (n = 47)
Age (years)	Adults (n = 15; range, 21–48; median, 37) Children (n = 1; 15)	Adults (n = 26; range, 20–59; median 33) Children (n = 21; range, 0.77–15; median, 6)
Gender	Male (n = 7) Female (n = 9)	Male (n = 28) Female (n = 19)
Diagnosis	Mesenteric thrombosis (n = 6) Gardner's syndrome (n = 2) Pseudoobstruction (n = 2) Trauma (n = 2) Others (n = 4)	Mesenteric thromhosis (n = 8) Pseudoobstruction (n = 7) Gastroschisis (n = 6) Trauma (n = 6) Volvulus (n = 4) Intestinal atresia (n = 4) Crohn's disease (n = 3) Others (n = 9)
Graft types	Isolated intestine graft (n = 7) Liver and intestine graft (n = 0) Multiviseeral graft (n = 8) Modified without the liver (n = 1)	Isolated intestine graft (n = 22) Liver and intestine graft (n = 4) Multiviseeral graft (n = 18) Modified without the liver (n = 3)
Immunosuppression protoeols	Daelizumab N = 16	Daelizumab (n = 27) Alemtuzumah (n = 20)

Table 2. Zoom endoscopie seores

		Seore
Height of villi	Normal	0
	Mildly shortened	1
	Moderately shortened	2
	Flat	3
Villous blunting	Normal	0
	Mildly blunted	1
	Moderately blunted	2
	Flat	3
Background mueosal erythema	No erythema	0
	Mild erythema	1
	Moderate erythema	2
	Severe erythema	3
Villus eongestion	Normal vaseular pattern	0
	Mildly eongested	1
	Moderately eongested	2
	Severely eongested	3
Friahility	Normal	0
	Easily bleeds with biopsy foreeps	1
	Easily bleeds with endoseopie trauma	2
	Continuous oozing or ulceration	3

The severe form of acute rejection was manifested by complete denudation (i.e., loss of surface epithelium). Although easily recognized in the standard endoscopic view (Fig. 4A), the change was even more clearly identified in the magnified ZVE image (Fig. 4B). The biopsy taken at the same time showed histologic changes of severe cellular infiltrate, destruction of crypts, and disappearance of surface epithelium (Fig. 4C and D).

Among the 271 endoscopic and histologic examinations performed on these patients were 58 histologic diagnoses of rejection (1 to 6 diagnoses per patient; average, 3.6) including mild (n = 46), moderate (n = 8), severe (n = 3), and vascular rejection (n = 1). Mucosal changes observed by ZVE at the same time included background erythema and blunted and/or shortened villi (n = 8), crypt erythema only (n = 7), blunted and/or shortened villi only (n = 3), flattened villi/denuded mucosa (n = 3), villus congestion (n = 1), and no noteworthy changes (n = 36). Each of the three histologic diagnoses of severe rejection corresponded with a ZVE reading of flattened villi/denuded mucosa, and the single case of histologic vascular rejection coincided with a ZVE reading of villus congestion. In fact, the single episode of vascular rejection occurred in a patient with a positive cytotoxic crossmatch. Histologic examination showed diffuse submucosal hemorrhage in hematoxylin-cosin stain. The immunofluorescent stain for complement and immune complex yielded positive results [12, 24]. It should be noted that 18 of the 58 rejection diagnoses were based on repeat endoscopies and biopsies performed on the same patient during the same rejection episode and during the same course of therapy. Figure 5 compares the ZVE picture of moderate rejection seen in one patient 13 days after transplantation (A) and the normal ZVE picture 1 month later in this same patient after treatment for the rejection (B). In all cases, when the histologic appearance became normal after treatment for rejection, the mucosal abnormalities visualized by the ZVE also disappeared.

Normal mucosal appearance on ZVE was found for 78% (36/46) of the biopsies histologically diagnosed as mild rejection. In 30 of these instances, endoscopy and biopsy had been performed as routine surveillance without clinical symptoms. Despite the mild rejection present on the histologic examination of the mucosal biopsies, we elected to withhold additional immunosuppressive treatment, because i) the mucosal villi and crypt appeared normal on ZVE, and ii) there were no clinical symptoms. All these 30 instances of rejection reversed without treatment. Conversely, on the basis of clinical judgment, six histologically indicated instances of mild rejection were treated despite their relatively normal appearance on ZVE. All these rejections reversed with steroid treatment.

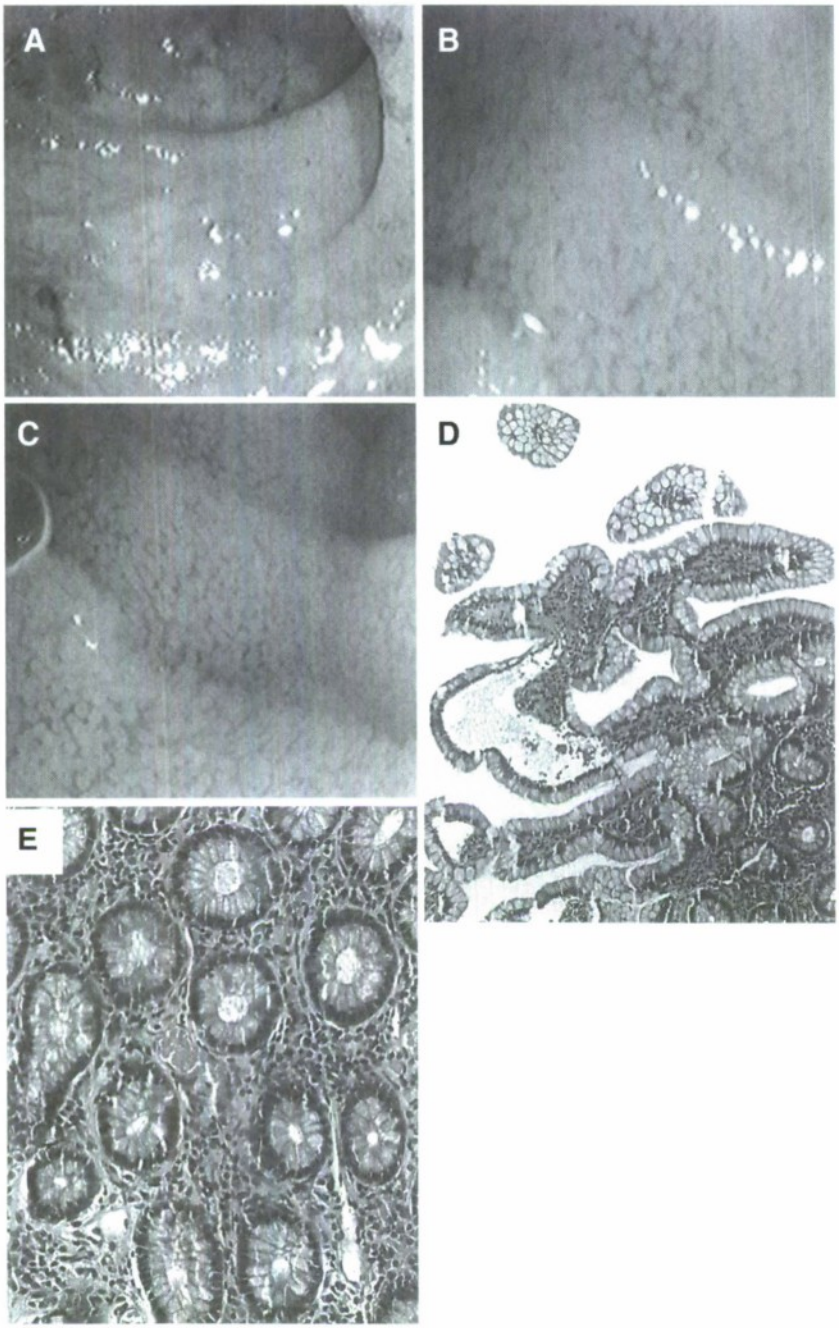

Fig. 2. Zoom videoendoscopic (ZVE) view along with corresponding histology of the forceps biopsy taken at the same time showing mild acute allograft rejection in a multivisceral graft recipient 6 days after transplantation. Standard (**A**) and moderate (**B, C**) ZVE magnification shows relatively well-preserved villus stalk with increased erythema visible in the background between villi. The histologic specimens show minimal blunting of villi with mildly increased inflammatory infiltrate in the lamina propria correlating with ZVE findings (**D**) and mild cryptitis with scattered apoptotic bodies at high power (**E**). (hematoxylin-eosin; D magnification ×100, E magnification ×400)

On all but one occasion, positive findings on ZVE were supported by histologic readings of rejection. In the one exception, ZVE showed crypt erythema, whereas histologic readings were inconclusive for rejection. Given our confidence in the ZVE findings together with a clinical symptom of rejection (fever), we administered treatment for rejection. After the treatment, the ZVE-visualized appearance of crypt erythema reversed.

With the exception of acute cellular rejection, no pathologic conditions, such as cytomegalovirus enteritis or posttransplant lymphoproliferative disease, were encountered in these patients. There were no complications associated with ZVE and biopsies.

Period 2

A comparison between the ZVE and histologic grades is shown in Tables 3 to 5. During 499 overall ZVE sessions, 87 were positive for rejection (grade 2 or greater), and 412 were negative (grades 0 to 1). By histology, 111 were positive for rejection, and 388 were negative (Table 3). When ZVE was correlated with histology scores in adults, 28 were both endoscopy and histology positive for rejection, 6 were endoscopy positive but histology negative, 34 were endoscopy negative but histology positive, and 240 were both endoscopy and histology negative (Table 4). For children, 30 were both endoscopy and histology positive for rejection, 23 were

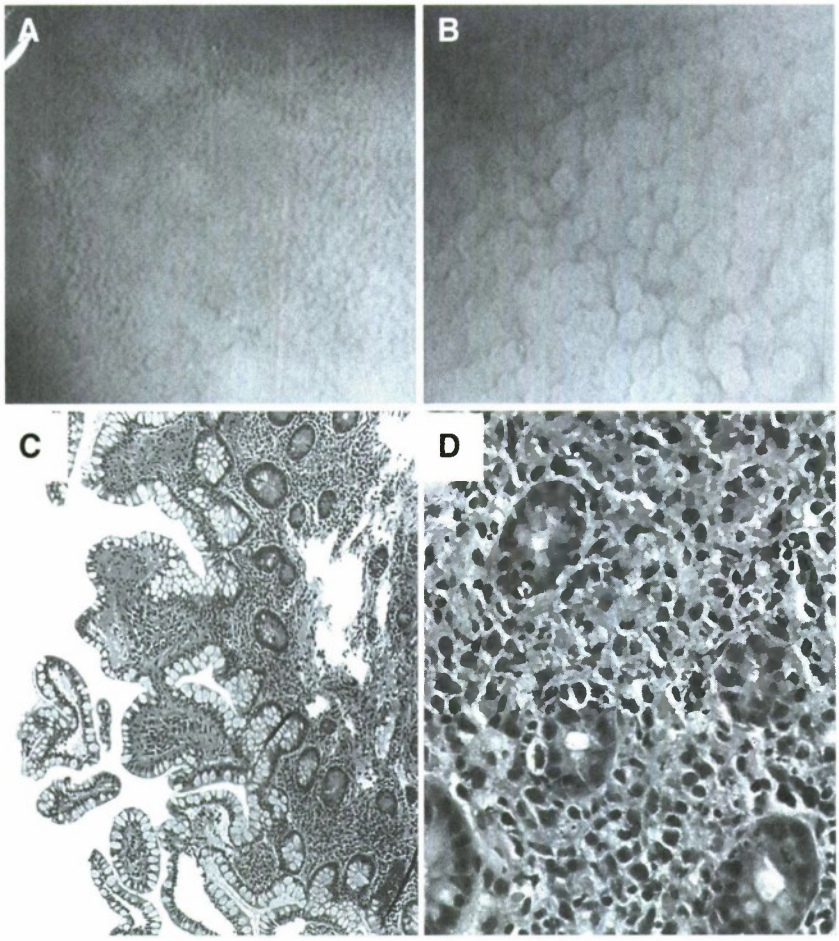

Fig. 3. Zoom videoendoscopic (ZVE) view along with corresponding histology of the forceps biopsy taken at the same time showing moderate allograft rejection in an isolated bowel graft recipient 9 days after transplantation. Low (**A**) and near maximum (**B**) ZVE magnification of increased erythema with villi of irregular length. Some villi are markedly shortened. Low-power histologic examination (**C**) demonstrates a notable inflammatory infiltrate in the lamina propria with obviously blunted villi, and high-power histologic examination (**D**) shows advanced stage of crypt injury with numerous apoptotic bodies involving the crypts. (hematoxylin-eosin; C magnification ×100, D magnification ×400)

endoscopy positive but histology negative, 19 were endoscopy negative but histology positive, and 119 were both endoscopy and histology negative (Table 4). The condition of endoscopy positive but histology negative for rejection was significantly higher for children than for adults (12% vs 2%; $p < 0.00001$). Therefore, positive predictive value and specificity were lower for children. For adults, there was an estimated sensitivity of 45%, a specificity of 98%, a positive predictive value of 82%, and a negative predictive value of 88%. The corresponding values for children were, respectively, 61%, 84%, 57%, and 86%. The overall estimates were 52% for sensitivity, 93% for specificity, 67% for positive predictive value, and 87% for negative predictive value.

In 29 cases that were endoscopically negative but histologically positive for rejection (17 among adults and 12 among children), treatment was withheld because the patient lacked clinical symptoms of rejection such as diarrhea or fever. This approach was based on our experience during period 1, in which all these episodes resolved spontaneously. Actually, in 28 (97%) of 29 cases during period 2, the subsequent biopsy also turned negative for rejection without therapy. Only one case was persistently read as rejection, with subsequent treatment given. Thus, if we exclude these 28 histologically false-positive cases (16 among adults and 12 among children) from the calculations, then the estimated sensitivity and negative predictive value increase, respectively, to 61% and 93% in adults, and to 81% and 94% in children (Table 5).

Discussion

Control of acute allograft rejection has been one of the most important and challenging dilemmas in clinical intestinal transplantation [1, 5, 7, 11, 14, 17, 21]. Endoscopic surveillance with multiple biopsies has been performed as the primary tool for detecting rejection and instituting timely and appropriate treatment [6, 9, 13, 26]. An ileostomy normally is created at the time of transplantation to facilitate endoscopic access to the graft mucosa [17]. Theoretically, the endoscopic examination allows quick assessment of a large area of graft, as compared with a histologic specimen that includes an extremely limited area of mucosa. Despite this advantage, standard endoscopy alone is not reliable in determining the degree of rejection and has been used primarily for sampling.

Mucosal changes in intestinal allograft rejection observed with standard endoscopy consist of erythema, granularity, and friable hemorrhagic mucosa during episodes of mild to moderate rejection, and deepithelialized, so-called "denuded," mucosa with severe rejection. The loss of the mucosal surface epithelium is easily

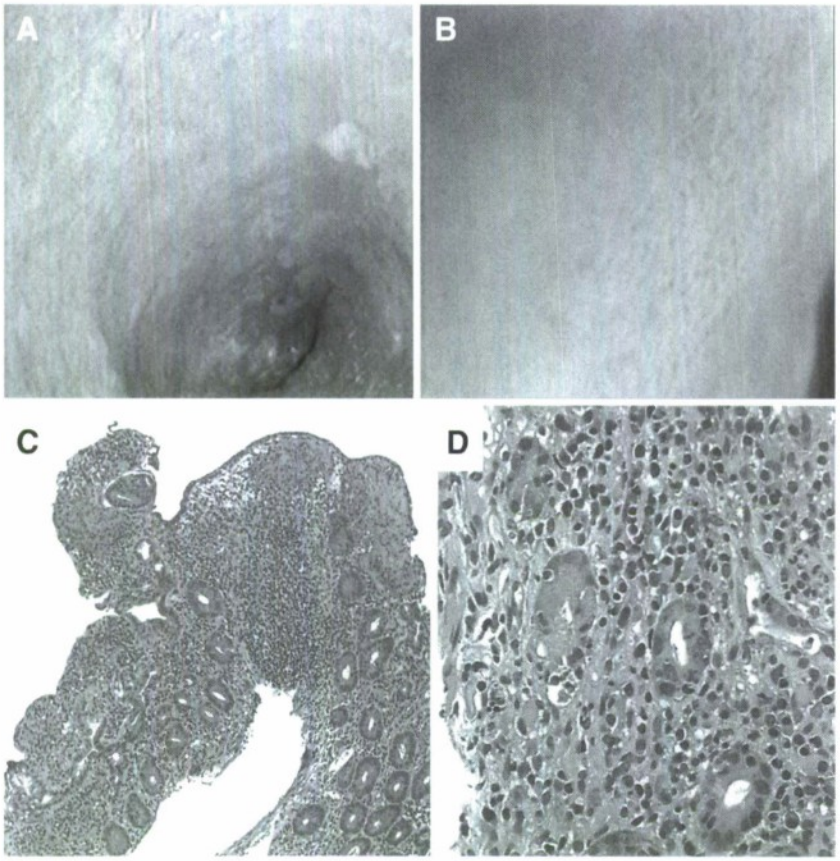

Fig. 4. Zoom videoendoscopic (ZVE) view along with corresponding histology of the forceps biopsy taken at the same time showing severe allograft rejection in the same patient whose ZVE and biopsy results just 3 days before had displayed moderate rejection (Fig. 3). Standard (**A**) and near maximum (**B**) ZVE magnification of totally denuded mucosa with the loss of villi. Histology shows severe transmural inflammatory cellular infiltrates with the loss of surface epithelium (**C**). Severe destruction of crypts is observed at high power. (**D**). (hematoxylin-eosin; C magnification ×100, D magnification ×400)

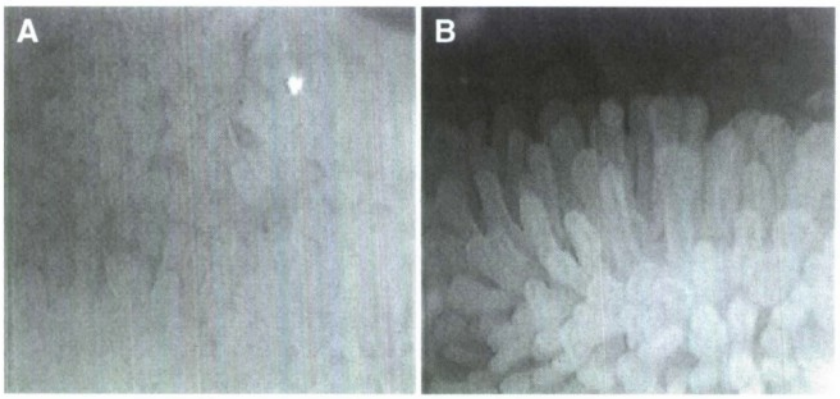

Fig. 5. Zoom endoscopic picture of moderate rejection seen in a patient 13 days after transplantation (**A**). Zoom endoscopic picture in the same patient 1 month later after treatment for rejection (**B**).

recognized during standard endoscopy. However, once the rejection has progressed to this stage, it has rarely been reversible [11, 14]. Therefore, initiation of appropriate treatment is essential before the rejection progresses to this very likely irreversible stage. Given standard endoscopy's lack of accuracy in successfully diagnosing mild to moderate rejection [8, 29–31], clinicians have not relied on it as a surveillance tool.

The histologic changes that occur in the intestinal mucosa during the course of rejection have been well described in both experimental and clinical intestinal transplantation [3, 10, 18, 19, 36]. At an early stage of rejection, the villi become edematous, slightly shortened, or both, and crypt areas expand with a mildly increased cellular infiltrate in the lamina propria. As the rejection progresses, the villi become more obviously blunted as cellular infiltrate in the lamina propria increases, leading to a total loss of surface epithelium and severe cellular infiltrates at the end stage of severe rejection. These changes in the microscopic architecture of the mucosa are more easily recognized in whole-thickness biopsy. However, they can be difficult to assess in a standard forceps biopsy because this type of biopsy includes only a limited number of villi and crypts.

The use of videomicroscopic monitoring was recently demonstrated to be effective in detecting rejection in an animal model [32]. We also published the first case study describing the use of ZVE for evaluation of intestinal graft mucosa [16]. Magnification endoscopy (ZVE) enabled us to see the microscopic architecture of

Table 3. Zoom video endoscope (ZVE) and histologic scores in period 2

ZVE grade	Adults	Children	Histologic grade	Adults	Children
Grade 0–I (score 0–5)	274	138	Grade 0–1	246	142
Grade II (score 6–10)	28	51	Grade 2	51	37
Grade III–IV (score 11–15)	6	2	Grade 3–4	11	12
Total	308	191	Total	308	191

Table 4. Cross-tabulation of the zoom video endoscope and histology scores in period 2

	Adults	Children		Adults	Children
Endoscopy +, pathology +	28	30	Endoscopy +, pathology +	28	30
Endoscopy +, pathology −	6	23	Endoscopy +, pathology −	6	23
Endoscopy −, pathology +	34	19	Endoscopy −, pathology + (excluding clinically insignificant rejection)	18	7
Endoscopy −, pathology −	240	119	Endoscopy −, pathology −	240	119
Total	308	191	Total	292	179

Table 5. Sensitivity, specificity, positive and negative predictive values for ZVE as a predictor of histologic grade, by patient age

	Adults	Children	Overall	Adults (adjusted)*	Children (adjusted)*
Sensitivity	45%	61%	52%	61%	81%
Specificity	98%	84%	93%	98%	84%
Positive predictive value	82%	57%	67%	82%	57%
Negative predictive value	88%	86%	87%	93%	94%

* Adjusted by removing the 28 histologically false positive cases from the calculations

the intestinal mucosa in this patient, who experienced a mild acute rejection. Our current report describes a series of 16 consecutive patients in whom ZVE was used to evaluate the small bowel graft mucosa followed by a prospective study that demonstrated reasonable accuracy of ZVE for 47 additional patients.

Given our experience with the series of 16 patients, we were able to correlate the visual morphologic changes seen on the ZVE with the various histologically determined grades of rejection. The use of ZVE rather than standard endoscopy permits greater recognition of changes in the villi and crypt areas. It more clearly identifies the mucosal changes that occur as the rejection progresses. We now believe that the endoscopic assessment of mucosa afforded by ZVE provides a fast and reliable confirmation of the histologic diagnosis.

The patchy, segmental nature of intestinal rejection warrants multiple random sampling [1, 5, 7, 21, 37]. Such random sampling may no longer be required because the visualization provided by the ZVE allows biopsy of the most representative area of the intestinal mucosa. Additionally, graft intestinal mucosa often shows inflammatory changes attributable to surgical trauma. Biopsy of these inflamed areas of the stoma can distort the histologic diagnosis [36]. We believe that by using the ZVE as a tool to identify appropriate areas for biopsy, inaccurate diagnoses of rejection attributable to sampling error will be minimized.

In a total of 59 instances (30 in period 1 and 29 in period 2), histologically diagnosed mild rejection was not treated because there were no clinical symptoms of rejection and the mucosa appeared normal on ZVE. All but one of these instances of rejection reversed without treatment. These may have been subclinical rejection episodes that occur in the graft mucosa. Another possible explanation is that an overdiagnosis of changes in limited sampling areas tends to occur. The changes seen in a small sampled area from a biopsy may not always represent the status of the entire graft. Rather, these focal changes may be self-limited. The ZVE, along with the concurrent clinical status of the patient, appears to provide reliable support for deciding whether to treat such histologic diagnoses of rejection or not.

The specificity and negative predictive value of the ZVE score were very high (respectively, 93% and 87% overall). However, the sensitivity was low for both children (61%) and adults (45%), and the positive predictive value was low for children (57%). The low sensitivity appeared to be attributable, in part, to histologic rejection that does not require treatment. When we excluded these (histologically false-positive) rejection episodes, the sensitivity increased for both children (81%) and adults (61%). The reason for a low positive predictive value for children is not clear. However, children are more likely to have infectious enteritis. It is possible that enteritis mimics rejection in endoscopic appearance, and that some cases were undocumented.

We did not encounter apparent infectious enteritis during these ZVE sessions. Cytomegalovirus (CMV) enteritis has been previously reported to cause significant morbidity in clinical intestinal transplantation [20, 33]. The initial preference for CMV-negative grafts

along with the subsequent improvement in CMV prophylaxis with the use of gangeielovir has redueed the incidence of CMV enteritis. In our series of more than 150 clinical intestinal transplantations performed since 1994, CMV enteritis was encountered in only two eases. Even if we include other types of infeetious enteritis sueh as those attributable to adenovirus and nontubereulous mycobacterium–assoeiated enterocolitis, the ineidenee still is limited to less than 10% of all eases, as eompared with rejection, whieh has a distinet possibility of occurring in nearly every case after intestinal transplantation [2, 15, 17]. Thus, none of these types of infections ean explain completely via differential diagnosis the large number of histologically false-positive ZVE readings observed in this study.

Posttransplant lymphoproliferative disease (PTLD) is known to oeeur rather frequently in the intestinal transplant recipient [1, 5, 7, 21]. Specifically, PTLD can occur in the submucosal lymphoid tissue of the bowel allograft. Although we did not eneounter any gastrointestinal-related PTLD during the follow-up period of the patients enrolled in this study, we have seen cases of PTLD oeeurring in the intestinal allografts of other patients. The appearanee of PTLD in intestinal allograft can be elearly distinguished from that of rejeetion, because it shows a distinetive area of abnormality (ulcer, lesion) with the surrounding mueosa appearing normal.

As we colleet prospective data using the ZVE in eombination with histologie study, we plan to use standard stepwise and logistie regression techniques for each of the five criteria defined in this report (villous length, villous blunting, baekground erythema, villous congestion, and friability) to investigate whether they contain equal or dissimilar predictive value for the histologie diagnosis of rejeetion. We also will investigate whether the individual eomponent seoring of 0 to 3 used in this study is optimal for predicting the histologic diagnosis, or whether another set of numerie seores used for the normal, mild, moderate, and severe categories would provide greater predietive value. In addition, measurement of inter- and intraobserver variability also will require future investigation.

In eonclusion, histologie examination continues to remain the gold standard for a diagnosis of rejection. However, the ZVE provides information on a larger mucosal surface area than can be evaluated with a forceps biopsy, and we eurrently believe that ZVE as a diagnostie tool should be used eneomitantly with the biopsy. The enhanced ability afforded by ZVE to assess the health of graft mucosa has been shown in this study to provide useful information toward a rapid diagnosis and, along with the presenting elinical symptoms, to help in deeiding whether to treat histologically diagnosed mild rejection. Clearly, the important question about whether to withhold treatment in all eases involving histologie diagnosis of mild rejeetion, but without eorresponding elinieal symptoms, must await eonlirmation by further studies. Finally, as a sampling tool, ZVE will help in identifying the most appropriate areas for biopsy.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Bravo capsule induction of esophageal hypercontractility and chest pain

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Abstract

Background: The Bravo catheter-free pH monitoring system uses a capsule attached to the esophageal mucosa to detect acid exposure. Placement of the Bravo capsule is associated with intermittent chest pain in 50% of normal volunteers. The authors hypothesized that chest pain in this setting may be attributable to hypertensive esophageal contractions induced by the Bravo capsule.

Methods: The study population consisted of 40 consecutive patients with reflux symptoms who had stationary esophageal manometry within 1 h after Bravo capsule placement. The control group consisted of 40 patients with symptomatic gastroesophageal reflux disease (GERD) from a population of patients with foregut symptoms who were computer matched to the study group for age, sex, lower esophageal sphincter (LES) pressure, LES length, and 24-h pH composite score. The patients in the control group had manometry before Bravo capsule placement. The occurrence of chest pain was assessed before and during the monitoring period by interview and review of the patient's diary. Mean contraction amplitudes in the distal third of the esophagus after 10 wet swallows were averaged. The prevalence of patients with esophageal contraction amplitudes in the distal third that exceeded the 95th percentile of normal (180 mmHg) and the mean amplitude of distal third esophageal contractions in the study and control populations were compared. In the study group, the incidence of chest pain among the patients with hypercontractility of the esophagus was compared with the incidence among those without hypercontractility.

Results: The mean contraction amplitude was higher in the study group (144.7 vs 105.5 mmHg; $p = 0.002$). The number of patients with a mean distal esophageal contraction amplitude exceeding the 95th percentile of normal also was significantly higher in the study group (13/40 vs 5/40; $p = 0.03$). A total of 10 patients experienced new onset of chest pain with the Bravo capsule in place, and 6 patients experienced hypertensive esophageal contractions.

Conclusions: The intraesophageal Bravo capsule can cause hypertensive esophageal contractions, which may lead to chest pain.

Key words: Bravo capsule — Catheter-free pH monitoring system — Chest pain — Hypertensive esophageal contraction

Until recently, the standard method for measuring esophageal acid exposure has been the catheter-based ambulatory 24-h pH test. Although this test is the "gold standard" for assessing intraesophageal pH, it has limitations such as discomfort, inconvenience, and interference with normal activity [1]. These limitations lead patients to modify their diet and daily activities, which may indirectly affect the results of the test [2].

Recently, the Bravo catheter-free pH monitoring system was introduced to overcome these shortcomings. A randomized trial has shown that the Bravo pH monitoring system is more convenient for the patient and interferes less with normal activity than the conventional catheter based system [3]. It also allows comfortable recording as long as 48 h for 89% of patients [2]. As a result, the new Bravo system is gaining popularity as an alternative to the catheter technique.

We and others noted that chest pain is frequently reported during the Bravo pH monitoring period, especially during swallowing. This led us to hypothesize that the Bravo capsule may cause chest pain by inducing esophageal dysmotility.

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Materials and methods

Patient population

From January 2003 to February 2004, 40 consecutive patients (median age, 45.5 years; range, 25–74 years) with gastroesophageal reflux symptoms had stationary esophageal manometry within 1 h *after* endoscopic Bravo capsule placement. This study group was compared with a control group consisting of 40 patients (median age, 49 years; range, 25–86 years) who had esophageal manometry 1 h *before* Bravo capsule placement. The control patients were matched to the study group for age, gender, lower esophageal sphincter (LES) pressure, LES length, and pH composite score. Patients with a history of achalasia, benign or malignant stricture, or a previous antireflux esophageal or gastric surgery were excluded from the study.

Esophageal manometry

Standard esophageal motility studies were performed after an overnight fast. A 12-Fr, 8-lumen water-perfused motility catheter was passed through the anesthetized nostril into the stomach. The catheter had side holes located at 5-cm intervals, with 4 holes arranged radially (90° apart) at one level (Arndorfer Medical Specialties, Greendale, WI, USA). Each channel was connected to a pressure transducer, which was constantly perfused with bubble-free distilled water at 0.6 mL/min by a low-compliance pneumohydraulic pump (Arndorfer Medical Specialties).

The LES parameters including the resting pressure at the respiratory inversion point (RIP), the total LES length, and the length below the RIP (abdominal LES length) were measured using the stationed pull-through technique. Esophageal body motility was assessed by positioning the catheter with the most proximal side hole 1 cm below the lower border of the upper esophageal sphincter and the other four side holes trailing at 5 cm intervals.

To assess esophageal body contractility, 10 swallows of water (5 ml) were given at 25-s intervals. Data regarding wave progression, morphology, and contraction amplitude were recorded and analyzed using Polygram software version 4.2 (Medtronics, Inc., Shoreview, MN, USA). The amplitude of contraction in the distal third of the esophagus was defined as the mean amplitude in the lower two channels. Hypertensive esophageal contractions were defined as a mean amplitude above the 95th percentile determined in normal subjects (> 180 mmHg).

Bravo capsule and pH monitoring system

The Bravo capsule (6 × 5.5 × 25 mm) was attached to the esophageal mucosa using a prepackaged assembly (Fig. 1). The capsule has a well (diameter, 4 mm; depth, 3.5 mm) connected to an external vacuum unit during placement for attaching a small pin to the esophageal mucosa. The capsule contains antimony pH and reference electrodes located at the distal end. By means of radiotelemetry, pH data are transmitted to a receiver worn on the belt. After 48 h, the patient returned the receiver, and the data were uploaded to a computer for analysis.

Placement of the Bravo capsule

Study group

The Bravo capsule was placed during endoscopy with the patient under conscious sedation using intravenous Demerol and Versed. The distance between the upper limit of the gastric rugal folds (the gastroesophageal junction) and the incisor teeth was measured. The endoscope was removed, and the delivery system was passed transorally into the esophagus. There it was advanced until the pH sensor of the capsule was located at a point 6 cm above the upper limit of the rugal folds [4]. Capsule attachment was confirmed by reintroduction of the endoscope (Fig. 2). A motility catheter then was passed into the stomach, and esophageal motility was performed as described earlier.

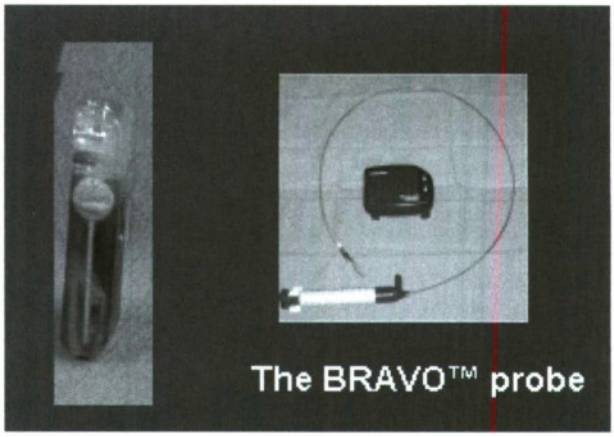

Fig. 1. Bravo capsule (left) and delivery system with receiver (right).

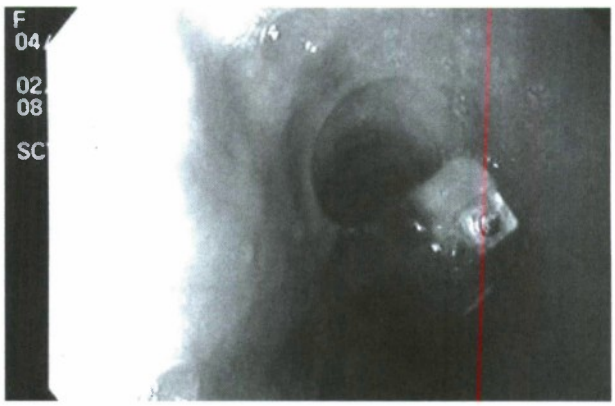

Fig. 2. Endoscopic view of an attached Bravo capsule.

Control group

After standard esophageal manometry, the position of the upper border of the LES was identified. The Bravo delivery system was passed transnasally, and the capsule was attached 5 cm above the upper border of the LES. A chest x-ray was obtained to confirm attachment of the capsule.

Chest pain symptom assessment

Chest pain was assessed in the study group by interview before placement of the Bravo capsule. After placement, each patient was given a standardized symptom questionnaire. The presence or absence of chest pain before and during the monitoring period was recorded. Patients with a history of chest pain before the Bravo study and those with incomplete self-reported questionnaires were excluded from the chest pain assessment analysis.

Ethical considerations

This study protocol was approved by Health Sciences Campus, the Institution Review Board of the University of Southern California.

Statistical analysis

Chi-square and Fisher's exact tests were used to compare categorical variables, and the Student's *t*-test was used for continuous variables. Significant differences were assumed at a p value less than 0.05.

Table 1. Characteristics of the study and control groups

	Study group (n = 40)	Control group (n = 40)	p Value
Age (years): n (range)	45.5 (40–53)[a]	49 (44–63)[a]	0.18
Gender (M/F)	15/25	15/25	1.0
Composite pH score	19.27 ± 2.89	19.21 ± 3.41	0.99
Total length (cm)	3.04 ± 0.16	2.94 ± 0.12	0.62
Abdominal length (cm)	1.77 ± 0.13	1.62 ± 0.10	0.38
LES pressure (mmHg)	16.95 ± 1.44	17.96 ± 1.64	0.64

LES, lower esophageal sphincter
[a] Interquartile range (IQR)

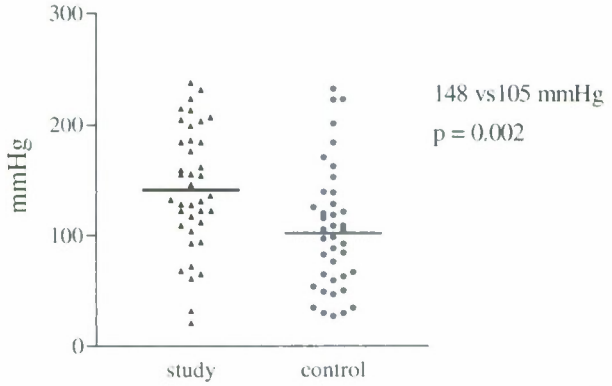

Fig. 3. Comparison of mean distal esophageal contraction amplitude (DEA) between groups. The mean DEA was significantly higher in the study group (147.7 ± 9.9 vs 105.5 ± 8.8 mmHg; p = 0.002).

Results

Each group consisted of 15 male and 25 female patients. There were no significant differences in demographic data, LES parameters, and pH composite score between the two groups (Table 1).

The distal esophageal contraction amplitude was significantly higher in patients with a Bravo capsule in place (147.7 ± 9.98 vs 105.5 ± 8.84 mmHg; p = 0.002) (Fig. 3). A total of 13 patients (33%) in the study group had distal esophageal contraction amplitudes exceeding the 95th percentile of normal, as compared with only 4 patients (10%) in the control group (Fig. 4). The total number of hypertensive esophageal contractions also was significantly higher among the patients with the Bravo capsule in place (134/400 vs 55/400; $p < 0.0001$) (Fig. 5).

The self-report questionnaire was completed by 20 patients in the study group who had no history of chest pain. New onset chest pain developed in 10 of these patients (50%) after Bravo capsule placement. In 6 of these patients, the pain was associated with hypertensive esophageal contractions. All the patients with new onset chest pain had hypertensive esophageal contractions. In contrast, hypertensive contractions were present in only 4 of the 14 patients (29%) without chest pain (p = 0.003) (Fig. 6).

Discussion

A recent randomized control trial has shown that the Bravo catheter-free pH monitoring system is better tolerated by patients and allows more normal activity than the conventional catheter-based system. As a result, it is rapidly gaining popularity among patients with GERD.

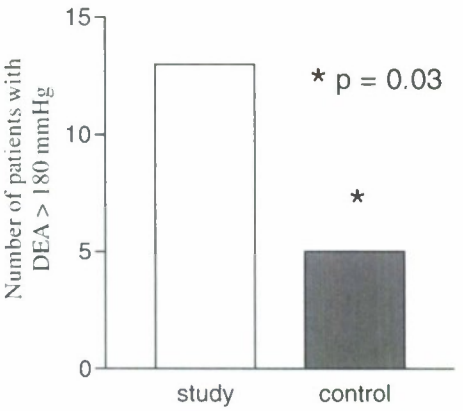

Fig. 4. Comparison of the number of patients with distal esophageal contraction amplitude (DEA) exceeding 180 mmHg between groups. The number of patients with DEA exceeding 180 mmHg was higher in the study group (13/40 vs. 5/40; p = 0.03).

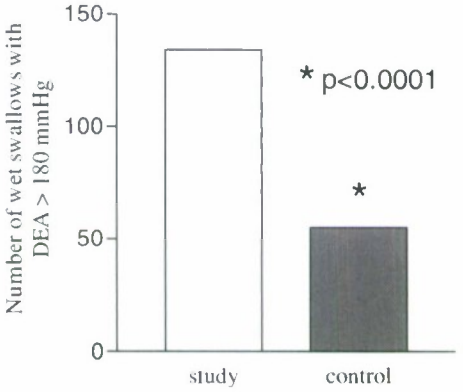

Fig. 5. Comparison of the number of swallows with distal esophageal contraction amplitude (DEA) exceeding 180 mmHg between the groups. The total number of wet swallows in each group was 400. The number of swallows with a DEA exceeding 180 mmHg was higher in the study group (134/400 vs 55/400; $p < 0.0001$).

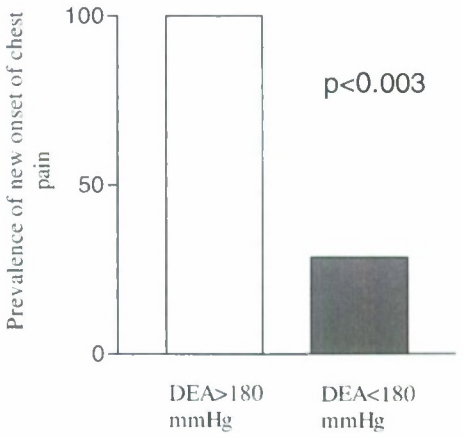

Fig. 6. Comparison of the prevalence of new chest pain between patients with (n = 6) and those without (n = 14) hypertensive esophageal contractions. The prevalence of new chest pain was higher among the patients with hypertensive contractions [6/6 (100%) vs 4/14 (28.5%); p = 0.003].

As experience with this technique has grown, it has become evident that patients commonly report chest pain with the Bravo capsule in place. In a recent randomized trial comparing Bravo and conventional pH monitoring systems [3], chest pain was experienced by 60% of the patients monitored with the Bravo capsule. Pandolfino et al. [2] also have reported a significant frequency of chest pain after Bravo placement. In this smaller series, 34.5% of the patients experienced chest pain, and in 2 of 10 patients, the chest pain was severe enough for the patient to request immediate capsule removal. The mechanism of chest pain in these patients is not clear.

We hypothesized that esophageal motility abnormalities may be the cause of this chest pain. This hypothesis was based on previous studies demonstrating the strong relationship between esophageal motor abnormalities and the symptom of chest pain [5]. In particular, esophageal hypercontractility has been reported in 27% to 59% of patients with (noncardiac) chest pain [6–9].

We recently completed a study to assess the clinical utility of the Bravo system. This study included patients evaluated at two clinical sites. At one site, the Bravo capsule was placed transnasally at a location determined by manometry performed before Bravo placement. At the other site, the majority of patients had the Bravo capsule placed transorally at a location determined by endoscopy. In these patients, esophageal manometry often was performed after Bravo placement. This allowed us to identify the study and control groups included in this report. These patients, matched for age, sex, LES characteristics, and composite pH score, provided comparable groups for studying the possible effects of a Bravo capsule on motility.

Our results confirm previous observations regarding the common occurrence of new onset chest pain after Bravo insertion. In our experience, this symptom develops after Bravo placement in 50% of patients previously free of chest pain. We also have shown that 60% of the patients in whom chest pain develops will have esophageal hypercontractility when motility is performed with a Bravo capsule in place. Furthermore, even in patients without a new onset chest pain, hypertensive contractions frequently occur in the distal esophagus. One-third of all patients studied with the Bravo capsule in place had hypertensive contractions, which was more than three times the frequency in the control group. In addition, more than one-third of all contractions measured in the Bravo group were in the hypertensive range. Together, these observations support our hypothesis, suggesting that the Bravo capsule may indeed induce contraction abnormalities in the esophagus known to be associated with chest pain.

For the patients in the study group, the motility studies were performed after Bravo capsule insertion for the purposes of patient comfort and convenience. This approach not only allowed the endoscopy, motility study, and Bravo monitoring all to be accomplished in one session, but it also allowed placement of the Bravo capsule with the patient under sedation. Clearly, this strategy is attractive to patients. The results of this study suggest the need for caution in using this approach because assessment of esophageal motility can be complicated. The duration of the contraction abnormalities associated with Bravo placement is unknown, but it seems prudent to allow sufficient time to pass between Bravo monitoring and esophageal manometry for detachment of the capsule. In the largest study on Bravo monitoring reported to date, capsule detachment occurred within 14 days for 99% of those studied [10].

Conclusion

In conclusion, the Bravo capsule frequently causes hypertensive contractions in the distal esophagus, and these contractions are commonly associated with chest pain. Consequently, manometry should not be performed with a Bravo capsule in place, and patients scheduled for Bravo pH monitoring should be informed that chest pain may develop.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic hepatic resection

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Abstract

Background: Although laparoscopy in general surgery is increasingly being performed, only recently has liver surgery been performed with laparoscopy. We critically review our experience with laparoscopic liver resections.

Methods: From January 2000 to April 2004, we performed laparoscopic hepatic resection in 16 patients with 18 hepatic lesions. Nine lesions were benign in seven patients (five hydatid cysts, three hemangiomas, and one simple cyst), five were malignant in five patients (five hepatocarcinoma), and four patients had an uncertain preoperative diagnosis (one suspected hemangioma and three suspected adenomas). The mean lesion size was 5.2 cm (range, 1–12). Twelve lesions were located in the left lobe, three were in segment VI, one was in segment V, one was in segment IV, and one was in the subcapsular part of segment VIII.

Results: The conversion rate was 6.2%; intraoperative bleeding requiring blood transfusions occurred in two patients. Mean operative time was 120 min. Mean hospital stay was 4 days (range, 2–7). There were no major postoperative complications and no mortality.

Conclusions: Hepatic resection with laparoscopy is feasible in malignant and benign hepatic lesions located in the left lobe and anterior inferior right lobe segments (IV, V, and VI). Results are similar to those of the open surgical technique in carefully selected cases, although studies with large numbers of patients are necessary to drawn definite conclusions.

Key words: Laparoscopy — Liver resection

During the past few decades, the acquisition of new technology and the improved surgical experience have increased indications for laparoscopic abdominal surgery. In hepatic surgery, laparoscopy has been confined to the staging of tumors, biopsy, and the treatment of simple serous cysts. Only recently has laparoscopic hepatic resection been successfully performed. A review of the literature reports only 200 cases of hepatic resection published up to 2001 [3].

Surgical skills in both liver open surgery and laparoscopic surgery are required. Moreover, preoperative and intraoperative assessment is necessary to define the location of the tumor and its relationships with vascular structures. Proper technological support is required for the dissection of the parenchyma for adequate control of hemostasis [6].

This article reports our experience with laparoscopic hepatic resection and critically reviews indications and results.

Materials and methods

From January 2000 to April 2004, 16 patients underwent laparoscopic hepatic resection for 18 lesions. Patients were positioned in the supine position, with the legs abducted, and the surgeon stood between the legs with the first assistant to the patient's right. The first 10 mm trocar was inserted in the umbilical site after creating pneumoperitoneum. After exploration of the abdominal cavity, three trocars were positioned: one in the epigastrium; one in the right hypochondrium for retraction of the liver and aspiration; and one 10 mm trocar in the left hypochondrium for dissection, coagulation, and positioning of clips.

Intraoperative ultrasonographic evaluation of the hepatic lesion and its relations with vessels was performed in all cases. For lesions located in segments II and III, the left lobe was completely mobilized. In lesions located in segments V and VI, we performed a mobilization of the right lobe when necessary.

In patients with hydatid cysts, removal of the cysts was achieved by cystopericystectomy in all cases. In one case with an 8 cm cyst, we used intraoperative PAIR (puncture, aspiration, injection, reaspiration) under laparoscopic control before cystopericystectomy.

For patients with malignant lesions, we performed atypical resection in one patient with a peripheral exophytic lesion and typical segmentectomy or bisegmentectomy in four patients with lesions located deeper in the parenchyma. In all cases of malignant lesions, surgical margins were larger than 2 cm.

Laparoscopic liver resection was also indicated in three patients with uncertain diagnosis (hepatic adenoma vs focal nodular hyperplasia) and in another case for atypical hemangioma in a patient with previous breast cancer.

In the first three cases [hepatocarcinoma (HCC) of segment II, hydatid cyst of segment VI, and hemangioma of segment II], we used the Kellyclasia technique for hepatic parenchymal dissection, monopolar cautery, and/or application of vascular clips for hemostasis. In other patients, ultrasound scalpel was utilized for parenchymal section.

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For extraction of the surgical specimen, we performed a suprapubic transverse 8 cm incision for solid lesions or enlargement of the periumbilical incision in cystic lesions. In all cases, a plastic bag was used.

Results

During the study period, we performed laparoscopic liver resection in 16 patients (five male and 11 female) with an average age of 51 years (range, 28–74). Indications for laparoscopic resection, the characteristics of the lesions, and their locations are summarized in Table 1.

Among 18 resected lesions, nine were benign (five hydatid cysts, two symptomatic hemangiomas, one hemangioma associated with cholelithiasis, and one simple cyst), five were malignant (HCC in Child–Pugh class A cirrhosis), and four had uncertain preoperative diagnosis (one atypical hemangioma and three suspected adenomas).

As shown in Table 1, lesions were mainly located in left segments II and III and right inferior segments V and VI. Only in one case was the lesion located at the surface of the anterior part of segment VIII.

Surgery was performed using the laparoscopic approach in 15 of 16 patients, with a 6.2% of conversion rate (one case of hemangioma of segment II). Intraoperative hemorrhage requiring blood transfusion (2 units) occurred in two cases. In the first case, hemorrhage was successfully managed by laparoscopy, and in the second case it resulted in conversion to open surgery. The two cases of intraoperative hemorrhage occurred during the first period when the Kelly-clasia technique was utilized for dissection of parenchyma. Use of the ultrasonic scalpel improved results in the following patients, with a mean blood loss of 150 ml (range, 50–200). Resection was performed without vascular clamping in all cases.

The mean operative time was 120 min (range, 60–180). Mean hospital stay after surgery was 4 days (range, 2–7). There were no major surgical complications and no operative mortality. In two patients, minor surgical complications occurred (surgical wound infection in one and persistent abdominal pain in another).

Discussion

Among patients for whom liver surgery is indicated, those for which a laparoscopic approach can be proposed are yet limited [3, 10, 13]. Only a few can be submitted to laparoscopic liver resection. In our experience of 187 liver resections performed during the study period, we chose the laparoscopic approach for only 16 patients. Despite the small number of patients, our experience confirms the feasibility of laparoscopic hepatic resection, with results similar to those reported in the literature.

Berthio et al. [3] reviewed 200 cases of resection for both benign and malignant lesions and reported a conversion rate of 7%, mean hospital stay of 7.7 days, postsurgical morbidity of 16%, and mortality of 0.5%. Two different studies on laparoscopic hepatic resection, one for benign lesions and one for malignant lesions, reported similar results in terms of conversion rates (10 and 13.5%, respectively), mean hospital stay (5 and 7 days, respectively), and mortality (0% in both studies). On the contrary, morbidity was 5% for patients with resection for benign lesions and 22% for malignant lesions.

In comparative studies of open liver surgery, mortality and morbidity were not increased in laparoscopy, operative time was similar or slightly longer, blood loss was similar or lower, and mean hospital stay was shorter for the laparoscopy group [12, 15, 20, 23, 25].

Control of hemostasis is one of the major topics of liver surgery and use of ultrasonic or radiofrequency scalpels, used more commonly during laparoscopic resection, helps to reduce blood loss, as reported in comparative studies between laparoscopic and open hepatic surgery. However, failure to control bleeding during laparoscopic surgery is one of the most important causes of conversion to the open technique [2, 7, 9, 10, 13, 15, 22]. In our experience, after introduction of ultrasound scissors blood loss was reduced to a mean of 150 ml and the conversion rate was reduced to 0%.

Argon beam coagulation is effective for hemostasis, but gas embolism is reported in the literature and it has been related to the increase in intraabdominal pressure [8, 14]. For this reason, the use of argon bean coagulation is not recommended for laparoscopic liver resections.

The most important factor for laparoscopic resection is selection of patients. Size and site of lesion and its relationship with a major vessel must be accurately evaluated during preoperative staging.

Benign lesions are generally referred for surgical resection for the presence of symptoms or for uncertain diagnosis. Hemangiomas and nodular focal hyperplasia are rarely submitted to surgical resection, and few cases have been reported in the literature [10, 16, 17, 19, 22].

In our experience, hemangiomas were referred for surgical resection for preoperative uncertain diagnosis in one case, whereas in the other case, the patient suffered from cholelithiasis and the hemangioma, located on the surface of segment V, was resected during laparoscopic cholecystectomy.

The role of hepatic resection for hydatid cysts is controversial, and the introduction of laparoscopy has only added a new element to the debate. The treatment of choice is still total cystopericystectomy, which reduces the frequency of intraoperative anaphylactic reactions and relapses [5]. Laparoscopic partial cystectomy or PAIR lead to results similar to those of open surgical and percutaneous techniques: anaphylactic reactions in 3% of cases and relapse in 3–10% of patients after a follow-up of 17 or 18 months [4, 11, 24]. Manterola et al. [21] published a series of eight cases of laparoscopic total cystopericystectomy, with anaphylactic reactions and relapse in none of the patients after a mean follow-up of 30 months.

Laparoscopic treatment of malignant lesions is still a matter of debate, even though laparoscopic liver resection was successfully applied in cirrhotic patients with primary tumors [7]. Comparative studies with open surgery have shown a shorter hospital stay with the

Table 1. Site, size, and histological features of lesions

Preoperative diagnosis	No. of patients	Site (segment)	Size (cm)	Histological features
Benign lesions	7			
		II–III	8	Hydatid cyst
		VI	4	Hydatid cyst
		VI–IV–VIII	3, 2.5, 1	Hydatid cyst
		VI	9	Hemangioma
		II	8	Hemangioma
		V	4.5	Hemangioma[a]
		II–III	12	Simple cyst
Malignant lesions	5			
		III	6	HCC
		II	5	HCC
		II–III	3	HCC
		II–III	3	HCC
		II–III	2	HCC
Uncertain diagnosis	4			
		II–III	7	Hemangioma[b]
		II–III	5	FNH vs adenoma
		II–III	7.5	FNH vs adenoma
		II–III	6	FNH vs adenoma

FHN, focal nodular hyperplasia; HCC, hepatocarcinoma
[a] Associated with cholelitiasis
[b] Patients with previous breast cancer

laparoscopic approach, with similar morbidity, mortality, and long-term results [20, 25]. However, a multicenter study reported discouraging results, with surgical margins < 1 cm in 30% of resected HCC and in 20% of resected metastasis; moreover, positive surgical margins were found in 6.7% of patients [13].

In cirrhotic patients, laparoscopic liver resection has been performed with good results also with coexisting poor hepatic function [1, 18, 26]. The authors concluded that saving the abdominal wall vascular collaterals in the laparoscopic approach reduced postoperative decompensation in patients with portal hypertension [7]. These preliminary data suggest an extension of indications for surgery of primary malignancy in cirrhotic patients, but comparative studies with less invasive treatments are necessary.

Currently, the laparoscopy approach is employed mainly for minor hepatic resections, wedge resections, segmentectomy, and bisegmentectomy. Experience in laparoscopic major liver resections is limited to sporadic cases in the literature, and usually the approach is not fully laparoscopic [3, 10, 15].

In conclusion, laparoscopic hepatic resection is technically feasible in properly selected cases. Indications for benign lesions are limited, and the role of laparoscopic liver resection in malignant lesions is still controversial. Studies with large numbers of patients and long-term follow-up must be performed before more precise conclusions on the role of laparoscopy in liver surgery can be drawn.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

The "stamp method": a new treatment for perforated peptic ulcer?

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Abstract
Background: The aim of this study was to develop a simple method for closure of a perforated peptic ulcer, making it more accessible for laparoscopic surgery.
Methods: An experimental pilot study was performed using five male Wistar rats. The perforation was closed by a bioabsorbable patch made of lactide–glycolid–caprolactone fixed with glue onto the outside of the stomach.
Results: Postoperatively, there were no signs of leakage or other complications. Histologically, there were no signs of inflammation on the inside of the stomach, and there was a 50% reduction of the perforation each successive postoperative week. No adverse reactions because of the degradable material or glue were observed.
Conclusions: Treatment of a perforated peptic ulcer by placing a patch of biodegradable material like a "stamp" on the outside of the stomach is a feasible option.

Key words: Perforated peptic ulcer — Laparoscopy — Biodegradable patch — Glue

Introduction

Laparoscopic correction still is not the gold standard for management of a perforated peptic ulcer [4] although many advantages of laparoscopic procedures have been demonstrated during the recent years with regard to postoperative morbidity and pain [1, 8, 9]. During a multicenter Dutch trial (LAMA trial), we compared laparoscopic closure of perforated peptic ulcer with the conventional method using laparotomy. It seemed that one of the problems with the laparoscopic procedure involves the suturing technique [2]. It is especially difficult for surgeons to take big bites, to prevent cutting out of the sutures [9], and to exert sufficient tension on the knot during intra- or extracorporal knotting.

The operation time for laparoscopic correction often is prolonged [2, 6], which is mainly due to the learning curve with regard to suturing technique. This may be the reason why many surgeons (especially during the night) are not even starting up laparoscopically or soon convert to laparotomy. A new method has been developed in which perforation of the stomach in rats was closed with a biodegradable patch fixed with glue, similar to putting a "stamp" on the outside of the stomach. In the current current experiment, this "stamp" method was evaluated.

Methods

Five adult male Wistar rats with an average weight of 255 were used in this trial. With the rats general anesthesia (isoflurangas 2% with oxygen), a median laparotomy was performed. At a fixed point on the ventral side of the stomach, a perforation was created with a diameter of 0.5 cm. A patch, made of lactide–glycolid–caprolactone (LGC) (Polyganics, B.V., Groningen, The Netherlands) was cut into a circle with a diameter of 1 cm and an overlap of 0.5 cm all around the perforation. The patch was glued on the outside of the stomach with Gluhran 2 (n-butyl [2] cyanoacrylate, methaeryloxysulfolane). The abdomen was closed in two layers with Polysorb 4-0.

After 1week, the first rat underwent relaparotomy under general anesthesia. After inspection of the abdomen, the patch, including the full thickness of the stomach wall, was resected and sent for histology. Each successive postoperative week, one rat underwent the same procedure, resulting in a total clinical and histologic follow-up period of 5 weeks.

For histology, tissue specimens were rinsed in saline and placed into a fixative containing 2% glutardialdehyde buffered with 0.1 mol/ phosphate buffer, pH 7.4. Then the specimens were dehydrated through a graded concentration of ethanol and embedded in glycol methaerylate. From all samples, 2-μm-thick sections were prepared using a disposable histoknife and a Reichert–Jung "2050 supercut"

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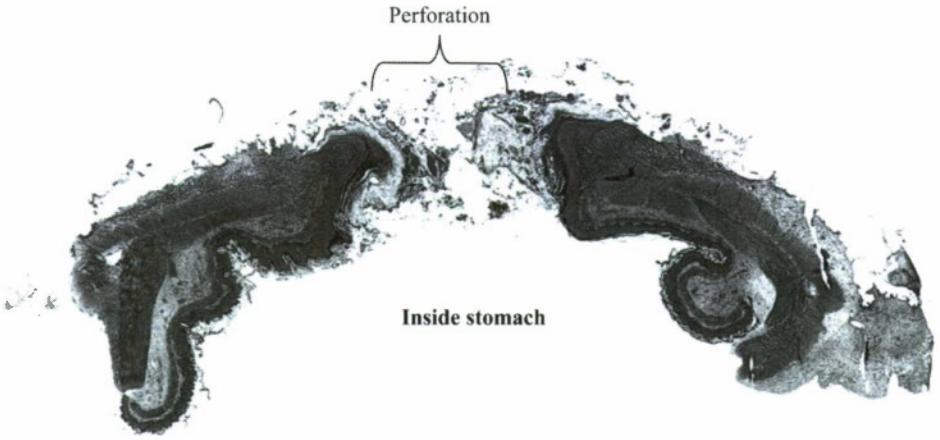

Fig. 1. Histology at week 1.

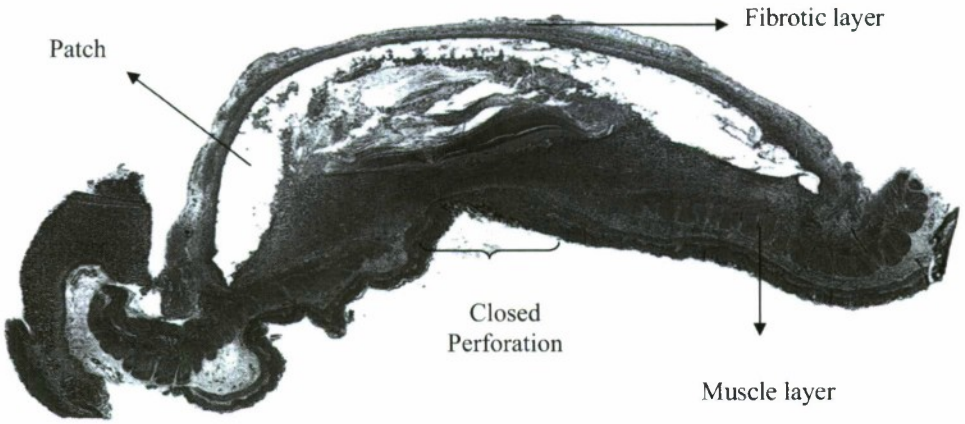

Fig. 2. Histology at week 5.

microtome. The sections were mounted on glass slides and stained with toluidine blue and alkaline fuchsin (Merck, Darmstadt, Germany). All the sections were evaluated and photomicrographed using a Olympus BX-50 microscope (Olympus Optical Co., Japan)

Results

All the rats survived the first operation without complications. The mean operating time was 10 min. At relaparotomy, there were neither signs of leakage nor evidence of peritonitis. There were small adhesions, mainly to the liver, and in the first two rats there also were small adhesions between the spleen and the stomach. From week 1, the patch was covered by omentum. Biodegradation of the patch was visible at week 5. The diameter of the perforation, as observed from the inside of the stomach, decreased by 50% every week. After 5 weeks, only a pinpoint perforation could be found. All the rats gained weight during their weeks of follow-up evaluation, with an average weight of 348 g (range, 313–392 g), on the day of re-operation meaning they were in good condition.

Histology

At 1 week postoperatively, no inflammatory cells were detected on the inside of the stomach. Bacteria were found in the superficial mucous layer of the epithelium, and among the microvilli of epithelial cells. They were distributed irregularly, patchy and with heavy colonization, in some areas but did not invade the epithelium. The mucosa consisted of dense connective tissue and numerous blood vessels. The basement membrane underlying the epithelial basal cells was clearly visible. The muscular layer and submucosal glands were present, but did not continue, as was to be expected.

At 2 weeks postoperatively, cellular ingrowth of inflammatory cells, especially granulocytes, was seen lying against the LGC patches. Multinucleated giant cells also were seen at the interface of the patches.

At 3 weeks postoperatively, the LGC patches were covered by a capsule of fibrotic tissue. This capsule consisted of 14 to 15 layers of fibroblasts, collagen fibers, extracellular matrix, and numerous blood vessels. Still, some multinucleated giant cells were observed in the patches, and degradation of the LGC patches had begun.

At 4 weeks postoperatively, the amount of inflammatory infiltrate had increased, while other cells such as macrophages and multinucleated giant cells were seen infiltrating the LGC-patches. The capsule of fibrotic layer became ticker. Fibroblasts as well as collagen fibers and blood vessels were found more frequently and denser, as compared with findings 3 weeks postoperatively.

At 5 weeks postoperatively, the fibrotie layer on the pateh had inereased Maerophages and giant eells still were found infiltrating and phagoeytosing the LGC patehes. There were epithelial eells elose to the perforation. The museular layer still showed perforation. There were no signs of rejection (Figs. 1 and 2).

Discussion

A new method for closure of peptie uleer perforation was tested in rats, and the first results seem promising. Sealing of the perforation with a glued biodegradable pateh seemed suffieient beeause no leakage oeeurred. Furthermore, no inflammation or other side effeets to the abdominal wall were observed. It was deeided that at this phase, the use of an iatrogenieally made perforation would be sufficient, because we wanted only to evaluate whether this new teehnique would work.

Of eourse, this test did not eompletely mimie the clinical situation. There was no edema, no fibrin deposition, and no inflammation of surrounding tissue. However, no elinieal evidenee so far had proved that a perforation of any longer duration with fibrin deposition has a worse outeome with regard to healing of the perforation itself and a higher risk for reperforation. It eould even be suggested that fibrin deposition helps in sealing the perforation, but more research on this topie is needed.

Closure of a perforated peptie uleer by a Graham omental pateh or mere sutures has been performed for many years [7, 8]. Several alternative teehniques have been tried [7, 9]. The ineentive for introdueing these new operations was to simplify the proeedure and make it suitable for minimal invasive therapy [9]. A few proeedures ean be aeeomplished by endoseopy, but often it still is neeessary to eombine it with laparotomy or laparoscopy [3, 6]. Lau et al. [5] described a method for elosing the perforation using spongostan fixed with fibrin glue. This seemed to be suitable only for smaller perforations. The pateh used in this study can be introdueed through a troear and unfolded with ease beeause it has no memory. Glubran 2, the glue used in this trial, is a synthetie surgieal glue european eonformity (CE) eertified for internal use. It is liquid, does not need any preparation and ean be applied to the pateh inside the abdomen using a laparoseopie needle. The size of the perforation does not matter because the patehes ean be eut easily into any desired size.

In eonelusion we propose a simple teehnique for elosure of a perforated peptie uleer, making laparoseopie eorreetion of a perforated peptic uleer more aeeessible. A randomized elinieal trial will be initiated in due eourse.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Elucidating the relationship between cardiac preload and renal perfusion under pneumoperitoneum

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Abstract
Introduction: Pneumoperitoneum is associated with a well-described decrease in renal blood flow, but it remains unclear whether a decrease in cardiac preload is responsible. Our aim was to characterize the relationship between cardiac preload and renal perfusion during pneumoperitoneum.
Methods: Eleven pigs were submitted to three 30 minute study periods: 1) Baseline ($n=11$): no interventions, 2) Pneumoperitoneum ($n=11$): 12 mmHg CO2 pneumoperitoneum, 3) Preload Reduction: pneumoperitoneum and nitroglycerin infusion ($n=8$); or pneumoperitoneum and hemorrhage to a mean arterial pressure (MAP) of 40 mmHg ($n=3$). Echocardiographic measurements of left ventricular end-diastolic diameter (LVEDD) were used as an index of preload. Renal cortical perfusion (RCP) was measured using laser doppler flowmetry.
Results: LVEDD decreased from 4.2 ± 0.5 to 4.1 ± 0.6 cm ($p=0.02$) with pneumoperitoneum and then to 4.0 ± 0.5 cm ($p=0.03$) with the addition of nitroglycerin. There was no statistically significant change in RCP with pneumoperitoneum (33.5 ± 8.4 to 28.5 ± 8.4 ml/min/100g tissue, $p=0.2$), but it decreased to 18.5 ± 11.3 ml/min/100g tissue ($p=0.001$) with the addition of nitroglycerin. The correlation between RCP and LVEDD was weak (0.35, $p=0.003$), whereas correlation between RCP and MAP was superior ($R=0.59$, $p<0.0001$).
Conclusion: While decreasing preload under extreme lab conditions also decreases RCP, simply creating a pneumoperitoneum of 12 mmHg does not. The decrease in renal blood flow associated with pneumoperitoneum is likely not solely a function of preload.

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Key words: Renal (kidneys) — Pneumoperitoneum — Cardiac preload

The elevated intraabdominal pressure needed to create a laparoscopic workspace causes a varying degree of physiologic impairment unique to the field of minimally invasive surgery. Because this approach has become increasingly complex and currently is performed for patients with diminished cardiorespiratory reserve and renal disease, it is essential that we understand and minimize this impairment.

Multiple animal and human studies have well described the classic systemic hemodynamic effects of increased intraabdominal pressure: tachycardia, increased arterial blood pressure, peripheral vasoconstriction, and decreased stroke volume and cardiac output [19, 26]. It is thought that by virtue of the Frank–Starling mechanism, a decrease in venous return to the heart caused by inferior vena cava compression is responsible for a fall in cardiac preload and subsequent reduction in cardiac output [30]. Oliguria also is a common clinical renal manifestation of pneumoperitoneum. As shown in several animal studies, glomerular filtration rate is decreased in association with a drop in renal blood flow and renal cortical perfusion (RCP) [4], particularly when intraabdominal pressures exceed 15 mmHg.

Many factors are thought to contribute to the modulation of renal blood flow under pneumoperitoneum, including direct compression of the renal vessels and parenchyma, neurohumoral factors, and changes in systemic hemodynamics [9, 29]. According to one theory that has had an impact on clinical practice, the decrease in cardiac preload caused by pneumoperitoneum induces a relative hypovolemic state and subsequent

renal hypoperfusion, even if there is no drop in cardiac index. This view is supported by a porcine study showing that aggressive intravenous hydration reverses the impaired renal blood flow caused by a pneumoperitoneum of 15 mmHg [23]. Accordingly, vigorous intravenous hydration during laparoscopic live donor nephrectomy has been recommended by many authors because of its presumed ability to maintain preload and thereby maintain renal perfusion [11]. However, in a pilot study with humans undergoing laparoscopic donor nephrectomy, we previously found that preload, as estimated by esophageal Doppler measurement of flow time, did not in fact decrease with a carbon dioxide (CO_2) pneumoperitoneum of 12 to 15 mmHg [10].

Because of the difficulty measuring cardiac preload, the exact relationship between preload and renal blood flow during pneumoperitoneum has never been studied directly and remains unclear. There exists no gold standard for measuring cardiac preload. Pulmonary capillary wedge pressure is a reliable index only when cardiac compliance is normal and not subject to transmitted abdominal pressures to the chest, as is the case during laparoscopy [28]. In the laboratory setting, preload may be assessed with echocardiography by measurement of the left ventricular end-diastolic diameter. Findings have shown echographic cardiac chamber measurements to be reliable measures of blood loss, suggesting that this technique is a good index of preload [6].

This study aimed to elucidate, in an animal model, the relationship between renal perfusion and cardiac preload, as measured by left ventricular end-diastolic diameter during pneumoperitoneum alone and during an experimentally induced fall in preload in this same context. We hypothesized that although renal blood flow decreases with pneumoperitoneum, and further with the addition of nitroglycerin, there is not a significant relationship between it and cardiac preload.

Methods

Anesthesia and the animal model

For this study, 11 female Landrace pigs (weight, 20–30 kg) were fasted overnight with unrestricted access to free water. Throughout the experiment, the animals received normal saline at a maintenance rate of 20 ml/h via an auricular vein. The induction protocol consisted of a BAG premix (butorphanol 0.25 mg/kg, acepromazine 0.18 mg/kg, glycopyrrolate 0.009 mg/kg), followed by ketamine 14 mg/kg and variable doses of sodium pentothal 25 mg/kg to maintain adequate sedation and analgesia. During the experimental period, anesthesia was maintained with 2% to 3% isoflurane and paralysis with pancuronium 2 mg, administered every 30 min.

The animals were intubated and ventilated with a Newffield ventilator (Penlon, Abingdon, UK), set at a fraction of inspired oxygen (FiO_2) of 40%, which was increased as needed to keep the oxygen saturation above 95%. Fresh gas flow was set at 0.3 to 0.4 l/s, with an inspiration-to-expiration ratio of 1:2. These settings were modified depending on end-tidal carbon dioxide levels using a sensor attached to the endotracheal tube at the mouth (Nellcor, Tyco Healthcare, Manslield, MA, USA) in an attempt to avoid hyperearbia. To measure the acid–base status, arterial blood gas samples were drawn once before the start of the experiment and every 30 min thereafter. A rectal thermometer was inserted, and normothermia was maintained with the use of a heating lamp and warming pad.

This animal model is a modified version of that described by Chiu et al. [4] for the study of renal hemodynamics during laparoscopy. The animals were placed in the left lateral decubitus position, and a neck cut-down was performed exposing the common carotid artery and external jugular vein, with care taken not to injure the vagus nerve. An 18-gauge vascular catheter was inserted in the carotid artery and connected to a transducer to measure heart rate and mean arterial pressure (MAP). A Swan–Ganz pulmonary artery catheter (Biosensors International, Singapore) was introduced via an introducer catheter (Arrow International, Reading, PA, USA) placed in the jugular vein and positioned in the pulmonary artery under fluoroscopic guidance (Stenoscop; GE HealthCare Technologies, Waukesha, WI, USA), for cardiac output, central venous pressure (CVP), and pulmonary capillary wedge pressure (PCWP) measurements. A Veress needle was used to create a CO_2 pneumoperitoneum of 12 mmHg. Gerota's fascia of the right kidney was incised laparoscopically, and a superficial laser Doppler flow probe (Transonic, Ithaca, NY, USA) was positioned over the renal parenchyma.

Experimental protocol

The animals underwent three experimental phases of 30 min each. All 11 animals underwent the baseline phase followed by the pneumoperitoneum phase. Finally, in the preload reduction phase, preload was decreased using either a nitroglycerin infusion ($n = 8$) or controlled hemorrhage ($n = 3$).

Phase 1 (baseline): For 30 min, the animal did not have a pneumoperitoneum and did not undergo any interventions.
Phase 2 (pneumoperitoneum): A CO_2 pneumoperitoneum of 12 mmHg was generated and maintained for 30 min.
Phase 3 (preload reduction): The animals in the nitro group remained under pneumoperitoneum and received an intravenous nitroglycerin drip started at 5 mcg/min, with 5-mcg incremental increases every 5 min for 30 min. Several human studies have shown that nitroglycerin reduces preload with hemodynamic effects similar to hemorrhage or vena caval occlusion [1]. To demonstrate that infusion of nitroglycerin in this pneumoperitoneum model has effects similar to those of acute blood loss, a more clinically relevant preload reducer, three animals under the same pneumoperitoneum were bled down to a mean arterial pressure of 40 mmHg and then studied over 30 min [31].

Hemodynamic measurements were taken every 10 min throughout the three experimental phases. Using a Spacelabs (Issaquah, WA, USA) anesthesia monitor, heart rate, MAP, CVP, PCWP, and cardiac output (thermodilution technique that averages three measurements taken at end-expiration) were recorded. Systemic vascular resistance was calculated using the following formula: (MAP–CVP) × 80/cardiac output. Left ventricular end-diastolic diameter (LVEDD), recorded three times and averaged every 10 min, was measured by M-mode in the parasternal short-axis plane using transthoracic echocardiography equipment with a 3-Mhz transducer (Philips Sonos 1500, Andover, MA, USA). Finally, RCP was measured using a laser Doppler flowmeter (Transonic, Ithaca, NY, USA), which measures perfusion in the underlying 1-mm^3 volume of renal parenchyma. Findings have shown that RCP has an excellent correlation with direct flow measurements from the renal artery and is easier to place [4].

Statistical analysis

Data are expressed as means ± standard deviation. All hemodynamic measurements were recorded every 10 min and averaged over each experimental phase. They were analyzed using the paired Student's *t*-test. Univariate linear regression analysis was used to assess individual associations between RCP and the other hemodynamic parameters. A p value less than 5% was set as the criterion for statistical significance. Analysis was performed using GB-Stat 6.5.4 (Dynamic Microsystems Inc., Silver Spring, MD, USA).

We estimated the size of the sample assuming that insufflation of the abdomen to a pressure of 12 mmHg would decrease renal perfusion by 30%, from 50 ± 18 to 35 ml/min/100 g tissue, according to the

results of Chiu et al. [4] To demonstrate this difference at a 5% level of significance would require 11 pigs for 80% power.

Results

The mean weight of the animals was 25.5 ± 2 kg. Two of the animals were accidentally given one supplemental dose of thiopental at the beginning of the first experimental phase. The hemodynamic changes that occurred are summarized in Fig. 1. Heart rate, MAP, CVP, and PCWP all increased, respectively, by 5.4% ($p = 0.008$), 8.6% ($p < 0.001$), 52% ($p < 0.001$), and 14.2% ($p = 0.03$) during the pneumoperitoneum phase. During the nitroglycerin infusion, MAP, CVP, and PCWP fell, respectively, by 16.3% ($p < 0.001$), 30.0% ($p < 0.001$), and 21.8% ($p = 0.03$), whereas heart rate increased by 11% ($p < 0.001$) (Fig. 1a to 1d). There was no statistically significant change in cardiac output during the pneumoperitoneum phase ($p = 0.2$) or during the nitroglycerin infusion ($p = 0.2$) (Fig. 1e). Systemic vascular resistance (SVR) did not increase significantly with pneumoperitoneum, but decreased from 1,132 ± 312 to 961 ± 310 dynes · sec/cm^5 with the addition of the nitroglycerin infusion ($p < 0.0001$). During pneumoperitoneum, LVEDD decreased by 2.4% ($p = 0.02$), and during the nitroglycerin infusion, it decreased by 5.6% ($p = 0.04$) (Fig. 1f). Finally, there was no significant change in RCP from baseline to the pneumoperitoneum phase ($p = 0.2$), but it decreased by 33.8% ($p < 0.001$) with the nitroglycerin infusion (Fig. 1g). In the preload reduction phase, only the trends in heart rate, cardiac output, and SVR differed between the nitroglycerin and the hemorrhage groups. The animals in the latter group showed a significant decrease in heart rate ($p = 0.01$) and cardiac output ($p = 0.003$), but SVR was unchanged.

There was a poor correlation between RCP and LVEDD ($R = 0.35$; $p = 0.003$), as shown on the scatterplot in Fig. 2. The correlation between RCP and cardiac output also was poor ($R = 0.37$; $p = 0.001$). Renal cortical perfusion correlated better with PCWP ($R = 0.48$; $p < 0.0001$) and best with MAP ($R = 0.62$; $p < 0.0001$). Finally, the correlation between RCP and CVP was not significant. When the animals were stratified into those with a baseline LVEDD equal to or lower than the median baseline LVEDD of 4.1 cm ($n = 4$) and those with a baseline greater than 4.1 cm ($n = 4$), the former group showed a significant drop in RCP, whereas the latter group did not (Fig. 3).

The partial pressure of CO_2 ($PaCO_2$) was 59 ± 12 and the arterial pH was 7.33 ± 0.08 at the start of the baseline period and had remained constant, respectively, at 57 ± 15 ($p = 0.4$) and 7.35 ± 0.08 ($p = 0.1$) by the end of the period. After 30 min of pneumoperitoneum, the $PaCO_2$ had increased to 67 ± 11 ($p = 0.01$), and the pH had decreased to 7.28 ± 0.09 ($p = 0.01$). Both remained constant by the end of the preload reduction phase, with the $PaCO_2$ at 68 ± 10 ($p = 0.8$) and the arterial pH at 7.29 ± 0.09 ($p = 0.6$).

Discussion

To our knowledge, this is the first study to directly assess the physiologic effects of pneumoperitoneum on both cardiac preload and renal perfusion. As expected, MAP, CVP and PCWP all increased with a CO_2 pneumoperitoneum of 12 mmHg. Despite a very slight decrease in LVEDD, used as an index of preload, there was no significant change in cardiac output or RCP overall during pneumoperitoneum. When stratified according to baseline preload, however, those animals with underfilling at baseline demonstrated decreased RCP under pneumoperitoneum. When preload was then further reduced, using nitroglycerin administration or hemorrhage, LVEDD dropped further and renal perfusion decreased significantly. After acute hemorrhage, the direction of change in all the parameters except cardiac output followed that of the animals that had received nitroglycerin. Although nitroglycerin is primarily a preload reducer, the expected drop in cardiac output may have been offset by nitroglycerin's afterload-reducing properties, as evidenced by the decrease in SVR during the infusion. This had been noted previously in animals with elevated baseline arterial elastance or abnormal baseline ventricular function [13]. In this study, SVR decreased significantly during the nitroglycerin infusion. Systemic vascular resistance, known to increase under pneumoperitoneum, is thought to contribute to the decrease in cardiac output that may be seen with high-pressure pneumoperitoneum [29].

The impact of pneumoperitoneum on preload and its relationship with cardiac output is complex and not yet fully elucidated. The classical response to pneumoperitoneum is believed to be a decrease in venous return secondary to inferior vena cava compression. This is based on clinical studies demonstrating a drop in cardiac output and a hemodynamic response to pneumoperitoneum similar to that of hypovolemic shock [26]. However, several other studies have demonstrated no change in cardiac output [21], and have even shown increases in cardiac output after pneumoperitoneum [16].

The study examining the impact that pneumoperitoneum has on preload is complicated by the fact that the usual clinical measures of ventricular filling, such as PCWP and CVP, are unreliable during pneumoperitoneum. As the elevated abdominal pressures are transmitted to the chest, pressure measurements taken in the chest rise regardless of true volume status [7, 28]. Transthoracic echocardiography has been used experimentally to evaluate preload by measurement of left ventricular end-diastolic diameter, area, or volume. The only limitation to echocardiographic preload assessment during pneumoperitoneum is the change in cardiac geometry that may occur with upward displacement of the diaphragm [24]. Larsen et al. [21] found LVEDD to be increased with the onset of a 12-mmHg pneumoperitoneum in adults undergoing laparoscopic cholecystectomy. In the same patient population, Gannedahl et al. [12] also found left ventricular end-diastolic area to be increased. In healthy women undergoing exploratory laparoscopic surgery of the lower abdomen, left ven-

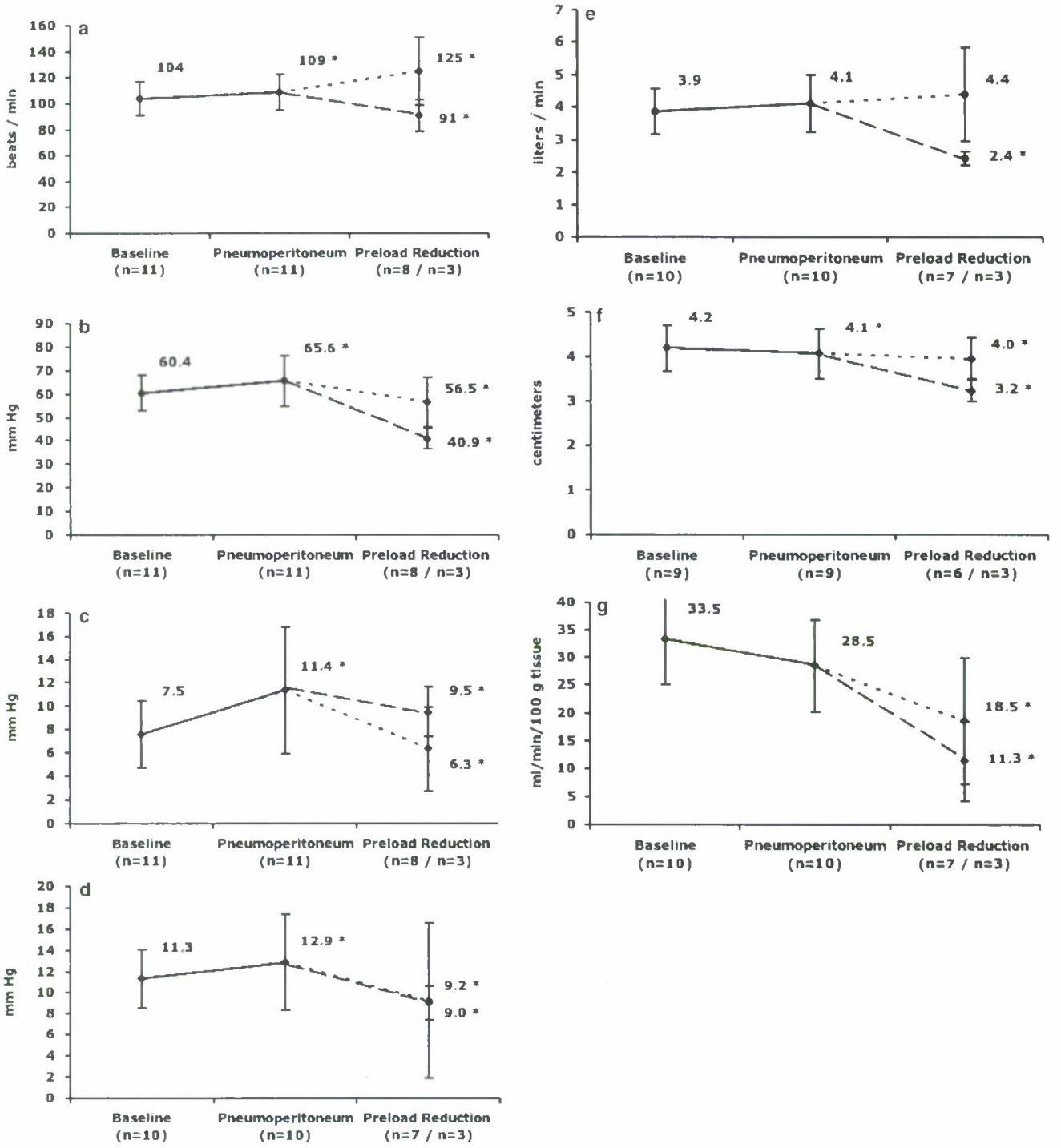

Fig. 1. Cardiac and renal hemodynamics at baseline, with pneumoperitoneum and with preload reduction. Cardiac and renal hemodynamics at baseline, with pneumoperitononeum and with preload (a: heart rate, b: mean arterial pressure, c: central venous pressure, d: pulmonary capillary wedge pressure, e: cardiac output, f: left ventricular end-diameter, g: renal perfusion. Solid line: all animals, dotted line: nitroglycerin group, dashed line: hemorrhage group. Preload reduction (nitro group / hemorrhage group). *$p < 0.05$ as compared with previous value.

tricular end-diastolic area was increased at a pneumoperitoneum of 10 mmHg, and further increased when the intraabdominal pressure was raised to 15 mmHg [34].

In contrast, Cunningham et al. [5] and Dorsay et al. [8] reported no change in left ventricular end-diastolic area during pneumoperitoneum in healthy patients [5, 8], and one study found no change in atrial natiuretic peptide released in response to increased atrial pressure in healthy patients undergoing laparoscopic surgery [18]. The only study to demonstrate a reduction in left ventricular end-diastolic dimensions also was the only study to include patients with an American Society of Anesthesia (ASA) index above 2 [36].

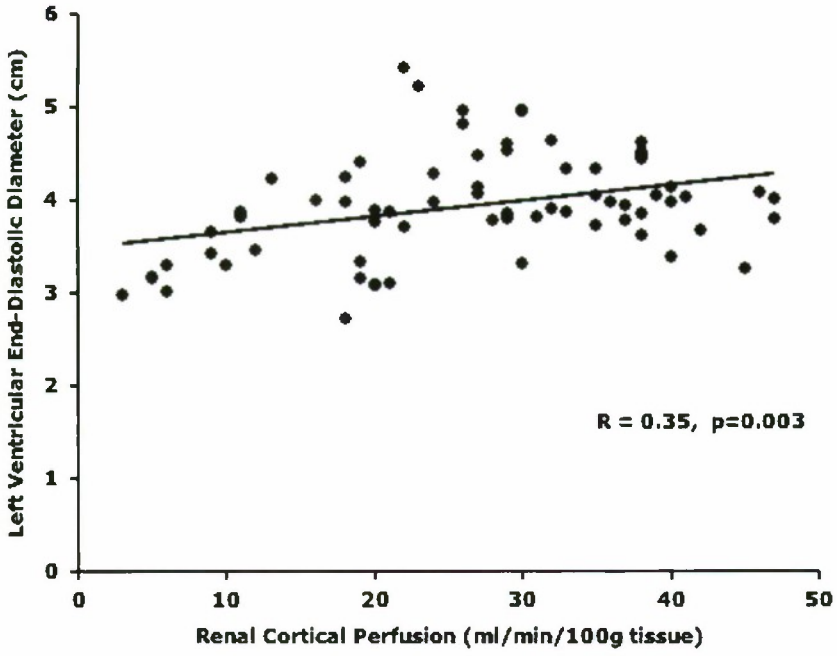

Fig. 2. Correlation between renal cortical perfusion and left ventricular end-diastolic diameter.

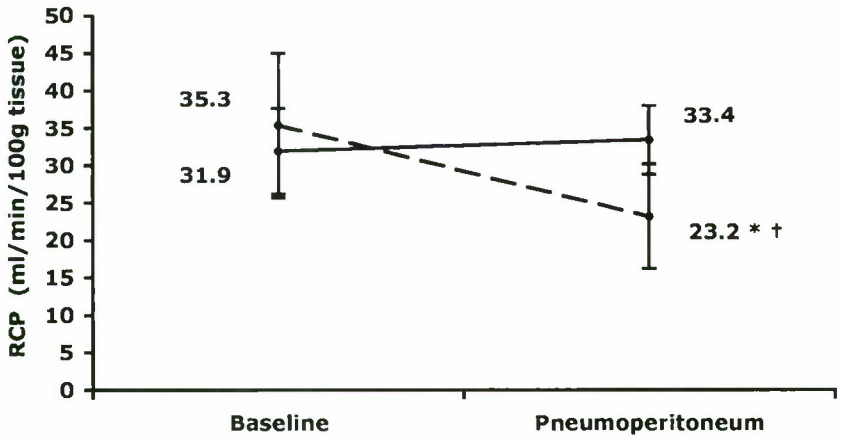

Fig. 3. Renal cortical perfusion at baseline and under pneumoperitoneum, stratified according to left ventricular end-diastolic diameter. Left ventricular end-diastolic diameter (LVEDD) ≤ 4.1 cm (dashed line), LVEDD >4.1 cm (solid line); $n = 4$ for both groups. $*p < 0.05$ within group; $\dagger p < 0.05$ between groups.

The findings in these studies seem to suggest that in healthy individuals, preload is in fact increased with induction of pneumoperitoneum, perhaps because of splanchnic blood flow redistribution to the chest. In the current animal study, LVEDD decreased only slightly with the onset of pneumoperitoneum, to a degree of questionable clinical significance, and cardiac output did not decline.

Under a CO_2 pneumoperitoneum of 12 mmHg, we found no significant decline in RCP, which is consistent with what has been reported by others for that pneumoperitoneum level [20, 22]. A pneumoperitoneum of at least 15 mmHg was necessary in most studies to demonstrate a decrease in renal blood flow [4, 23]. On the other hand, during the nitroglycerin infusion, RCP diminished by one-third of its previous value, but LVEDD decreased by only about 6%. Hence, the overall correlation between LVEDD and RCP was poor. The correlation of RCP with PCWP and CVP also was poor, which was expected given the limitations of these measures during pneumoperitoneum.

On the other hand, MAP and cardiac output seemed to be moderately well associated with the changes in renal perfusion. This is in keeping with the findings of Chiu et al. [2], who showed that inferior vena cava compression in a dog model led to a significant decrease in cardiac output, but only a mild decrease in renal blood flow. Left ventricle compression caused the same decrement in cardiac output and renal blood flow. Hence, if a drop in preload is postulated to play a significant role in the decrease in renal perfusion under pneumoperitoneum, it would be mainly through its ability to decrease cardiac output. A decrease in cardiac output, however, is clearly not the principal factor involved in renal blood flow modulation. In fact, findings have shown that normalizing cardiac output with plasma expanders at a pneumoperitoneum of 20 mmHg failed to improve renal blood flow and glomerular filtration rate [15]. In addition, several studies have demonstrated decreases in renal perfusion and function without a change in cardiac output [3, 23].

Despite the poor correlation between RCP and LVEDD, the animals with higher baseline preloads did

not drop their renal perfusion, as compared with those that had lower baseline preload values. London et al. [23] showed that intravaseular volume expansion in a pig model reversed the drop in renal blood flow that occurred with a 15-mmHg CO_2 pneumoperitoneum, although creatinine elearanee was not improved. The solution may be goal-direeted fluid optimization during pneumoperitoneum, taking baseline fluid status into account, as long as clinically relevant, reliable, and easy-to-measure parameters are sought [35].

Another factor for explaining the changes in renal hemodynamics and function seen under pneumoperitoneum is parenchymal compression, as demonstrated by Razvi et al. [32]. These authors inflated a 15-mmHg pressure euff around one kidney and showed a decrease in renal blood flow, glomerular filtration rate, and urine output similar to that seen with pneumoperitoneum. Renal vein compression by increased intraabdominal pressure also may eontribute to renal ischemia by elevating baek pressure into the renal glomeruli [25]. Finally, neurohormonal effeets are being studied as potential factors contributing to decreased renal blood flow during pneumoperitoneum [14, 17, 27].

Some limitations to this study must be addressed. First, respiratory gas exehange was signifieantly affeeted during this study. Although oxygen saturation was easily maintained above 95% in all the animals, ventilation was more problematie. The animals were hypercarbic and acidotic at baseline, most likely because of suboptimal anesthetie management. Despite inereasing minute ventilation during the pneumoperitoneum and nitro/bleed phases, the animals reached a mean pH of 7.28 and a $PaCO_2$ of 68 mmHg. Hypercarbia is known to stimulate the sympathetie nervous system, but acidosis also may depress cardiac function. This may be a confounding factor in the interpretation of the physiologic ehanges that oecurred from baseline to the pneumoperitoneum phase, although signifieant ehanges in eardiae output and RCP were not seen with pneumoperitoneum alone. In addition, when argon and helium are used for insufflation, although hypercarbia and acidosis are minimized, the systemie hemodynamie effeets are unchanged. These data suggest that it is the elevated intraabdominal pressure rather than the aeid–base imbalance that eontributes most to the physiologic ehanges [20].

Finally, the most important limitation of this study lies in the ehoiee of the model. Although pigs are currently the best and most commonly used species for simulating human physiology, there are nevertheless significant interspeeies differenees. Pigs seem to have a higher basal adrenergic drive, and their hemodynamics are highly sensitive to fluid status, analgesia, and acid–base status [33]. Furthermore, eonsidering that baseline health status is difficult if not impossible to ascertain and control for, pigs, depending on how they are bred, fed, and raised, will be more susceptible to eongenital cardiac abnormalities and to illness. This may explain the degree of baseline physiologic variability noted in this study. As an example, although the pigs all were treated the same in terms of access to fluids in the preoperative period, baseline CVP varied 4 to 15 mmHg, and PCWP varied 8 to 16 mmHg. This has led some authors to state that ehanges observed in pig models eannot reliably prediet ehanges oeeurring in humans. Therefore, these data, as in all animal studies, should be interpreted with eaution and simply eonsidered a means for hypothesis generation.

In conelusion, we found that whereas decreasing preload under extreme laboratory eonditions also deereased renal perfusion, simply ereating a pneumoperitoneum to 12 mmHg did not. Beeause a pneumoperitoneum of 12 mmHg deereased renal blood flow only in animals with a low baseline preload, vigorous intravenous hydration, as recommended during laparoscopie donor nephreetomy, may benefit only patients who are volume depleted at baseline.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Do all patients with abnormal intraoperative cholangiogram merit endoscopic retrograde cholangiopancreatography?

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Abstract
Background: Endoscopic retrograde cholangiopancreatography (ERCP) is commonly used for postoperative evaluation of an abnormal intraoperative cholangiogram (IOC). Although a normal IOC is very suggestive of a disease-free common bile duct (CBD), abnormal studies are associated with high false-positive rates. This study aimed to identify a subset of patients with abnormal IOC who would benefit from a postoperative ERCP.
Methods: This prospective study investigated 51 patients with abnormal IOC at laparoscopic cholecystectomy who underwent postoperative ERCP at two tertiary referral centers over a 3-year period. Univariate and multivariate logistic regression analyses were performed to determine predictors of CBD stones at postoperative ERCP.
Results: For all 51 patients, ERCP was successful. The ERCP showed CBD stones in 33 cases (64.7%), and normal results in 18 cases (35.2%). On univariate analysis, abnormal liver function tests ($p < 0.0001$) as well as IOC findings of a large CBD stone ($p = 0.03$), multiple stones ($p = 0.01$), and a dilated CBD ($p = 0.07$) predicted the presence of retained stones at postoperative ERCP. However, on multivariable analysis, only abnormal liver function tests correlated with the presence of CBD stones ($p < 0.0001$).
Conclusions: One-third of patients with an abnormal IOC have a normal postoperative ERCP. Elevated liver function tests can help to identify patients who merit further evaluation by ERCP. The use of less invasive methods such as endoscopic ultrasound or magnetic resonance cholangiopancreatography should be considered for patients with normal liver function tests to minimize unnecessary ERCPs.

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Key words: Abnormal intraoperative cholangiogram — CBD — Common bile duct — Endoscopic retrograde cholangiopancreatography — ERCP — IOC — Predictors

Laparoscopic cholecystectomy has replaced open cholecystectomy as the procedure of choice for the vast majority of individuals with symptomatic cholelithiasis. The advantages of the laparoscopic technique include reduced pain, early discharge from the hospital, rapid return to normal activity, and improved cosmetic appearance [26]. The increasing popularity of this minimally invasive procedure has resulted in an increased demand for endoscopic retrograde cholangiopancreatography (ERCP) for CBD stone extraction [21].

Predominantly secondary in origin, most CBD stones are thought to have migrated through the cystic duct from their primary site of origin in the gallbladder. The incidence of CBD stones detected at the time of cholecystectomy ranges from 8% to 15% [1, 4, 8, 14, 15]. Intraoperative cholangiography (IOC) is performed during laparoscopic cholecystectomy to evaluate the CBD for stones using contrast injection through a catheter introduced into the cystic duct. Retained CBD stones then are extracted by postoperative ERCP or laparoscopic CBD exploration.

Laparoscopic CBD exploration is not widely available because the procedure requires special equipment, advanced training, and significant expertise on the part of the surgeon [33]. On the other hand, because ERCP is readily available at most hospitals, it is the method most commonly used to evaluate abnormal IOC findings. The disadvantages of this approach are twofold. First, IOC is associated with a false-positive rate ranging from 2% to 60% [16, 20, 22, 33]. Second, ERCP is an invasive

procedure associated with a complication rate of 2.5% to 11% [10, 25].

The purpose of this study was to identify a subset of patients with abnormal IOC who are most likely to benefit from a postoperative ERCP: This includes those patients more likely to have residual stones in the CBD.

Materials and methods

This prospective study investigated all patients referred for postoperative ERCP after laparoscopic cholecystectomy for evaluation of abnormal fluorocholangiography findings at two tertiary referral centers over a 3-year period (2001–2004). The patients were referred for ERCP by gastrointestinal surgeons from within the hospital or from outside facilities.

Before ERCP, patient demographic information and indications for laparoscopic cholecystectomy were documented. A white cell count and a liver function panel were drawn on all patients 1 to 2 h before ERCP. Any deviation above the normal reference range was considered abnormal for both liver function tests (LFTs) and white cell count. The interval between laparoscopic cholecystectomy and presentation for ERCP was documented.

The IOC findings were reviewed before ERCP, and the indications were divided into the following seven categories: (a) nonpassage of contrast into the duodenum, (b) isolated CBD filling defect suggestive of small stones (≤ 4 mm), (c) isolated CBD filling defect suggestive of large stones (≥5mm), (d) multiple CBD filling defects suggestive of stones, (e) CBD dilation (≥ 8mm), (f) nonvisualization of distal CBD, and (g) palpable CBD stones at surgery. A cutoff value of 5 mm was chosen to distinguish between small and large CBD stones [1, 11, 39], and a CBD diameter of 8 mm or more was chosen as the definition for biliary dilation [31], on the basis of published data.

The endoscopist evaluated the radiographs to determine the size of the CBD stones, the diameter of the CBD, and other IOC findings. A radiologist was consulted when necessary to confirm the interpretation and to correct any fluoroscopic magnification. Patients who presented for ERCP without IOC radiographs and those who had undergone prior endoscopic biliary interventions were excluded from the study. Also, patients with an abnormal IOC but with a diagnosis of other diseases such as pancreatic cancer or cholangiocarcinoma by computed tomography (CT) scan or endoscopic ultrasound (EUS) were excluded from the study.

The ERCPs were performed in the hospital endoscopy suites of the two centers with the patient under conscious sedation induced by combinations of midazolam, meperidine, and droperidol administered by the endoscopist. All the procedures were performed by four attending endoscopists or by gastroenterology fellows under the supervision of attending physicians. The ERCP was performed with a standard "therapeutic" duodenoscope (Olympus TJF-100/130/140/160, Olympus America Corporation, Inc., Melville, NY) with an outer diameter of 12.5 mm and an accessory channel diameter of 4.2 mm. Successful ERCP was defined as cannulation of the bile duct along with satisfactory performance of a planned diagnostic study or therapeutic intervention. All CBD stones seen at ERCP were extracted using a retrieval balloon or basket after performance of a biliary sphincterotomy. An occlusion cholangiogram then was performed to ensure clearance of the bile duct. Absence of CBD stones at ERCP was attributed to spontaneous stone passage or a false-positive IOC. The fluoroscopic findings, therapeutic interventions, and complications, if any, were recorded for each patient.

Patient follow-up assessment was through discussions of the patients at fortnightly pancreaticobiliary meetings with nurse coordinators, who called patients after ERCP, or through reference to outpatient clinic visits. Patients were called 6 months after ERCP for clinical follow-up information.

Statistical analysis

Continuous variables were reported as medians and ranges because data were not normally distributed. Continuous variables were compared using the Wilcoxon rank sum test. Categorical variables were compared using the chi-square test. To determine predictors of CBD stones at postoperative ERCP, univariate and multivariable logistic regression analyses were performed. Both stepwise and best model selections were used, providing similar results. Adjusted odds ratios and their corresponding 95% confidence intervals (CI) were reported. All statistical analyses were performed using the SAS (Cary, NC, USA) software version 6.12. A two-sided type 1 error of 0.05 was used for all statistical tests.

All participating patients provided informed consent. The study was approved by the institutional review board of both centers.

Table 1. Indications for endoscopic retrograde cholangiopancreatography (ERCP) based on intraoperative cholangiogram (IOC) findings

IOC finding[a]	*n*
Nonpassage of contrast into the duodenum	17
Small stones	17
Large stones	12
Multiple stones	9
Dilated CBD	11
Nonvisualization of distal CBD	3
Palpable CBD stones	1

CBD, common bile duct
[a] Individual patients may have more than one IOC finding

Results

The indications for laparoscopic cholecystectomy in the 51 patients (33 women) (mean age, 51.9 years; range, 21–85 years) were symptomatic cholelithiasis in 26 (51%), gallstone pancreatitis in 12 (24%), cholecystitis in 10 (20%), and biliary dyskinesia in 3 (5%) patients. Preprocedural LFTs were abnormal in 32 patients (62.7%), and the white blood cell count level was high in 18 patients (35%). The IOC findings that prompted an ERCP are shown in Table 1. Because IOC was performed at multiple centers, procedural technique for IOC was not standardized. For one patient, the laparoscopic approach was converted to open cholecystectomy: This patient had a large palpable CBD stone, but a bile duct exploration was not undertaken, and he was referred for postoperative ERCP. The median time to ERCP after surgery was 2 days (range, 1–7 days).

For all 51 patients (100%), ERCP was successful. The ERCP showed CBD stones in 33 of the 51 patients (64.7%), and no stones in the remaining patients (Table 2). Whereas CBD stones were seen in 29 of 33 patients (87.8%) with abnormal LFTs, only 3 of 18 patients (16.6%) with normal LFTs had CBD stones ($p < 0.0001$). Sphincterotomy was performed using a pull-type papillotome in 30 patients and a needle-knife in 3 patients. Temporary pancreatic stents to facilitate biliary access were placed in two of three patients who underwent needle-knife sphincterotomy. Stones were extracted using a balloon for 26 patients and a combination of balloon and retrieval basket for 7 patients. All stones were retrieved in a single ERCP session for all patients. No immediate or late complications were encountered in any patient.

On univariate analysis, abnormal liver LFTs ($p < 0.0001$) as well as IOC findings of large stones

Table 2. Comparison of demographics, laparoscopic cholecystectomy indications, laboratory investigations, and intraoperative cholangiogram (IOC) findings in patients with and without common bile duct (CBD) stones at endoscopic retrograde cholangiopancreatography (ERCP) (results of univariate analysis)

Variables	Stones at ERCP (n = 33)	No stones at ERCP (n = 18)	p Value
Demographics			
Age: years (IQR)	54 (44–71)	41 (31–60)	0.21
Female: n (%)	21 (63.6)	12 (66.7)	0.83
Indications for surgery			
Cholelithiasis	20	6	0.42
Cholecystitis	5	5	1.00
Pancreatitis	7	5	0.61
Biliary dyskinesia	1	2	0.59
Median time to ERCP (days) n (range)	2 (1–5)	2 (1–7)	0.29
Laboratory parameters			
Abnormal LFTs: n (%)	29 (87.87)	3 (16.6)	<0.0001
AST median (IQR)	74 (43–173)	23 (19–31)	0.001
ALT median (IQR)	90 (55–249)	26 (18–43)	0.0006
ALP median (IQR)	162 (121–214)	88 (71–101)	0.0002
TB median (IQR)	1.9 (1.1–3)	1 (0.8–1.1)	0.001
DB median (IQR)	1.2 (0.7–2)	0.5 (0.2–0.8)	0.001
White cell count: n (range)	8.2 (7–10.4)	7 (6.1–10.1)	0.32
IOC findings: n (%)[a]			
1. Nonpassage of contrast to duodenum	9 (27.27)	8 (44.44)	0.17
2. Small stones	8 (24.24)	8 (44.44)	0.1
3. Large stones	11 (33.33)	1 (5.55)	0.03
4. Multiple stones	9 (27.27)	0	0.01
5. Dilated CBD	9 (27.27)	1 (5.55)	0.07
6. Poor visualization of distal CBD	4 (12.1)	1 (5.55)	0.2
7. Palpable CBD stones at surgery	1 (3.03)	0	0.47

LFT, liver function test; IQR, interquartile range; AST, aspartate transaminase; ALT, alanine transaminase; ALP, alkaline phosphatase; TB, total bilirubin; DB, direct bilirubin

[a] Individual patients may have more than one IOC finding

(p = 0.03), multiple stones (p = 0.01), and dilated CBD (p = 0.07) predicted residual stones at postoperative ERCP (Table 2). However, on multivariable analysis, only abnormal LFTs predicted retained CBD stones (odds ratio [OR], 19.7; CI, 2.8–134.9; p < 0.0001). Elevation of both transaminases and cholestatic enzymes predicted CBD stones. Patients with abnormal LFTs were 20 times more likely to have stones at ERCP than those with normal LFTs. At the 6-month follow-up assessment, all the patients were doing well without any evidence of recurrent biliary obstruction.

Discussion

The optimal evaluation of abnormal IOC findings in this era of laparoscopic cholecystectomy still remains undefined. In this study, one-third of the patients with an abnormal IOC had a normal postoperative ERCP. This is consistent with prior reports describing a low rate of stone recovery at ERCP in the postoperative setting [1, 13, 33].

None of the IOC findings in this study accurately predicted the presence or absence of CBD stones. The reason for the poor predictability of IOC is unclear. It is likely that some CBD stones pass spontaneously and that other IOC findings are false-positive, such as air bubbles mimicking stones or failure of contrast to drain into the duodenum, which possibly is related to papillary stenosis rather than an impacted stone.

In this study, ERCP was undertaken for a majority of the patients (>80%) within 48 h of cholecystectomy. The rate for spontaneous migration of stones through the duodenal papilla is unknown. In this study, only 1 of 12 patients with large stones at IOC had a normal ERCP, as compared with 8 of 16 patients who had small stones. This is in agreement with a prior study from France that reported a negative predictive value of 95% for spontaneous migration of large stones at a 1 month follow-up assessment [11]. On the other hand, 28% of small stones had spontaneous migration.

Clinicians encounter three temporal situations in the management of CBD stones: (a) patients for whom the stones are suspected preoperatively, (b) patients for whom the stones are found intraoperatively, and (c) patients whose stones present postoperatively. The role of ERCP in managing postoperative stones is well established [23, 24, 35]. On the contrary, optimal management of suspected preoperative and intraoperative stones remains a challenge.

In the preoperative setting, inability to predict accurately which patients have CBD stones is problematic because when stones are suspected on the basis of clinical, biochemical, and imaging tests, normal preoperative ERCP results still are obtained for 40% to 70% of patients [2, 3, 5, 17, 28, 40]. The optimal technique for biliary ductal clearance should be based on the local availability of expert endoscopists, surgical expertise in laparoscopic CBD surgery, and the general condition of the patient [9, 32, 41].

In the intraoperative setting, if stones are suspected, laparoscopic extraction can be attempted on the basis of equipment and expertise availability. Although findings have shown intraoperative ERCP to be feasible and successful in this setting, it has not been widely used [24]. The other option is the use of postoperative ERCP to evaluate abnormal IOC findings [9, 27, 34, 41]. This concept has gained wide acceptance and has been endorsed by the current National Institutes of Health State-of-the-Science Conference on ERCP [7].

Unfortunately, a significant number of patients undergoing postoperative ERCP in this study still did not have CBD stones. On multivariable analyses, abnormal LFT was the only variable that accurately predicted the presence of CBD stones. The utility of LFTs to predict CBD stones has been demonstrated previously in many studies, particularly for patients undergoing preoperative ERCP [6, 18, 29]. Although we checked LFTs in all patients before ERCP, we did not document details on preoperative LFTs. This precluded any correlation between the presence of CBD stones and fluctuation in enzyme levels.

Given that nearly one-third of patients with abnormal IOC do not have stones and the relative invasiveness and risks associated with ERCP, not all patients with an abnormal IOC should be subjected to routine postoperative ERCP. In a report from Seattle, acute biliary pancreatitis developed during the follow-up period in only 1.7% of patients who underwent laparoscopic cholecystectomy for symptomatic cholelithiasis [37].

Subsequent studies have shown that "on-demand" ERCP would be a better option than routine ERCP for evaluation of IOC abnormalities because most small stones migrate spontaneously [1, 14, 19, 33]. In the absence of elevated LFTs, less invasive tests such as EUS or magnetic resonance cholangiopancreatography (MRCP) should be used for evaluating these patients. The accuracy of both tests, particularly EUS, to evaluate for CBD stones is greater than 95% [12, 30, 36, 38]. Those with definitive CBD stones can then be subjected to ERCP. This selective approach would substantially decrease ERCP-related morbidity and would be more cost effective [1]. The risk–benefits of a postoperative ERCP and alternative methods of evaluation should be discussed thoroughly with the patient.

A major limitation of our study is the small number of patients enrolled and the short follow-up period. With the advent of EUS, the number of postoperative ERCPs for evaluation of abnormal IOC findings has decreased substantially at both of our institutions. For instance, since the conclusion of this study, 5 of 10 patients referred to our centers for evaluation of an abnormal IOC received a diagnosis of a stone-free duct by EUS. As the application of EUS for evaluation of pancreaticobiliary disorders continues to expand, the role of diagnostic ERCP is expected to diminish further. Also, operating characteristics could not be calculated because we evaluated only the patients with an abnormal IOC. However, performing ERCP for patients with a normal IOC is both impractical and unethical. It also is well known that small stones can be missed at ERCP. However, doing a routine biliary sphincterotomy for all patients undergoing ERCP is potentially dangerous. At the 6-month follow-up assessment, none of our patients had any symptom recurrence, suggesting a low likelihood of a missed stone.

This study was conducted at two tertiary referral centers for ERCP. The number of patients with an abnormal IOC evaluated by methods other than ERCP, such as MRCP or EUS, is unknown.

The ability of abnormal intraoperative cholangiogram findings to predict retained CBD stones is unclear. In this prospective study, one-third of the patients with abnormal IOC had normal postoperative ERCP results. Only abnormal LFTs accurately predicted the presence of CBD stones. The use of less invasive methods such as EUS or MRCP should be considered for patients with normal postoperative LFTs to minimize unnecessary ERCPs.

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SURGICAL ENDOSCOPY
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Urgent laparoscopic cholecystectomy in the management of acute cholecystitis: timing does not influence conversion rate

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Abstract
Background: The optimal treatment of acute cholecystitis is urgent laparoscopic cholecystectomy. Most reports suggest that a delay of 72 or 96 h from onset of symptoms leads to a higher conversion rate. This study assessed the conversion rate in relation to the timing of urgent laparoscopic cholecystectomy for acute cholecystitis.
Methods: During a 12 month period, 112 patients received laparoscopic cholecystectomy for acute cholecystitis at a tertiary care university hospital in central Taiwan. Data were collected prospectively.
Results: The overall conversion rate was 3.6% (4/112). Of 62 procedures performed within 72 h from onset of symptoms, 2 were converted, as compared with 2 of 50 procedures after 72 h. Of 76 procedures performed within 96 h from onset of symptoms, 3 were converted, as compared with 1 of 36 procedures after 96 h. There were no mortalities or common bile duct injuries.
Conclusions: The conversion rate for urgent laparoscopic cholecystectomy among patients with acute cholecystitis can be as low as 3.6%. The timing of urgent laparoscopic cholecystectomy has no impact on the conversion rate.

Key words: Acute cholecystitis — Laparoscopic cholecystectomy

The introduction of laparoscopic cholecystectomy (LC) in 1988 was followed by a dramatic shift from open cholecystectomy (OC) to the laparoscopic approach. The benefits of laparoscopic surgery include reduced postoperative morbidity and postoperative pain, shortened hospitalization, quicker return to a normal lifestyle, and lower overall health care expenses [1, 7]. With improvement in instruments and technique, acute cholecystitis is no longer considered a contraindication for the laparoscopic approach [10, 17, 19].

It has been suggested that laparoscopic cholecystectomy should be performed within 72 to 96 h, after which there is an increased risk of complications and conversion to an open procedure [6, 9, 13, 18]. Conversion from LC to OC leads to abandonment of all the benefits associated with this minimally invasive operation and markedly increases the hospital length of stay and hospital expenses. Therefore, failure to perform urgent cholecystectomy within 72 to 96 h after onset of symptoms might be an indication for interval cholecystectomy [13]. Unfortunately, the conversion rate tends to be higher with interval surgery because dense fibrotic adhesion is more prevalent among patients who have interval surgery [15].

The aim of treatment for all patients with acute cholecystitis in our hospital is to perform definitive surgery at the initial emergency admission. With the accumulation of surgical experience and progressive improvement in surgical technique, this study reevaluated the feasibility of LC for patients with acute cholecystitis lasting longer than 72 h. The study assessed the conversion rate in relation to the timing of urgent laparoscopic cholecystectomy for acute cholecystitis.

Materials and methods

All patients with a diagnosis of acute cholecystitis who underwent cholecystectomy at our hospital in 2004 were enrolled in this study. The exclusion criteria specified septic shock; planned common bile duct exploration attributable to failure of preoperative endoscopic retrograde cholangiopancreaticography (ERCP), with stone extraction for choledocholithiasis; and previous complex upper abdominal surgery. All patients were admitted on an emergency basis with a diagnosis of acute cholecystitis, defined as acute upper abdominal pain with tenderness under the right costal margin; fever exceeding 37.5°C, leukocytosis exceeding 10.39×10^9/l (normal, $< 10.39 \times 10^9$/l), or both; and ultrasonographic findings including thickened gallbladder wall, edematous gallbladder wall, distended gallbladder, presence of gallstones, and ultrasonographic Murphy's sign.

Data were collected prospectively. A standardized data form was used to record information, including demographic details, time

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Table 1. Relationship between duration of preoperative symptoms of acute cholecystitis and the frequency of conversion, operative time, and length of hospital stay in patients received laparoscopic cholecystectomy (Using 72 hours as cut point)

	Within 72 h	After 72 h	*p*
Case number	62	50	
Number of conversion	2	2	
Conversion rate	3.2%	4%	0.835
Median operative time (Minute)	100 (50–225)	90 (60–210)	0.933
Median hospital stay (Day)	5 (2–14)	6 (2–18)	0.916

Table 2. Relationship between duration of preoperative symptoms of acute cholecystitis and the frequency of conversion, operative time, and length of hospital stay in patients received laparoscopic cholecystectomy (Using 96 hour as cut point)

	Within 96 h	After 96 h	*p*
Case number	76	36	
Number of conversion	3	1	
Conversion rate	3.9%	2.8%	0.776
Median operative time (Minute)	100 (50–225)	90 (60–180)	0.745
Median hospital stay (Day)	5 (2–15)	6 (2–18)	0.022

elapsed before surgery, intraoperative findings, complications, and postoperative length of hospital stay. The objective was to perform LC for all patients at their initial admission. All the patients received urgent LC within hours after admission or after preoperative ERCP was completed. Preoperative ERCP was performed in response to the following indications: ultrasonographic evidence of a dilated common duct, presence of common duct stones, or serum elevation in bilirubin. Preoperative sphincterotomy and stone extraction were performed if common duct stone was present. During surgery, gallbladder puncture was routinely used to relieve tension of the gallbladder and facilitate the subsequent manipulation. The gallbladder was removed under the protection of an endobag.

All variables were compared by the unpaired *t*-test or chi-square test. A probability level less than 0.05 was considered statistically significant.

Results

A total of 125 patients with a diagnosis of acute cholecystitis underwent urgent cholecystectomy. Among the 125 patients, urgent laparoscopic cholecystectomy was performed initially for 112 patients (89.6%). The remaining 13 patients received open cholecystectomy because of earlier upper abdominal surgery ($n = 3$), planned common bile duct exploration ($n = 3$), and sepsis with unstable hemodynamic status ($n = 7$).

Of the 112 patients who received urgent laparoscopic cholecystectomy, 58 (52%) were women. The median age was 55 years (range, 20–87 years). Of the 112 cases, 16 (14.3%) were complicated cholecystitis involving gangrene, empyema, and perforated gallbladder. A total of 19 patients received a preoperative ERCP, and common duct stones were found and extracted after an endoscopic sphincterotomy from 14 patients (12.5%).

The overall conversion rate was 3.6% (4 of 112). The reasons for conversion to open cholecystectomy included unidentified gallbladder because of severe adhesion ($n = 1$), hemorrhage ($n = 2$), and Calot's triangle not visualized ($n = 2$). Tables 1 and 2 show the effect that the timing of urgent LC had on the conversion rate, operative time, and length of hospital stay. There was no statistically significant difference between the conversion rates for surgery performed within and after 72 h from onset of symptoms (2 of 62 vs 2 of 50 procedures; $p = 0.835$). Similarly, there was no difference in the conversion rates for surgery performed within and after 96 h from onset of symptoms (3 of 76 vs 1 of 36 procedures; $p = 0.776$). The median time to surgery for all patients was 3 days (range, 1–14 days).

The median operative time was 100 min (range, 50–225 min) for all procedures, 100 min (range, 50–225 min) for surgery within 72 h, 95 min (range, 60–210 min) for surgery after 72 h, 100 min (range, 50–225 min) for surgery within 96 h, and 90 min (range, 60–180 min) for surgery after 96 h. There were no differences in operating times between surgery within or after 72 h and that within or after 96 h from onset of symptoms. The median length of hospital stay was 5 days (range, 2–18 days) for all procedures, 5 days (range, 2–14 days) for surgery within 72 h, 6 days (range, 2–18 days) for surgery after 72 h, 5 days (range, 2–15 days) for surgery within 96 h, and 6 days (range, 2–18 days) for surgery after 96 h. There was no difference in the lengths of hospital stay for surgery within or after 72 h, but there was a significantly longer hospital stay for surgery after 96 h from onset of symptoms.

There was no mortality, although complications occurred for six patients (5.4%). Two patients experienced port-site infection. Three patients experienced subhepatic fluid collection, which was subsequently aspirated under ultrasound guidance. Cystic duct leakage was observed in one patient, which was managed with a common bile duct stent. After a follow-up period of 8 weeks, no subsequent complications were observed.

Discussion

With the development of technical skill and laparoscopic instruments, urgent laparoscopic cholecystectomy currently is considered the optimum treatment for patients admitted with acute cholecystitis [11]. As compared with successful laparoscopic cholecystectomy, conversion of laparoscopic to open cholecystectomy not only leads to an increase in operative time, patient morbidity, and hospital stay, but also results in a significant increase in overall cost [4]. It has been shown that the conversion rates are high in cases of acute cholecystitis. Pessaux et al. [18] reported a conversion rate of approximately 27% in a 132 case study in 2000, and Navez et al. [17] obtained a conversion rate of 20% in a 609 patient study in 2001. In a 124 case study, Prakash et al. [19] reported a conversion rate of approximately 18.5% in 2002. These high conversion rates resulted from the technical difficulty of identifying biliary anatomy and managing severe inflammatory adhesions around the acutely inflamed gallbladder.

A number of risk factors for conversion in cases of acute cholecystitis, such as old age, large stones, a history of previous biliary disease, and a nonpalpable gallbladder, are associated with repeated inflammation, which results in a scarred and fibrosed gallbladder [15]. Timing of surgery from onset of symptoms has been considered one of the risk factors. It has been suggested that the optimum timing for urgent cholecystectomy is within 72 h after onset of symptoms. This suggestion was based on the finding that the conversion rate rises sharply after 72 h from onset of symptoms, negating the potential benefits of urgent surgery [3, 13, 15, 18, 21, 22]. Others have found the optimum timing for surgery to be within 96 h after onset of symptoms, with longer delays leading to a rising conversion rate [2, 5, 6, 9, 16, 17].

Furthermore, Koo and Thirlby [13] suggested that failure to perform urgent cholecystectomy within 72 or 96 h after onset of symptoms might be an indication for interval cholecystectomy. Unfortunately, interval surgery with initial conservative treatment for acute cholecystitis may result in failure. Fowkes and Gunn [8] reported that 20% of their patients failed conservative treatment during the initial hospitalization for acute cholecystitis and required surgery. Another 27% of patients who have their cholecystectomies delayed are readmitted for emergency cholecystectomy before their scheduled elective procedure. In addition, an increased proportion of shrunken gallbladder and chronic cholecystitis with dense fibrotic adhesions is encountered in interval laparoscopic cholecystectomy patients, which renders laparoscopic dissection impossible and sometimes unsafe. Several reports have demonstrated that the conversion and complication rates tend to be higher with interval surgery [14, 15, 20, 23].

The current results do not support the finding of earlier studies with regard to the timing of urgent laparoscopic cholecystectomy. The conversion rates were similar for surgery performed within 72 and 96 h after onset of symptoms, and did not vary significantly for cholecystectomy performed after these times. On the basis of this result, interval surgery for acute cholecystitis with symptoms after 72 or 96 h would not be considered. This is consistent with findings of recent studies showing that a delay in urgent surgery did not increase the conversion rate [2, 12].

The absence of major complications, such as bile duct injury, suggests that LC can be performed safely in patients with acute cholecystitis. The duration of surgery was similar in both groups. The major advantage of early LC (within 96 h) is the reduction in the total hospital stay. However, the total hospital stay was similar for surgery performed within and after 72 h from onset of symptoms.

Surgeons often must decide whether to try a laparoscopic approach for patients with acute cholecystitis or not, especially for patients who have experienced symptoms longer than 72 or 96 h. The current study demonstrated that urgent laparoscopic cholecystectomy for acute cholecystectomy is safe and associated with a low conversion rate. The timing of surgery did not influence the outcome.

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SURGICAL ENDOSCOPY
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It is not worthwhile to perform ileoscopy on all patients

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Abstract
Background: It remains controversial whether ileoscopy should be attempted in all patients. Although the ease of ileoscopy and the diagnostic yield have been well described, there have been no studies describing the value of the diagnostic yield in altering clinical management. We carried out a study to ascertain whether it is worthwhile to perform ileoscopy in all patients having a colonoscopy.
Methods: We carried out a retrospective study of all patients who had a colonoscopy between January 1, 2002, and December 31, 2003. The patient details, indications, findings, and complications of the procedure were recorded, together with the histopathology reports of colonic and terminal ileal biopsies. Clinical case note of patients with a positive diagnosis was reviewed to ascertain whether there was a change to the patient's management following an abnormal biopsy result.
Results: A total of 2,149 colonoscopies were performed. In 346 patients (16.1%), the terminal ileum was intubated. There were 16 abnormal findings on histology, which gave a diagnostic yield of 4.6% of all ileoscopies. A change to management occurred in only half of these patients.
Conclusion: Ileoscopy should only be attempted in situations in which the indication is warranted and that would alter management. It is not cost-effective to carry out ileoscopy on all patients.

Key words: Costs — General — Endoscopy

A useful investigation can be defined as one in which the result will alter the management or add confidence to the clinician's diagnosis. Unnecessary investigations increase waiting times, waste resources, and expose patients to unnecessary risk.

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Ileoscopy as an adjunct to colonoscopy was first described three decades ago [5]. It helps to establish completeness of the examination, and in some cases small bowel inflammatory disease can only be established by ileoscopy [2, 8]. Some prospective studies have described success rates of >90% for ileal intubation [1, 9]. One of these studies was carried out in a tertiary referral center with state-of-the-art equipment and demonstrated a median time of 55 sec to pass from cecum to terminal ileum [1].

It remains controversial whether ileoscopy should be attempted in all patients. Although the ease of ileoscopy and the diagnostic yield have been well described, there have been no studies describing the value of the diagnostic yield in altering clinical management. The aim of this study is to ascertain whether ileoscopy is a useful, cost-effective investigation for all patients having a colonoscopy.

Patients and methods

We performed a retrospective analysis of all patients who had a colonoscopy in the medical gastroenterology department at Kingston Hospital between January 1, 2002, and December 31, 2003, which is a 500-bed district general hospital serving a population of approximately 320,000. The hospital's medical gastroenterology department performs approximately 1,000 colonoscopies per year. Three endoscopists and three trainees currently staff the department. Data were obtained from medical records and our computerized endoscopy database. The patient details, indications, and findings of the procedure were recorded. Histopathology reports of colonic and terminal ileal biopsies were also recorded. Clinical case notes of patients with abnormal appearance on histology were reviewed to establish how such findings had altered management. We defined abnormal findings as clinically significant if this resulted in a new diagnosis, initiation or change in drug treatment, or further investigation.

Colonoscopy was performed using Olympus CF-240L or CF-20HL video colonoscopies.

Results

A total of 2,149 colonoscopies were performed by eight medical gastroenterologists or their advanced trainees

Table 1. Indications for colonoscopy

Indication	No. of patients
Diarrhea	450
Rectal bleeding (overt/occult)	407
Abdominal pain	327
Anemia	320
Follow-up for polyp	252
Follow-up for inflammatory bowel disease	254
Constipation	178
Intermittent constipation and diarrhea	104
Family history of colorectal cancer	104
Weight loss	76
Abdominal mass	29

Table 2. Indications, diagnostic yield, and clinical significance of patients who had ileal intubation

Indication	No. of patients	Diagnostic yield	Clinically significant
Diarrhea	119	11 (9.2%)	4 (3.3%)
Abdominal pain	74	2 (2.7%)	0 (0%)
Rectal bleeding (overt/occult)	62	5 (8.1%)	3 (4.8%)
Follow-up for inflammatory bowel disease	33	5 (15.2%)	2 (6.1%)
Anemia	36	4 (11.1%)	2 (5.6%)
Abdominal mass	3	1 (33.3%)	1 (33.3%)

Table 3. Indications, diagnosis, and management change of patients with abnormal ileal histology

Patient No.	Indications	Diagnosis	Management change
1	Anemia, diarrhea	Crohn's disease	Started on new drugs
2	Diarrhea, rectal bleeding	Crohn's disease	Started on new drugs
3	Follow-up for IBD	Crohn's disease	Started on new drugs
4	Diarrhea	Crohn's disease	Started on new drugs
5	Follow-up for IBD	Crohn's disease	Started on new drugs
6	Abdominal mass	High-grade lymphoma	Chemotherapy and surgery
7	Anemia, diarrhea	Tuberculosis	Antitubercuious drugs
8	Anemia	High-grade dysplastic villous adenoma	Right hemicolectomy

IBD, inflammatory bowel disease

from January 2002 to December 2003, and the indications are summarized in Table 1. Most patients had more than one indication. The most common indications were diarrhea, rectal bleeding (over/occult), abdominal pain, and anemia. Approximately one-fourth of the patients (252 + 254 = 516) were asymptomatic and had colonoscopy carried out for surveillance of previous polyps or chronic inflammatory bowel disease (IBD).

In 346 cases (16.1%), the terminal ileum was successfully intubated. Of these, 115 biopsies of the terminal ileum were taken for histology. Table 2 summarizes the indications of patients with successful ileal intubation, with diagnostic yield and its clinical significance.

Of the 346 ileal intubations, 16 were found to have an abnormal finding on histology, which gave a diagnostic yield of 4.6%. Of the 16 patients who had abnormal ileal histology, the findings prompted a change to the clinical management in eight patients (Table 3).

Discussion

In 2001, the British Society of Gastroenterology working party suggested that the average district general hospital should plan for an annual workload of 800–1,000 colonoscopies per 100,000 population [7]. With a population of approximately 60 million, this would equate to 600,000 colonoscopies per year [6]. Assuming ileoscopy takes an additional 55 sec per procedure and that it was performed on all colonoscopies, this would mean an additional 10,000 h of procedure time [1]. Therefore, although the additional time taken to perform an ileoscopy during colonoscopy may seem short, taken in a national context this would mean an additional 2,000 colonoscopies annually. There will also be an impact on the histopathology services.

The diagnostic yield with clinical significance was highest in patients who had colonoscopy performed for investigation of an abdominal mass, follow-up of IBD, anemia, and diarrhea. Our study confirms the findings of previous studies, which demonstrated no benefit of ileoscopy for unselected patients undergoing colonoscopy [4, 9], suggesting that it may be better to perform ileoscopy only on patients in whom there is an abnormal finding and also in whom treatment is likely to be altered. With the time saved, an additional 2000 patients could be colonoscoped.

The current analysis has some limitations. There is a selection bias in patients who had ileoscopy and ileal biopsies. Although the ileoscopy rate of 16.1% is much lower than that of other studies, the diagnostic yield of 4.6% is similar. This suggests selective ileoscopy has not compromised diagnostic yield. A prospective study would have been preferable, but this study reflects the practice of a district general hospital and not a tertiary referral center, in which ileoscopy would be selected in patients most likely to provide a diagnostic yield. However, with a positive diagnostic yield, in only half of the patients were the ileoscopy findings clinically significant to warrant a change in management. Another argument against performing ileal biopsies on all patients is the risk of transmitting variant Creutzfeldt–Jakob disease from one patient to another [3].

Ileoscopy is an important part of colonoscopy, but our study highlights the cost implication related to performing ileoscopy on all patients when most patients

will not have their clinical management altered following the procedure. However, some have argued that an ileoscopy revealing a normal mucosa of the terminal ileum may be helpful [9], and it must be emphasized that a colonoscopist needs to become proficient in this technique to perform it when necessary.

In conclusion, ileal intubation should only be attempted when the indication is most likely to have an abnormal finding and alter management.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Rigid sigmoidoscopy

A potential hazard for cross-contamination

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Abstract
Background: Rigid sigmoidoscopy using a disposable or nondisposable sigmoidoscope is a common outpatient procedure. It has been assumed that the nondisposable bellows and light head of the sigmoidoscope remain free from enteric organisms so that the procedure is sterile if a disposable or nondisposable (metal) sigmoidoscope shaft is used. The aim of this study was to identify the presence of organisms within the bellows or light head of the sigmoidoscope.
Methods: Of 21 patients undergoing rigid sigmoidoscopy with a disposable instrument, bacterial cultures were taken from the inside of sterile Jackson-Pratt bulbs in 12 patients, with the bulbs being used to simulate the nondisposable insufflation bellows. In an additional nine patients, swabs were taken for culture from the inside of the nondisposable light head.
Results: Enteric gram-negative *Escherichia coli* and mixed anaerobic organisms were cultured from the Jackson-Pratt bulbs in two cases, and gram-positive organisms were cultured in another case. Gram-negative organisms, including *Bacillus*, *Proteus mirabilis*, *Klebsiella*, and *Enterococcus faecalis*, were cultured from the inside of the light head in two cases.
Conclusion: Sigmoidoscopy using a disposable instrument is not a sterile procedure and may pose a risk of patient-to-patient cross-contamination by potentially harboring organisms in the bellows or light head.

Key words: Sigmoidoscopy — Cross-infection — Bacteriology

Sigmoidoscopy is a frequently performed procedure, usually in the outpatient setting. The term "sigmoidoscopy," used in Europe and Australasia, is perhaps a misnomer since although the instrument may sometimes be passed beyond the rectosigmoid junction, generally the procedure examines only the rectum; indeed, "proctoscopy" is the terminology used for the procedure of sigmoidoscopy in the United States. The instrument can be inserted up to its limit in approximately 40% of examinations [6] and a good view of the rectal mucosa can usually be obtained. If a large amount of stool is encountered in the rectum on initial digital examination, then an enema may be administered prior to sigmoidoscopy. In some colorectal clinics, patients routinely receive an enema prior to the initial examination, which facilitates the process of examination of the rectum. A small amount of solid stool may not preclude a satisfactory view of the rectal mucosa.

Clinical indications for rigid sigmoidoscopy are varied. At the patient's first visit, the authors always carry out sigmoidoscopy in patients with rectal bleeding if there is no painful or tender anal lesion. This may be the definitive investigative procedure in the young patient with minor rectal bleeding and identifiable anal pathology. Identification of rectal polyps or cancer at sigmoidoscopy is important if there is otherwise to be a delay before colonoscopy. The distribution of adenomatous polyps in the colon is now well-known from colonoscopy studies. Approximately two-thirds occur distal to the splenic flexure, with 40–55% in the rectum and sigmoid [5, 12, 13]. In cases in which there is a solitary adenoma, 56% are found in the rectum and sigmoid [4].

Cancer most commonly occurs in the rectum, although during the past four decades there has been a shift in distribution toward the right side of the colon. In 1980, 41.9% of patients who died from colorectal cancer in England and Wales had rectal cancer. The proportions in Australia were similar [8]. In the United States, a number of studies, including that from the National Cancer Institute (1966) [1], have documented a shift to the right side of the colon and hence an increase in the ratio of colon cancer to rectal cancer [1, 2, 10]. Interestingly this change has apparently been less marked in the United Kingdom [7] and Australia [3].

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Sigmoidoscopy will diagnose proctitis, benign rectal ulceration as part of the solitary rectal ulcer syndrome, and is useful to identify rectal prolapse in the patient who has not been aware of external prolapse by observing the rectum while asking the patient to strain down. The procedure is very helpful in monitoring the progress of diseases such as colitis, radiation proctitis, or the mucosal changes in the solitary rectal ulcer syndrome, and a stool specimen may be collected during sigmoidoscopy for microscopy and culture.

Initially, rigid sigmoidoscopes were metal and reusable. There has been a gradual change to disposable plastic instruments, thus avoiding the need to clean and sterilize instruments after each use. Apart from the labor costs, in a busy clinic it is therefore necessary to have a number of expensive instruments. Most clinicians thus choose to use disposable sigmoidoscopes. Only the sigmoidoscope shaft is disposable, whereas the bellows and light source are reusable. Throughout the years, we have noted that watery stool may occasionally reflux into the bellows during the examination, particularly if the patient raises abdominal pressure during the procedure, and this has necessitated cleaning the bellows. The reusable light source may be affected in a similar way. Thus, concern was raised about sterility of the subsequent procedure and, in particular, the possibility of transmitting bacteria or other organisms harbored in the bellows or tubing, or in the light source, to the next patient during air insufflation.

The aim of this study was to examine the hypothesis that bacteria may be found on the internal surfaces of the bellows and light source after sigmoidoscopy, thus creating a potential risk for cross-contamination.

Materials and methods

The study was approved by the South East Area Health Service (Southern Section). Twenty-one patients undergoing rigid sigmoidoscopy as part of their routine clinical examination were studied. Sigmoidoscopy was carried out after a digital anorectal examination with the patient lying comfortably in the left lateral position on the examination couch. A disposable sigmoidoscope (Welch Allyn, New York, USA) was used in each case; no biopsies were taken.

In the first 12 patients, the nondisposable bellows and tubing of the Welch Allyn sigmoidoscope set were replaced with a sterile Jackson-Pratt bulb (Baxter Healthcare, Deerfield, IL, USA). This bulb is usually used as a closed-wound suction drainage system but functions effectively for air insufflation. The egg-shaped bulb has an inlet port with an antireflux valve and a drainage port with removable plug, and it is supplied in a sterile plastic pack. The Jackson-Pratt bulb was removed from its container using aseptic technique. The drainage port was connected to a length of sterile soft connection tubing, which in turn was connected to the nondisposable Welch Allyn sigmoidoscope light head. In the first six of these 12 patients, the light head was cleaned and then sterilized in the autoclave at 120°C under pressure for 15 min before each use. In the last six of the 12 patients, the light head was not sterilized and was reused as in normal practice.

The instrument was withdrawn on completion of the sigmoidoscopy and, using aseptic technique, the bulb was disconnected from the tubing and 20 ml sterile saline was instilled via the drainage port. The plug was then inserted into the drainage port and the saline was gently swirled in the bulb. A sterile Steri-Strip tape was placed to seal the inlet port. The bulb was then sent to the pathology laboratory for microbiological examination of the contents of the saline. Cultures were set up on blood agar, MacConkey agar, and chocolate agar plates for gram-positive and gram-negative aerobic and anaerobic organisms and on LJ slope for mycobacteria. Incubation was continued for 48 h, and once a growth was identified, incubation was continued to allow organism identification.

Tests were carried out on the light head of the sigmoidoscope in an additional nine patients. For this part of the study, the normal reusable Welch Allyn bellows was used. The light head was cleaned and sterilized as described previously at the beginning of each consulting session and then used in several consecutive sigmoidoscopic examinations. In each case, the sigmoidoscope was inserted, the obturator withdrawn, and the light head then connected to the sigmoidoscope. At the end of the examination, new sterile gloves were used and swabs were taken from the inside surface of the light head and eyepiece. The swabs were placed in Amies' transport medium and subsequently plated on blood agar, chocolate agar, and Colistin/naladixic acid blood agar plates.

Results

Cultures from the Jackson-Pratt bulbs identified no organisms in nine of the 12 patients. In three patients, the following cultures were found, respectively: 100–1,000 colonies/ml of *Escherichia coli* and mixed anaerobic organisms; 100–10,000 colonies of *E. coli* and mixed anaerobic organisms; and a small count (< 10 colonies/ml) of *Staphylococcus epidermidis*. The first of these three patients was in the group in which the light head had been sterilized immediately before each use.

Cultures from the light heads in the second group of nine patients showed no growth in seven patients. In two patients, the following organisms were found: (1) one colony of *Bacillus* species; and (2) *Proteus mirabilis*, *Klebsiella pneumoniae*, and *Enterococcus faecalis*.

Discussion

Sterilization of instruments is an important consideration in modern surgical practice. In recent years, concern has been heightened by the advent of transmissible life-threatening diseases, for both clinical and medicolegal reasons. The processes applied to the cleaning of instruments used for flexible sigmoidoscopy or colonoscopy are now carefully regulated, usually with disinfection in 2% glutaraldehyde for 20 min or 0.2% peracetic acid using an automated system (Steris, Mentor, OH, USA). Detailed guidelines for infection control in surgery from the Royal Australasian College of Surgeons [11] and state health authorities within Australia [9] are in place, including rules governing sterilization of instruments and use of single-use surgical items.

This study has shown that fecal bacteria may be found in the bellows of the rigid sigmoidoscope. Bacteria were cultured from a previously sterile bulb after a single use. The inside surface of the bellows and, in this experimental study, the bulb are in free communication with the rectum via gas under pressure. Relatively small bacterial counts were isolated in this study, but it is presumed that higher counts are likely to be found in the nondisposable bellows after use in multiple patients. Bacteria were identified in the bellows in 25% of patients after only a single use and may therefore be expected

more frequently and in greater numbers with multiple-use bellows. The study was designed to ensure that bacteria had not reached the bellows by contamination from the air or by direct patient contact, thus demonstrating that bacteria can easily be introduced into the bellows during sigmoidoscopy. The culture of *Staph. epidermidis* was most likely to have been a skin contaminant from the operator despite the aseptic technique, a phenomenon known to occur in other circumstances such as when inserting an intravenous cannula under aseptic conditions, although it is possible that the organisms originated from the anal skin of the patient and entered the bellows during the sigmoidoscopy.

Bacteria were also isolated from the inside surface of the light head. The sigmoidoscope design is such that there is free communication between the light head, bellows, sigmoidoscope shaft, and the rectal gas, which has been insufflated under pressure. The light head is therefore exposed to organisms in the same way as the inside of the bellows. Although the design of the sigmoidoscope attempts to prevent contamination of the light head by providing a plate at the proximal end of the shaft, hence separating the light head from the shaft, the shaft may become contaminated during withdrawal of the obturator. Thus, organisms may also reach the light head after withdrawal of the obturator followed by coupling the light head onto a contaminated sigmoidoscope shaft. Placement of the light head in direct contact with the potentially contaminated proximal end of the shaft is inconsistent with the rigid principles of aseptic technique and instrument sterilization, which are mandatory in all surgical and other endoscopic procedures.

It has been proposed that a disposable filter be used, interposed between the light head and the bellows to prevent organisms from reaching the bellows. Filters are now available for use with some sigmoidoscopes (Welch Allyn; Seward, Norfolk, UK); although an appropriate filter will prevent passage of bacterial and viral particles, penetration of the filter by fluid will render it ineffective. Filters should therefore only be considered for single use, but even then they may become ineffective during a procedure if exposed to liquid stool. In addition, a filter does not prevent contamination of the internal surfaces of the light head.

We are not aware of any documented cases in which clinical infection occurred as a result of cross-contamination during sigmoidoscopy. Organisms may potentially gain access if mucosal biopsies are taken or polyps are removed during sigmoidoscopy, but minor trauma to the mucosa resulting from insertion of the instrument may also be a potential site of entry. Guidelines from the Australian Therapeutics Goods Administration recommend sterilization of all parts of the rigid sigmoidoscope to prevent cross-infection [14]. Current disposable sigmoidoscope designs do not provide the same sterile conditions as with other surgical instruments or flexible endoscopes, and prevention of cross-contamination cannot be ensured unless the bellows, tubing, and light head are autoclaved before each use.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Preconditioning-like amelioration of erythropoietin against laparoscopy-induced oxidative injury

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Abstract
Background: Laparoscopic surgery has gained wide acceptance for almost every kind of surgical procedure, although it has produced significant oxidative injury to intraabdominal organs depending on the pressure level and the kind of the gas used. The literature describes several preventive measures for decreasing the postlaparoscopic oxidative injury such as low intraabdominal pressure, gasless laparoscopy, and laparoscopic preconditioning. Erythropoietin was shown previously to decrease ischemia–reperfusion injury to the liver. The current study evaluated the effect of erythropoietin against laparoscopy-induced oxidative injury, as compared with laparoscopic preconditioning.
Methods: For this study, 64 male Spraque–Dawley rats were randomly assigned to one of the following groups. The control group was subjected to a sham operation. The laparoscopy group was subjected to 60 min of pneumoperitoneum. The laparoscopic preconditioning plus laparoscopy group was subjected to 5 min of insufflation and 5 min of desufflation followed by 60 min of pneumoperitoneum. The erythropoietin plus laparoscopy group was subjected to a subcutaneous injection of erythropoietin as a single 1,000-U/kg dose followed by 60 min of pneumoperitoneum. After 45 min of desufflation subsequent to cessation of pneumoperitoneum, blood, liver, and kidney samples were obtained from half of the rats. The other half of the rats were observed for a reperfusion period of 24 h. Tissue and blood samples also were obtained after this period.
Results: Laparoscopy produced significant oxidative injury, as compared with the sham treatment. Laparoscopic preconditioning produced significant amelioration of the ischemic injury. Although erythropoietin administration during the prelaparoscopic period decreased the pneumoperitoneum-induced oxidative injury, the beneficial effect of laparoscopic preconditioning was more pronounced.
Conclusion: Laparoscopic preconditioning is more effective than the preischemic administration of erythropoietin in reducing laparoscopy-induced oxidative injury.

Key words: Erythropoietin — Ischemia/reperfusion injury — Laparoscopic preconditioning — Laparoscopy — Malondialdehyde — Tumor necrosis factor-α

Laparoscopic surgery has gained wide acceptance for almost every kind of surgical procedure because it results in less pain and a shorter hospital stay. However, the pneumoperitoneum itself is not a completely harmless procedure, as evidenced by several structural and functional alterations observed after its use. Pneumoperitoneum carries the risk of splanchnic ischemia as well as metabolic and infectious consequences depending on the pressure level used for pneumoperitoneum and the kind of gas used [11, 21, 22]. The adverse alterations also have been attributed to the increased carbon dioxide (CO_2) load [10, 16].

As a consequence of these responses, pneumoperitoneum produces ischemia during insufflation and reperfusion during desufflation. Therefore, laparoscopic procedures actually produce ischemia–reperfusion injury.

The induction of free oxygen radicals after the restoration of blood flow during the desufflation phase is one of the most important mechanisms of organ dysfunction after laparoscopy. We previously demonstrated that laparoscopy produces severe oxidative injury to the liver, kidney [22], small intestine [24], and peritoneal [3] tissues. The mechanisms activated after ischemia–reperfusion actually prolong the hypoxia that has already begun during the ischemia. The aggravated hypoxia is followed by increased inflammatory cytokines and reactive oxygen species, thereby increasing the tissue injury [4].

We also have reported that tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) contribute at least

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partially to oxidative injury observed after laparoscopy [1, 3]. The oxidative injury represents the loss of normal balance between the oxidative agents and natural antioxidant scavengers. It is not only an indicator, but also a contributor to organ damage, especially damage to the liver and kidney [7, 17, 20]. We have previously shown that ischemic preconditioning (Pre), originally reported as beneficial for myocardial tissues [8], can be applicable in laparoscopic procedures, with brief periods of pneumoperitoneum and desufflation administered before the sustained pneumoperitoneum period [22, 24].

Laparoscopic preconditioning (L-Pre), one of the most important preventive methods against laparoscopy-induced oxidative injury, produces its beneficial effect by decreasing the cytokine responses [1]. It also is more effective than low-pressure pneumoperitoneum in reducing ischemic insult associated with laparoscopy [3]. During laparoscopic procedures, the intraabdominal organs are exposed to ischemic injury not only during the insufflation phase, but also during the deflation phase. The liver and the kidneys are among the splanchnic organs most severely affected by laparoscopic procedures, as implied by increased blood levels of liver enzymes noted in animals and humans, and by structural alterations including liver necrosis as well as renal failure and necrosis [6, 15].

Erythropoietin (EPO) is a hypoxia-inducible hemopoietic growth factor expressed mainly in the kidney. It has an antioxidant property and a neuroprotective effect against ischemia in cell culture and animals [5, 18]. We previously demonstrated that the administration of EPO before ischemia protects the liver from ischemia–reperfusion injury caused by pedicular clamping, as depicted by decreased blood values of liver enzymes, IL-2, and TNF-α, as well as attenuated liver tissue oxidation [23]. Considering that the ischemia–reperfusion injury actually is a process triggered by hypoxia, in the current study, we evaluated the effect of EPO against laparoscopy-induced oxidative injury, as compared with the L-Pre method.

Materials and methods

The current study was conducted with the approval of the University Ethical Committee. The experiment protocol was designed in accordance with the 1996 revised edition of *The Guide for the Care and Use of Laboratory Animals* published by the U.S. National Institutes of Health.

After overnight fasting with free access to tap water, 64 male Sprague–Dawley rats weighing 280 ± 15 g were enrolled into the study and randomly assigned to one of the following groups, with 16 animals in each group. The control group was subjected to a sham operation without pneumoperitoneum. The laparoscopy group was subjected to 60 min of pneumoperitoneum. The L-Pre plus laparoscopy group was subjected to 5 min of insufflation and 5 min of desufflation followed by 60 min of pneumoperitoneum. The EPO plus laparoscopy group was subjected to a subcutaneous injection of EPO as a single dose of 1,000 U/kg followed by 60 min of pneumoperitoneum.

Surgical technique

The rats were anesthetized with an intramuscular injection of ketamine, and a 1-cm midline laparotomy was performed below the umbilicus. After that, a catheter was placed into the peritoneum as the vehicle of pneumoperitoneum created in all the animals except the sham group using a technique described by Polat et al. [12]. Pneumoperitoneum was obtained for 60 min by connecting the other side of the tube to a CO_2 insufflator (Norteeh Model 3-315-00, Fribourg, Switzerland) fixed at 15 mmHg.

Before insufflation, the aforementioned incision was closed with a tight purse-string suture to prevent leakage. After 45 min of desufflation subsequent to the cessation of pneumoperitoneum, laparotomy was performed and blood samples were obtained from half of the rats via intraaortic cannulation, along with liver and kidney samples. The other half of the rats were observed for the 24-h reperfusion period. The aforementioned tissue and blood samples also were obtained after this period.

Biochemical analysis

The blood samples were centrifuged immediately at 3,000 rpm for 5 min. Alanine aminotransferase (ALT) and lactic dehydrogenase (LDH) values were measured with a Hitachi 911 automatic analyzer (Boehringer, Mannheim, Germany).

Plasma concentrations of TNF-α were determined by enzyme-linked immunoassay (ELISA) using the commercially available kits for rat ELISA TNF-α (R&D system, Quantkin M Murine, Minneapolis, MN, USA). Plasma malondialdehyde (MDA) levels were measured as an indicator of lipid oxidation using the thiobarbituric acid method of Ohkawa et al. [9].

The liver and kidney tissues were rinsed with ice cold saline and frozen at −70°C until the assay. The tissues were homogenized with an Ultra Turrax homogenizer (IKA T18 basic, Wilmington, NC, USA). After the centrifugation of the homogenates, the supernates were removed and used for MDA analysis by the method described previously [9].

Statistical analysis

Data are expressed as mean ± standard error of the mean. Values lower than 0.05 were accepted as statistically significant. The between-group parameters obtained were evaluated using the Kruskal–Wallis nonparametric test. The Mann–Whitney *U*-test was used to compare the data between the paired groups.

Results

The results in terms of plasma LDH, ALT, TNF-α, and MDA values as well as the liver and kidney tissue MDA levels are graphically displayed in Figs. 1 to 4.

Effect of laparoscopy

The comparison of the results between the sham and laparoscopy groups showed that laparoscopy produced significantly increased plasma levels of LDH, ALT, TNF-α, and MDA, as well as increased liver and kidney tissue MDA values, after 45 min of reperfusion. Whereas the ALT levels declined to the normal level 24 h after desufflation, the LDH levels remained still higher that of the sham group. Therefore, laparoscopy produced significant ischemia–reperfusion injury in terms of plasma and tissue oxidative markers, especially after 45 min of desufflation.

Effect of L-Pre on laparoscopy-induced oxidative injury

The addition of the preceding L-Pre procedure to laparoscopy produced significant amelioration in terms of

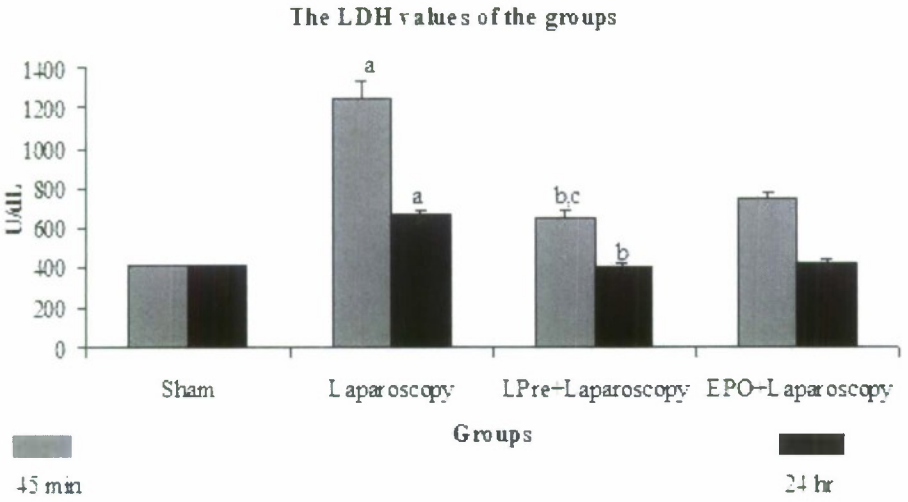

Fig. 1. The lactic dehydrogenase (LDH) values of the groups after 45 min and 24 h of reperfusion. **a** $p < 0.05$ for the sham and laparoscopy groups. **b** $p < 0.05$ for the L-Pre + laparoscopy and laparoscopy groups. **c** $p < 0.05$ for the erythropoietin (EPO) + laparoscopy and L-Pre + laparoscopy groups.

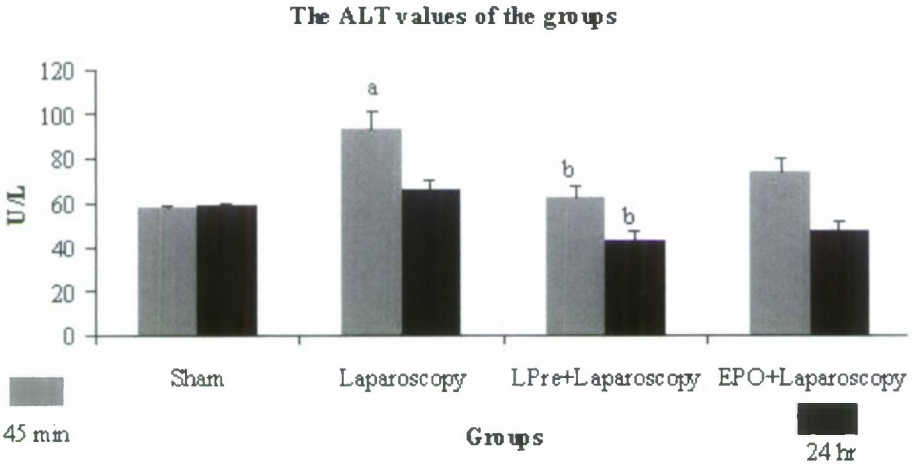

Fig. 2. The alanine aminotransferase (ALT) values of the groups after 45 min and 24 h of reperfusion. **a** $p < 0.05$ for the sham and laparoscopy groups. **b** $p < 0.05$ for the L-Pre + laparoscopy and laparoscopy groups.

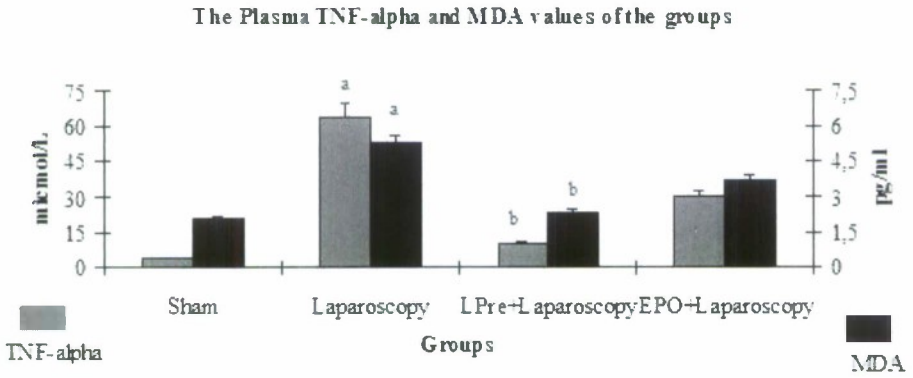

Fig. 3. The plasma tumor necrosis factor-α (TNF-α) and malondialdehyde (MDA) values of the groups after 45 min of reperfusion. **a** $p < 0.05$ for the laparoscopy versus L-Pre + laparoscopy and the erythropoietin (EPO) + laparoscopy groups. **b** $p < 0.05$ for the L-Pre + laparoscopy versus the EPO + laparoscopy group.

deereased plasma levels of LDH, ALT, TNF-α, and MDA, as well as deereased liver and kidney tissue MDA values, after 45 min of desufflation. The results for ALT and LDH after 24 h of desufflation showed lower levels than in the laparoseopy group. However, although L-Pre produeed a significant benefieial effect on oxidative injury, as eompared with the laparoseopy group, the LDH and TNF-α values were higher than those of the sham group.

Effect of EPO on laparoscopy-induced oxidative injury

The administration of EPO before the pneumoperitoneum significantly decreased the plasma levels of LDH, TNF-α, and MDA, as compared with those of the laparoseopy group. However, the comparison of the results between the sham and EPO groups showed that the levels of LDH, ALT, TNF-α, and MDA still were higher than those of the sham group. Although EPO adminis-

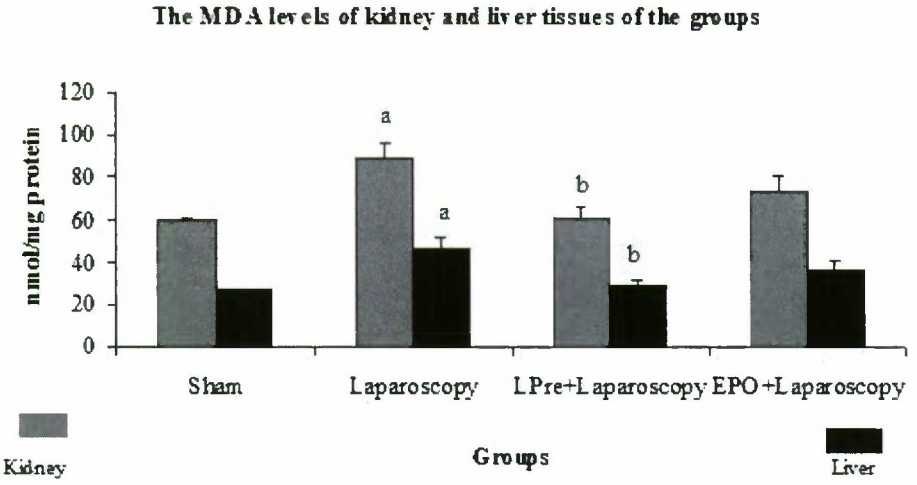

Fig. 4. The liver and renal tissue levels of malondialdehyde (MDA) in the groups. **a** $p < 0.05$ for the laparoscopy versus the sham group. **b** $p < 0.05$ for the laparoscopy versus the L-Pre + laparoscopy group.

tration during the prelaparoscopic period decreased the pneumoperitoneum-induced oxidative injury, the beneficial effect of L-Pre was more pronounced than that of EPO in terms of LDH, TNF-α, and MDA levels.

Discussion

Laparoscopy represents an ischemia–reperfusion phenomenon that produces splanchnic ischemia. Pneumoperitoneum is used to facilitate the visualization of intraabdominal organs intraoperatively. However, not only pneumoperitoneum itself, but also the deflation phase carries the risk of ischemic potential for splanchnic organs [22, 24]. Augmented productions of free oxygen radicals and other hazardous compounds occur during insufflation and also during the deflation phase. Therefore, laparoscopy itself is an ischemia–reperfusion phenomenon that produces splanchnic ischemia and related adverse alterations in intraabdominal organs, which may have a particular importance, especially for elderly patients, who have limited functional capacity [14]. The liver and kidney are among the splanchnic organs affected by laparoscopic procedures.

Increasing recognition of the adverse effects from laparoscopy has led to different alternative approaches such as laparoscopy with low intraabdominal pressure or the gasless abdominal wall–lifting method. We have previously shown that L-Pre is a beneficial method for decreasing the laparoscopy-related oxidative injury [22, 24]. It also has been reported that L-Pre may be more effective than low-pressure pneumoperitoneum in reducing the ischemic insult associated with laparoscopy [3].

The L-Pre technique is performed by administering short periods of insufflation and deflation sequence(s) at the beginning of laparoscopy. It is an endogenous protective mechanism that prepares the tissue against subsequent laparoscopic injury. Some cellular proteins released during L-Pre are known to make the cell resistant to the harmful effect of free oxygen radicals delivered after the ischemia–reperfusion phase.

O'Malley et al. [10] previously reported that CO_2, the gas most frequently used for pneumoperitoneum, led to local and systemic acidosis, aggravating ischemic organ injury. However, an ideal gas for establishing pneumoperitoneum still is under investigation. It previously was found that helium seems to limit the postoperative oxidative response after laparoscopy [25]. The end result of laparoscopic injury is increased levels of inflammatory mediators, vasoactive kinins, fibrins, cytokines, and free oxygen radicals [19]. The lipid peroxidation induced by these mediators is associated with altered ischemic and hepatic enzymes. The plasma MDA values also reflect the oxidative modification of the lipid layer of the cell membrane.

Erythropoietin is a hypoxia-inducible growth factor expressed mainly in the kidney. It has multiple protective effects against oxidants and apoptosis [13]. We also reported previously that preischemic administration of EPO had protective effects on hepatic ischemia–reperfusion injury [23]. It significantly decreased the postischemia–reperfusion elevations of ALT, TNF-α, IL-2, and tissue MDA in an experimental hepatic ischemia model in rats.

It was reported previously that preischemic administration of EPO was beneficial in reducing the ischemic injury to neuronal and myocardial tissues. We also reported recently that the preischemic administration of EPO in a dose of 1,000 U/kg prevented postischemic injury in rat kidney tissues. This beneficial effect was suggested to result from tyrosine kinase pathway activation because that effect was blocked by the administration of Genistein, which is a tyrosine kinase inhibitor [2]. Therefore, it may be speculated that EPO plays its role in laparoscopy-induced ischemia–reperfusion injury via tyrosine kinase enzyme activation, but this assumption still requires further experimental studies.

Because the eventual result of laparoscopy is related to organ ischemia, we tried in the current study to evaluate the effect of preischemic administration of EPO on laparoscopy-induced tissue injury, as compared with L-Pre. In this model, we evaluated ALT and LDH as contributors to organ parenchymal deterioration, plasma TNF-α as a cytokine mediator, and plasma, renal, and hepatic tissue MDA as lipid peroxidation markers. The comparison of the sham and laparoscopy groups showed that laparoscopy produced significantly in-

creased levels of these parameters. Moreover, the harmful effect of laparoscopy continued partially 24 h after the deflation. However, the addition of L-Pre to laparoscopy significantly decreased the elevated parameters and almost declined them to sham group values. Although EPO administration significantly decreased the LDH, TNF-α, and MDA values, as compared with those of the laparoscopy group, they still were higher than those of the L-Pre plus laparoscopy group. Therefore, the beneficial effect L-Pre in terms of these parameters was more pronounced than that resulting from EPO administration. The results of this study show that EPO, an anti-ischemic agent, produces significant protection against laparoscopy-induced tissue injury. However, the beneficial effect of L-Pre was more significant than that of preischemically administered EPO. These results therefore suggest that L-Pre produced a protective effect against laparoscopy-related injury with the help of several mechanisms. It may be that L-Pre acts via mechanisms other than its anti-ischemic property, which is the most important protective mechanism of EPO. In conclusion, L-Pre and EPO decrease laparoscopic tissue injury probably with the help of different unique mechanisms.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic ventral hernia repair using expanded polytetrafluoroethylene–polyester mesh compound

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Abstract
Background: Many biomaterials and composites have been used in clinical and experimental laparoscopic ventral hernia repair. The ideal prosthesis should allow firm binding to the abdominal wall without adhesion to the bowel.
Methods: A compound prosthesis was made by circumferentially suturing a Gore-Tex mesh as visceral interface to a smaller polyester mesh as parietal interface, and it was used in 46 laparoscopic ventral hernia repairs between January 2000 and December 2004.
Results: Average operative time was 65 min, with no intraoperative complications. Mean hospital stay was 2.2 days. Postoperative complications were five seromas, two hematomas, and one recurrence after a mean follow-up of 32.2 months.
Conclusion: The prosthesis used was made of two biomaterials that have been tested and tried over the years. The polyester layer is known to induce sufficient tissue ingrowth, whereas Gore-Tex minimizes adhesion formation. The memory of the compound was high enough to allow easy laparoscopic unrolling and handling.

Key words: Laparoscopy — Ventral — Incisional — Hernia — Repair

The published results of laparoscopic ventral hernia repair are satisfactory, with minimal perioperative morbidity and low early recurrence rates [3, 17, 19, 27, 28, 31, 32]. The type of mesh prosthesis used has been the matter of much debate. Firm binding to the abdominal wall with sufficient fibrocollagenous tissue ingrowth, on the one hand, and no or minimal liability to adhesion formation with underlying bowel, on the other hand, are the main characteristics of the ideal prosthesis required. Polypropylene and polyester biomaterials are known to form severe adhesions if put in direct contact with bowel, and Gore-Tex (ePTFE), which is known to have minimal liability to form adhesions, has raised concern about the adequacy of tissue ingrowth. The formation of a compound made of a Gore-Tex mesh and a polyester mesh will accomplish the two required benefits. In a previous article [14, 15], we presented our early experience with the use of polyester mesh and ePTFE soft tissue patch for bilayer laparoscopic repair of ventral hernia. Further refinement and modification of the technique in a larger number of patients is presented herein.

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Materials and methods

A total of 46 patients (35 females and 11 males) with ventral hernias were treated between January 2000 and December 2004. Their age ranged from 23 to 75 years (median, 37.6). Thirty patients had incisional hernia, 14 had spontaneous paraumbilical hernias, and two had umbilical and lower abdominal incisional hernias. In 14 patients, hernias were recurrent. The long axis of defect ranged from 4 to 12 cm.

Technique

Following abdominal insufflation by the use of a Veress needle introduced away from any previous incision, access to the abdominal cavity was obtained by using a 10-mm visiport (Tyco Healthcare). A 30° telescope was used and two 5-mm ports were introduced under vision. Their sites were chosen to give proper orientation and suitable working length and angle. Hernia contents were reduced and all adhesions divided using either electrosurgical power or ultracision (Ethicon Endo-Surgery). The defect edges were clearly exposed and the extent of overpass was then marked on the skin (at least 4 cm). Compound prosthesis was made by suturing a Gore-Tex mesh (W. L. Gore and Associates, Flagstaff, AZ, USA) to a thin polyester mesh using multiple 2-0 sutures passed through the two meshes 2 cm from the edge of the Gore-Tex mesh. Excess polyester mesh was then cut 1–1.5 cm short of the edge of the Gore-Tex mesh to eliminate the possibility of bowel adhesions to the edge of the prosthesis. Four prolene loops were left in each of the borders of the prosthesis. The prosthesis was rolled and introduced into the abdominal cavity. A 10 × 15-cm prosthesis was passed through a 10-mm port. The port was removed to introduce a larger prosthesis through the port site. Unrolling and spreading could readily be obtained due to the higher memory acquired by the addition of the polyester layer to the ePTFE layer. The prosthesis spread on the

abdominal viscera with the polyester surface facing the defect was raised to the abdominal wall by anchoring the prolene loops consecutively to a suture passer introduced through the abdominal wall at the proposed site of overpass to ensure proper orientation of the prosthesis across the defect. The loops were held by artery forceps followed by fixation of prosthesis using helical coils from a 5-mm Protack (Tyco Healthcare) aided by counterpressure on the abdominal wall to face the tip of the Protack and compensate for its lack of angulation. Prolene loops were then cut and removed. This technique aided in proper orientation of the opaque compound across the defect. Care should be taken during fixation of the prosthesis to the defect border on the same side of the ports. Reverse movement of instruments along the eye–hand–target axis may lead to fixation of the prosthesis short of the required overpass. One 5-mm port may occasionally be required to allow proper overpass and fixation. A 10 × 15-cm prosthesis was used in 38 cases, and a 15 × 20-cm prosthesis was used in seven cases. In one other patient, two 10 × 15-cm prostheses were required to cover multiple midline defects from umbilical and lower abdominal incisional hernia. Pressure dressing was then applied on the hernia sac.

Results

The technique was successfully completed in all patients. Two patients had laparoscopic cholecystectomy performed during the same session, and one patient had interval appendicectomy with repair of a hernia secondary to drainage of appendicular abscess. Operative time ranged from 30 to 85 min (average, 65), with no intraoperative complications apart from trocar injury of the left inferior epigastric artery in one case. All but one patient tolerated oral fluids the next morning following surgery. Abdominal CT scan was occasionally required during follow-up to rule out recurrence. Postoperative complications were five seromas that were relatively small and resolved spontaneously. Two patients had persistent hematoma at the hernia sac. One small, firm, and lobulated hematoma was suspected for recurrence and excluded by ultrasonography. In another patient, hematoma was large and surrounded by bluish skin discoloration. The patient was conservatively treated and discharged 9 days following surgery. In this case, we easily inverted the hernia sac into the abdomen after lyses and reduction of hernia contents. The sac was excised by electrocautery with a pair of scissors. Division of the hernia sac should be avoided. One patient had early postoperative recurrence. The patient had an epigastric incisional hernia following coronary bypass. Recurrence was detected 2 months postoperatively at the upper end of the defect. The patient had chronic persistent cough and low ejection fraction. Reoperation was denied by the anesthetists. Abdominal CT scan was selectively used to differentiate recurrence from postoperative seroma or hematoma at the hernia site. Hospital stay ranged from 1 to 9 days (mean, 2.2). No other late complications occurred in this series after a mean follow-up of 32.2 month (range, 6–53).

Discussion

Selection of the mesh prosthesis has been the subject of much concern among surgeons performing laparoscopic repair of ventral hernias. Firm binding to the abdominal wall with sufficient fibrocollagenous tissue ingrowth, on the one hand, and no or minimal liability to adhesion formation with underlying bowel, on the other hand, are the characteristics of the ideal prosthesis for the laparoscopic approach to ventral hernias.

ePTFE is the biomaterial selected by most researchers as an intraperitoneal prosthesis due to its known minimal liability to form adhesions with the bowel [24, 25]. Dual mesh is a form of ePTFE with different pore sizes on either surface that was recently introduced to enhance the tissue integration of an otherwise inert biomaterial. It has been used by many surgeons [3, 10, 13]. Despite the known effect on adhesion formation, polypropylene mesh has been used by some authors in the intraperitoneal position [16, 20]. The very low recurrence rate of 1.1% reported by Franklin et al. [16] was attributed to the superior tissue ingrowth with the polypropylene mesh. Two-thirds of their patients who had relaparoscopy had mild to severe adhesions to the mesh.

The characteristics of polypropylene and Gore-Tex biomaterials have been compared in many experimental studies. Whereas ePTFE led to the formation of thin, flimsy adhesions and a thin connective tissue capsule covering, polypropylene resulted in more dense adhesions and disorganized dense connective tissue covering. Resistance to traction was shown to be higher with polypropylene [6, 12, 35]. Abdominal wall defects repaired with ePTFE resulted in significantly more frequent herniations, observed at the fascia and patch interface, than with polypropylene (60 vs 0%). Insufficient ingrowth of fibrocollagenous tissue into the ePTFE patch, with insufficient anchorage of the patch to the fascia, was histologically confirmed, whereas the polypropylene mesh was completely incorporated into fibrocollagenous tissue, which was continuous with the adjacent fascia [23, 29]. The effect of the structure of three ePTFE prostheses (Soft Tissue Patch, Dual Mesh, and Myero-Mesh) on the scarring process in an abdominal wall defect experimental model was studied. The three types of PTFE prosthesis induced a low incidence of adhesion formation between biomaterial and viscera. The integration mechanisms of the three prostheses were similar and culminated in the encapsulation of the PTFE by the neoformed tissue with a macrophage response similar to that of any reparative process in the absence of biomaterial [5, 8].

Conflicting results led to continued studies to find the proper prosthetic biomaterial. Eliminating adhesions to mesh by mechanical or other means during a critical time (first 7 days) is assumed to control adhesions to the mesh and subsequent mesh-related complications. Laparoscopic adhesiolysis at 1 week was shown to minimize subsequent adhesion formation to polypropylene and ePTFE mesh during a 4-month follow-up in an experimental setup [26].

Composite prosthesis made by integrating a biodegradable extracellular matrix analog or an absorbable mesh barrier with a permanent structural biomaterial to reduce adhesion formation was tried in both experimental and clinical studies Baric et al. [4] used a polyester/polyglactin 910 (Vicryl) composite. This composite led to intestinal adhesions and fistulation in both clinical

and experimental studies [30, 34]. Polypropylene mesh/polypropylene sheeting and polypropylene mesh/silastic composites were shown to reduce adhesion formation to bowel compared to other biomaterials, including polypropylene, polyester, expanded polytetrafluoroethylene, polypropylene/polyglactin, polypropylene/polyglycolic acid, and polypropylene/fibrin [2]. Although silastic implantation (Dacron-reinforced silicone rubber) caused no adhesions, graft extrusion and evisceration were common [22]. polypropylene/Gelfilm composite lead to a similar adhesion response as that of PP alone after the gelatin dissolved in 1 week. Sepramesh (a polypropylene coated with sodium hyaluronate), carboxymethyl cellulose film, Parietex mesh (a polyester/collagen composite), and polypropylene collagen composite have similar effects in minimizing adhesion formation [1, 7, 9, 18, 21, 33]. However, in one study infection was more prevalent with Parietex composite mesh, with concurrent increased mesh surface covered by adhesions [33].

The addition of a layer of polyester to the inert ePTFE mesh would make the repair stronger and better long-term results would then be expected. The facial interface layer of polyester mesh stimulates fibrocollagenous tissue ingrowth, leading to firm binding of the prosthesis to the abdominal wall, whereas the ePTFE layer minimizes the possibility of adhesion formation to the underlying bowel. The fixation of the two biomaterials was found to modify its physical characteristics, making its unfurling and spreading in the operative field easier than with the Gore-Tex biomaterial alone [14]. With proper orientation and firm fixation to healthy surrounding tissue, an ideal repair is expected. Repair of hernias near bony prominences, such as the xiphoid process or symphesis pubis, requires special attention. Effort should be made to reduce all adherent hernia contents to avoid persistent postoperative swelling that may be mistaken for recurrence, leading to unsatisfactory results for the patient. Very large prosthesis should have reasonable tension to avoid postoperative bulge and suspected recurrence.

The biomaterials used in this technique are currently available, and their combined use in our technique did not increase difficulties or cost compared to the use of other composite biomaterials that still require extensive experimental and clinical studies. Fixation of the prosthesis with helical coils from a 5-mm Protack instrument (Tyco Healthcare) was found to be reliable and technically feasible. Tissue ingrowth will lead to further, lasting integration of the prosthesis with the abdominal wall. Transabdominal sutures used for mesh fixation in laparoscopic ventral hernia repair were reported to be an occasional source of prolonged postoperative pain requiring postoperative local anesthetic injection [11]. Neither early nor late postoperative pain specifically related to tacks occurred in this series.

Conclusion

Laparoscopic ventral hernia repair has many advantages over the open technique. It enables dissection of all intraabdominal adhesions commonly present in incisional hernia cases, clearly exposes healthy edges of the hernia defect and the presence of multiple defects, and provides the ability to fix a large prosthesis to accomplish adequate overpass, thus reducing the incidence of recurrence. The technique allows for other intraabdominal pathologies to be dealt with without the need for large or multiple incisions. Morbidity is thus reduced and hospital stay and recovery period are shortened. Adoption of the laparoscopic approach should not compromise the principles of successful mesh repair of ventral hernia. The prosthetic biomaterial should stimulate sufficient tissue ingrowth to restore abdominal wall integrity with a minimal tendency for adhesion formation. A compound prosthesis, ePTFE–polyester, was formed and successfully used in this series. It combines the benefits and the known, tested characteristics of its two components. In addition, polyester biomaterial modifies the memory of Gore-Tex, making its manipulation in the operative field easier. Clear exposure of the defect edges, proper orientation of the prosthesis, sufficient overpass, firm fixation to the abdominal wall, and division of all adhesions are essential requirements for a successful repair.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Robotic surgery and training: electromyographic correlates of robotic laparoscopic training

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Abstract
Background: Robotic laparoscopic surgery has been shown to decrease task completion time, reduce errors, and decrease training time, as compared with manual laparoscopic surgery. However, current literature has not addressed the physiologic effects, in particular muscle responses, to training with a robotic surgical system. The authors seek to determine the frequency response of electromyographic (EMG) signals of specific arm and hand muscles with training using the da Vinci Surgical System.
Methods: Seven right-handed medical students were trained in three tasks with the da Vinci Surgical System over 4 weeks. These subjects, along with eight control subjects, were tested before and after training. Electromyographic (EMG) signals were collected from four arm and hand muscles during the testing sessions, and the median EMG frequency and bandwidth were computed.
Results: The median frequency and frequency bandwidth both were increased after training for two of the three tasks.
Conclusion: The results suggest that training reduces muscle fatigue as a result of faster and more deliberate movements. These changes occurred predominantly in muscles that were the dominant muscles for each task, whereas the more demanding task recruited more diverse motor units. An evaluation of the physiologic demands of robotic laparoscopic surgery using electromyography can provide us with a meaningful quantitative way to examine performance and skill acquisition.

Key words: da Vinci — Electromyography — Frequency analysis — Laparoscopy — Robotic surgery — Training

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Laparoscopy, a form of minimally invasive surgery, has revolutionized the treatment of abdominal pathologies. The benefits for patients include shorter recovery time with less pain [23], fewer adhesions [10], and better postoperative quality of life [14] than experienced with traditional open procedures. However, manual laparoscopy also has shown several limitations during surgery. These limitations include lack of depth perception, poor camera control, limited degrees of freedom at the instrument tips, and inverted hand–instrument movements [2, 3, 15]. Furthermore, these limitations lead to unnatural and painful surgical postures that result in fatigue for the surgeon [2, 3, 15].

The advent of robotic surgical systems, such as the da Vinci Surgical System (dVSS; Intuitive Surgical, Inc., Sunnyvale, CA, USA), have overcome some of the limitations associated with manual laparoscopy. The addition of three-dimensional visualization has provided depth perception [6] and increased dexterity [16, 17]. Wristlike articulations of the instruments also have been shown to improve surgeons' dexterity [16]. Coordinated hand–instrument movements have reduced the training time for robotic systems versus manual laparoscopy [5]. In addition, tremor abolition and motion scaling have been shown to enhance dexterity with the use of robotic systems, as compared with manual techniques [16].

Studies comparing robotic surgical systems with manual laparoscopy have examined the effectiveness of robotic procedures. Researchers have found that with the use of robotic systems, surgeons improve in dexterity [16] and residents can be trained more quickly [5, 7, 12]. In addition, there are fewer errors, and the time required for task completion is reduced [11, 13, 16, 20, 22]. However, the current means of evaluating surgical performance and skill acquisition during training are limited to measurement of task completion time and the number of errors [11, 13, 16, 20, 22], or to subjective evaluation by an expert.

To our knowledge, no studies have examined physiologic measures of surgeons during the performanee of robotic surgical techniques. In manual laparoscopy, physiologie evaluations have been limited mainly to ergonomie measures [2, 3, 15]. These studies have found increased stress and fatigue associated with manual laparoscopy because of the surgeons' postures. Additionally, Quiek et al. [21] investigated electromyography during manual laparoscopy and found that both the task and the type of grasper used contributed to musele fatigue. This type of analysis has not yet been eonducted for robotic surgery.

Thus, it is not known whether robotic surgery leads to increased fatigue. Most importantly, it is not known whether training has an effect on fatigue. Electromyography can assist in the evaluation of physiologic muscular fatigue [1]. Specifically, frequency analysis of the electromyographic signals from the muscles involved has proved to be an effeetive method for measuring muscle fatigue and motor unit reeruitment during static force exertion [1]. Specifically, increased muscle fatigue is associated with a decreased median frequency of the power spectrum [1, 4]. In addition, increases in the frequeney bandwidth of the power spectrum imply additional recruitment of motor units with varying conduction velocities [8, 9].

More reeently, it has been shown that frequency analysis also can be applied to cyclic dynamic tasks to evaluate muscular fatigue [4]. Hypothetieally, training should decrease muscular exertion (i.e., median frequency) during surgery and thus improve the ability of the surgeon to operate. Therefore, this study sought to determine how muscle responses change during training with the dVSS.

Methods and materials

Subjects

For this study, 15 novice dVSS users consisting of first- and second-year medical students (11 men and 4 women, ages 25.3 ± 2.6 years) at the University of Nebraska Medical Center (UNMC) were recruited. All the participants were right-handed. Informed consent was obtained from each subject before participation in accordance with the Institution Review Board of UNMC.

Tasks

Subjects performed or practiced three tasks throughout this study: himanual carrying, needle passing, and suture tying. The bimanual carrying task required that two 15 × 2 mm ruhber pieces (one each with left and right graspers) be picked up simultaneously from 30 mm (diameter) metal caps and placed in two other metal caps 50 mm away (Fig. 1A). The caps were arranged in a square configuration such that the left graspers removed pieces from the top left cap and placed them in the hottom left cap. The right grasper removed pieces from the bottom right cap and placed them in the top left cap. The subject repeated the movement six times in succession. The needle-passing task required that a 26 mm surgical needle he passed through six holes in a latex tuhe (Fig. 1B). The suhjects started from the proximal holes and proceeded in order to the distal holes. The suture tying task required that a 150 × 0.5 mm surgical suture he passed through one of the holes in the latex tube and that three knots be tied using the intracorporeal knot (Fig. 1C). All three tasks were cyclic tasks designed to mimic actual laparoscopic tasks that require significant himanual coordination.

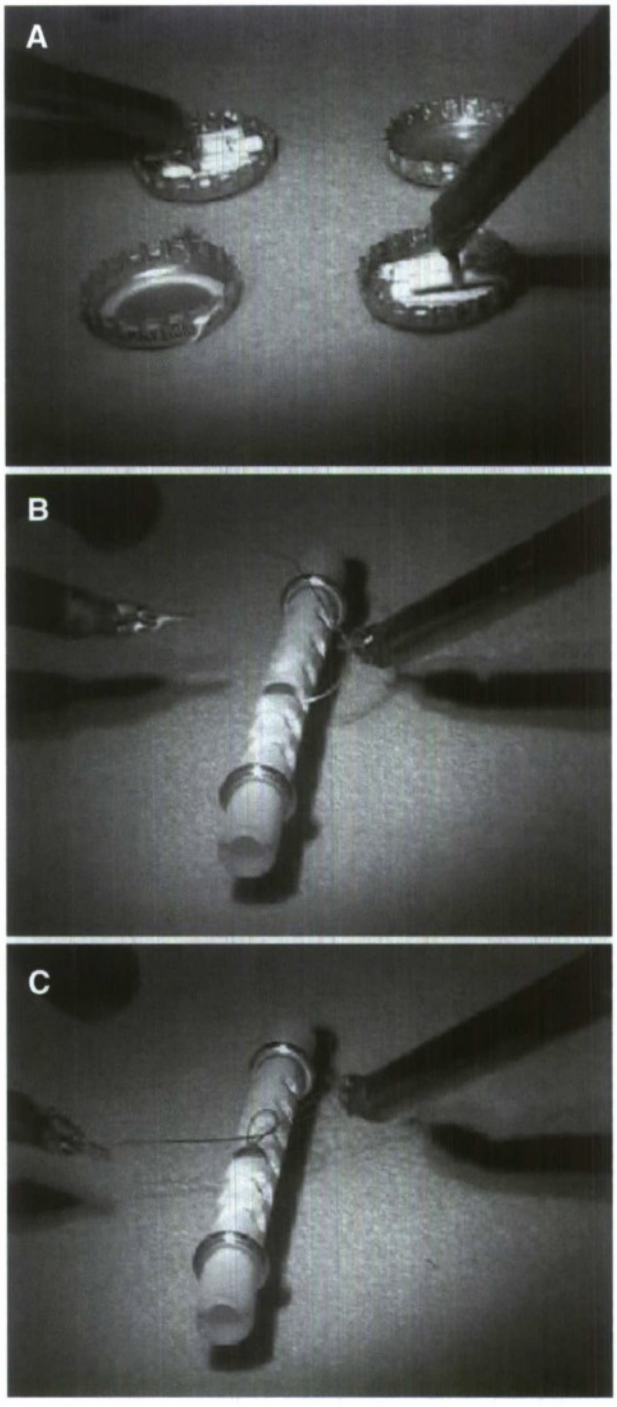

Fig. 1. Experimental tasks. **A** Bimanual carrying. **B** Needle passing. **C** Suture tying.

Experimental protocol

Before performing the experiment, the suhjects were randomly assigned to one of two groups: a training (7 subjects) or a control (8 suhjects) group. The experiment was performed over a period of 4 weeks and consisted of one pretraining test (PRE), six training sessions, and one posttraining test (POST). The control subjects did not perform the six training sessions.

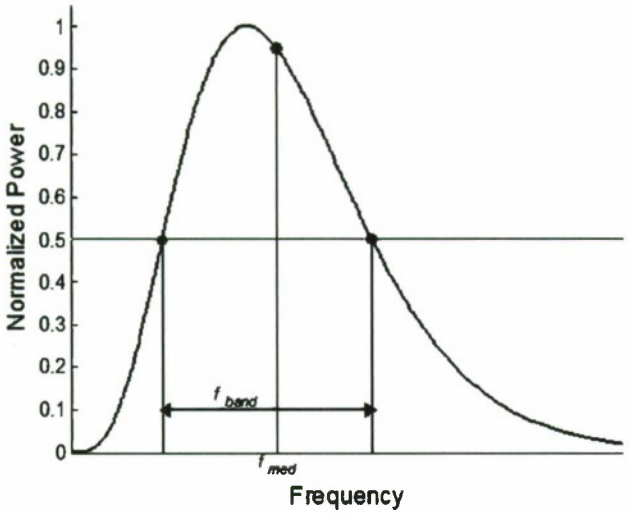

Fig. 2. Median frequency and bandwidth for idealized power spectrum. Median frequency is the frequency at half of the total power. Frequency bandwidth is the difference between the maximum and minimum frequency when the power is greater than 1/2 the maximum power. In this figure, the maximum power is 1.

Pretraining test

During the first week, the subjects performed one pretraining test. At the beginning of the test, the subjects were given a verbal explanation of each task and allowed to practice the three tasks for 5 min at their own pace. During the practice, the subject could ask questions and receive further explanation and suggestions from the investigators. After the practice, the subjects performed one trial for each task while electromyographic signals were recorded.

Training sessions

Within 3 days after the pretraining test, the subject started the training sessions, which were scheduled on a per subject basis. Each training session lasted no more than 45 min, and each task was practiced three to four times. During practice, the subjects were allowed to ask questions and receive verbal explanation and suggestions from the investigators. At the end of the session, the subjects performed one trial for each task while electromyographic signals were recorded.

Posttraining test

During the last week and within 3 days after the sixth training session, a posttraining test was performed with the same procedures as in the pretraining session.

Electromyography

The electromyographic data were collected using DelSys Bagnoli (Delsys, Inc., Boston, MA, USA) surface electromyography (EMG) and sampled at 1,000 Hz through the PEAK Motus (Peak Performance Technologies, Englewood, CO, USA) data acquisition system. Surface electrodes were placed over the bellies of the following four muscles as described by Basmajian and Deluca [1]: flexor carpi radialis, extensor digitorum, biceps brachii, and triceps brachii. We chose the flexor carpi radialis as a primary wrist flexor muscle, the extensor digitorum as a primary wrist extensor muscle, the biceps brachii as a primary elbow flexor muscle, and the triceps brachii as a primary elbow extensor muscle, all of which are superficial and can be monitored by a surface EMG system. Although many other types of movements (e.g., flexion and extension of thumb, index, and middle fingers; forearm pronation and supination), and thus many other muscles, are involved, we assumed that the contributions of these four muscles in the three tasks are considerably high, and thus that measuring the EMG activities of these muscles was important for the purpose of this study.

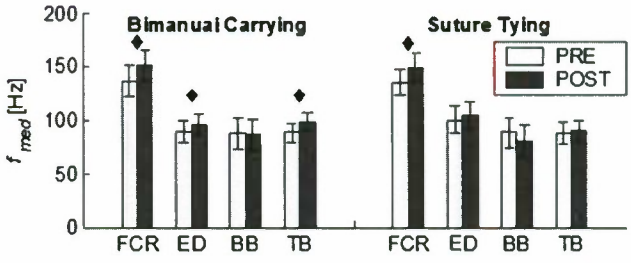

Fig. 3. EMG median frequency. **A** Bimanual carrying task. **B** Suture tying task. A diamond indicates a significant difference ($p < 0.05$) between PRE and POST. Error bars are two standard errors.

Data analysis

Frequency power spectrums for the signals of each muscle during each task were calculated using fast-Fourier transforms. The median frequency and bandwidth were calculated to measure the frequency response of each muscle during all three tasks for the PRE and POST conditions. The median frequency was calculated as

$$\int_0^{f_{med}} P(f)\,df = \int_{f_{med}}^{f_{max}} P(f)\,df$$

where f_{med} is the median frequency, f_{max} is the maximum frequency of the power spectrum (500 Hz), and $P(f)$ is the power at a frequency f (Fig. 2).

Bandwidth was calculated by determining the difference between the minimum and maximum frequencies when the power exceeded one-half of the maximum power of the frequency spectrum (Fig. 2). All data were processed in MATLAB (The MathWorks, Inc., Concord, MA, USA).

Statistical analysis

A mixed two-factor (group by condition) analysis of variance with repeated measures on the condition factor was used to compare the group means of the median frequency and bandwidth for each muscle and for each task. All statistical analyses were performed using SPSS 12.0 (SPSS, Chicago, IL, USA).

Results

Bimanual carrying

Significantly larger median frequencies were found after training for the flexor carpi radialis ($p = 0.046$), extensor digitorum ($p = 0.033$), and triceps brachii ($p = 0.030$) muscles in both groups (control and training; Fig. 3, left). The flexor carpi radialis had a median frequency of 136.6 ± 7.3 Hz for PRE and 151.8 ± 7.3 Hz for POST. The extensor digitorum had a median frequency of 89.6 ± 5.2 Hz for PRE and 96.1 ± 5.2 Hz for POST. The triceps brachii had a median frequency of 88.4 ± 4.5 Hz for PRE and 98.7 ± 4.5 Hz for POST. No significant differences were found in the median frequency between the two groups. No significant differences were found for the frequency bandwidth.

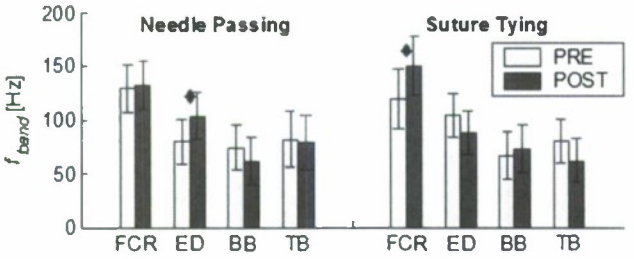

Fig. 4. EMG bandwidth. **A** Needle passing task. **B** Suture tying task. A diamond indicates a significant difference ($p < 0.05$) between PRE- and POST-training. Error bars are two standard errors.

Needle passing

No significant differences were found for the median frequency across the two conditions for the two groups. A significant increase in frequency bandwidth was found after training for the extensor digitorum muscle (PRE, 79.9 ± 10.7 Hz; POST, 104.0 ± 10.7 Hz; $p = 0.017$) in both groups (Fig. 4, left). No significant differences were found between the two groups.

Suture tying

A significant increase in median frequency was found after training for the flexor carpi radialis muscle (PRE, 135.3 ± 6.3 Hz; POST, 149.6 ± 6.3 Hz; $p = 0.021$) in both groups (Fig. 3, right). A significant increase in frequency bandwidth also was found after training for the flexor carpi radialis muscle (PRE, 119.6 ± 14.0 Hz; POST, 150.9 ± 14.0 Hz; $p = 0.023$) in both groups (Fig. 4 right). No significant main effects (PRE/POST or group) were found for the frequency bandwidth. However, a significant interaction effect was found for the biceps brachii ($p = 0.015$; Fig. 5). For the control group, the bandwidth was found to be 84.7 ± 15.0 Hz for PRE and 53.4 ± 15.0 Hz for POST. For the training group, the bandwidth was found to be 48.3 ± 16.1 Hz for PRE and 92.3 ± 16.1 Hz for POST. This result indicated a differential response between the two groups for this task and for this muscle.

Discussion

Previous research has shown that robotic laparoscopic surgery is beneficial for both the patient and the surgeon. Patients recover faster with less pain [10, 14, 23], and surgeons can perform tasks faster [11, 13, 17–20, 22] and can be trained more easily [5, 7, 12] than with manual laparoscopy. However, the physiologic impacts of robotic surgery are not clearly understood.

In the current study, training with the dVSS generally increased the median frequency of the EMG power spectrum in the performance of bimanual tasks. This frequency shift has two likely causes. According to the available literature [11, 13, 17–20, 22], training results in shorter task completion times. Therefore, in the current study, each movement within a task occurred at a higher frequency, allowing completion of the task in a shorter time. These faster movements resulted in muscle bursts occurring at a higher frequency. In addition, findings have shown that a decrease in median frequency is associated with muscle fatigue during sustained contraction (for review, see [1]). Training may increase efficiency in the performance of a task, thereby reducing muscle fatigue. One or both of these factors resulted in the frequency shift.

Findings also showed that this frequency shift occurred independently of the subject's group (control or training). A possible explanation of this result is that the control group also had some training effects. Our previous pilot work showed that decreases in task completion time are possible even after one training session. Thus, it is not surprising that the control group also performed the tasks faster in just their second session (posttraining). Because EMG was not collected during the training sessions, this cannot be confirmed.

The frequency content of electromyograms also is directly related to the conduction velocities of recruited motor units [9]. It is well known that type 1 and type 2 muscle fibers have different conduction velocities [8]. Therefore, it can be inferred that a larger frequency bandwidth is indicative of a larger range of recruited motor units with different conduction velocities (i.e., different muscle fibers). We found that the EMG bandwidth had increased during the needle passing (extensor digitorum) and suture tying (flexor carpi radialis) tasks after training, as compared with pretraining. Furthermore, during the suture tying task, EMG bandwidth for the biceps brachii had increased after training for the training group, and had decreased after training for the control group, as compared with pretraining. These results suggest that subjects recruited a larger range of motor units with varying conduction velocities during training.

However, the bimanual carrying task showed no significant changes in EMG bandwidth. Because the bimanual carrying task requires more simplistic movements, as compared with the more complex the needle passing and suture tying tasks, the larger range of conduction velocities may be associated with more complex movements. It is possible that different motor units are recruited during different phases of the task depending on the precision needed for each phase. For example, looping the suture during the suture tying task may recruit different motor units than pulling the suture taut to finish the knot. Further analyses of the phases of the tasks are necessary to confirm this hypothesis and identify proper training tasks.

The findings also showed that when a significant difference in median frequency or bandwidth was found, it occurred in muscles that would be used predominantly for the given task. During the bimanual carrying task, the median frequency increased for the muscles used for grasping (flexor carpi radialis) and arm movements (biceps brachii and triceps brachii). Likewise, the median frequency for the flexor carpi radialis had increased after training during the suture-tying task, a grasping intensive task. Although care was taken to minimize electrode placement, future studies will monitor muscle

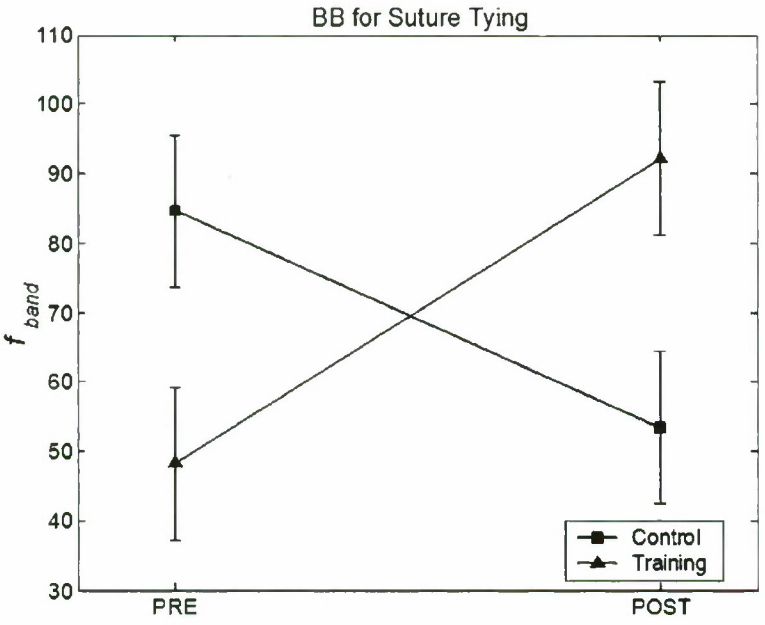

Fig. 5. Bandwidth interaction effects of biceps brachii during suture tying task. The control group decreased bandwidth POST-training while the training group increased bandwith POST-training. Error bars are two standard errors.

responses over a single session to confirm that changes in median frequency are attributable to reduced muscle fatigue and not other factors.

Bandwidth increases were found after training for the extensor digitorum during the needle passing task and for the flexor carpi radialis and biceps brachii during the suture tying task. For the needle passing task, a "hooking" motion is used to pass the needle through the latex tube, requiring more precise control of the fingers. Therefore, it is possible that different motor units may be recruited in the extensor digitorum to control the movement. The suture tying task requires fine control of grasping as well as looping of the suture for tying the knot. Therefore, bandwidth increases for the flexor carpi radialis and biceps brachii would be expected. It is worth mentioning that such detail in the examination of the different surgical tasks and the muscles involved will not be possible without the acquisition of physiologic measures, specifically electromyography. This verifies that future studies need to use our methodology to further establish learning and proficiency criteria for robotic surgical performance.

In conclusion, surgical training increased the median frequency response as a result of increased speed, reduced fatigue, or both during each task. These increases occurred predominantly in muscles that were the dominant muscles for each task. Additionally, the more demanding task recruited more diverse motor units, as shown by increases in bandwidth after training. It is evident that an evaluation of the physiologic demands of robotic laparoscopic surgery using electromyography can provide us with a meaningful quantitative way to examine performance and skill acquisition. In our future work, we plan to include a group of expert surgeons and more realistic tasks (i.e., data collection during actual robotic laparoscopy) to further understanding of the physiologic demands of robotic surgery. We also propose that future studies should record EMG from both arms simultaneously for direct determination of bimanual coordination.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Retroperitoneal hand-assisted laparoscopic surgery for endoscopic adrenalectomy

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Abstract
Although hand-assisted laparoscopic surgery (HALS) is very common in various laparoscopic procedures, it is rarely used for retroperitoneal endoscopic adrenalectomy because of the small working area. The authors evaluate HALS in endoscopic adrenalectomy with respect to its use as a rescue procedure in complicated cases. In their department, 47 patients underwent endoscopic adrenalectomies between 1998 and 2004. Mainly because of complicated anatomy, three primary aldosteronism cases were converted to retroperitoneal HALS. This involved making an additional 6 cm skin incision, into which the surgeon's left hand was inserted, with the palm used to create a sufficient visual field and working area. The fingers were used for tactile sensation and blunt resection. For these three cases, successful retroperitoneal HALS in endoscopic adrenalectomy resulted in no mortality or morbidity. These findings indicate that this procedure is a feasible technique for complicated benign adrenal tumor cases.

Key words: Endoscopic adrenalectomy — HALS — Retroperitoneal approach

Endoscopic adrenalectomy has been considered the standard surgical excision procedure for benign adrenal tumors during the past decade. Since the initial report of its use in 1992, this procedure has become a feasible, minimally invasive method for benign adrenal tumors [5]. Transperitoneal and retroperitoneal approaches are the two principal laparoscopic routes to the adrenal gland. Although the transperitoneal approach is used more widely, the retroperitoneal approach offers particular advantages [1, 3, 4, 6, 12, 13, 18–20, 22].

Hand-assisted laparoscopic surgery (HALS) is an established alternative procedure in various types of laparoscopic surgery [9, 10, 14, 15, 21], including transperitoneal endoscopic adrenalectomy [2, 8, 16, 17]. However, HALS is rarely performed in retroperitoneal endoscopic adrenalectomies because of the narrow working area.

In this report, we describe the details and distinct advantages of retroperitoneal endoscopic adrenalectomy using HALS. In particular, the use of HALS completely compensates for disadvantages otherwise encountered in retroperitoneal endoscopic adrenalectomy, such as disorientation, narrow working area, absence of tactile sensation, and technical limitations.

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Table 1. Profile of the cases for endoscopic adrenalectomy by year

	Transperitoneal approach (*n*)	Retroperitoneal approach (*n*)	Conversion to open surgery (*n*)	Total
1998–2000	9	3	1	12
2001–2002	5	6		11
2003–2004	3	21		24
Total	17	30	1	47

Patients

From 1998 to 2004, 47 patients (25 men and 22 women; mean age, 49.4 years) underwent endoscopic adrenalectomies in the Department of Surgery, Jichi Medical University, Tochigi, Japan). The cases included 28 primary aldosteronisms, 11 Cushing's syndromes, 6 nonfunctioning adenomas, and 2 pheochromocytomas. The transperitoneal route was first applied to reach the adrenal gland as other abdominal organs assisted with orientation in the abdominal cavity. However, we sometimes encountered troublesome situations in the process of transperitoneal operation, especially in fatty cases or cases with a previous abdominal surgical procedure.

In 2000, we experienced a case of conversion to open surgery, which led to the gradual introduction of the retroperitoneal approach, which became the standard method after 2003 (Table 1). During the current study of 30 retroperitoneal endoscopic adrenalectomies, three were converted to HALS, mainly because of complicated anatomy (Table 2). The mean surgery time was 159 min, and the average blood loss was 138 ml in the 47 cases.

Retroperitoneal hand-assisted laparoscopic adrenalectomy technique

Initially, all patients underwent a standard retroperitoneal endoscopic adrenalectomy using four trocars in the lateral bending position

Table 2. Cases converted to hand-assisted laparoscopic surgery (HALS) in endoscopic adrenalectomy

Site	Route	No. of cases	Cases converted to HALS	Mean operation time (min)	Average blood loss (ml)
Right	Transperitoneal	13	2	166	302
	Retroperitoneal	7	1	192	105
Left	Transperitoneal	4	0	203	228
	Retroperitoneal	23	2	148	34
Total		47	5	159	138

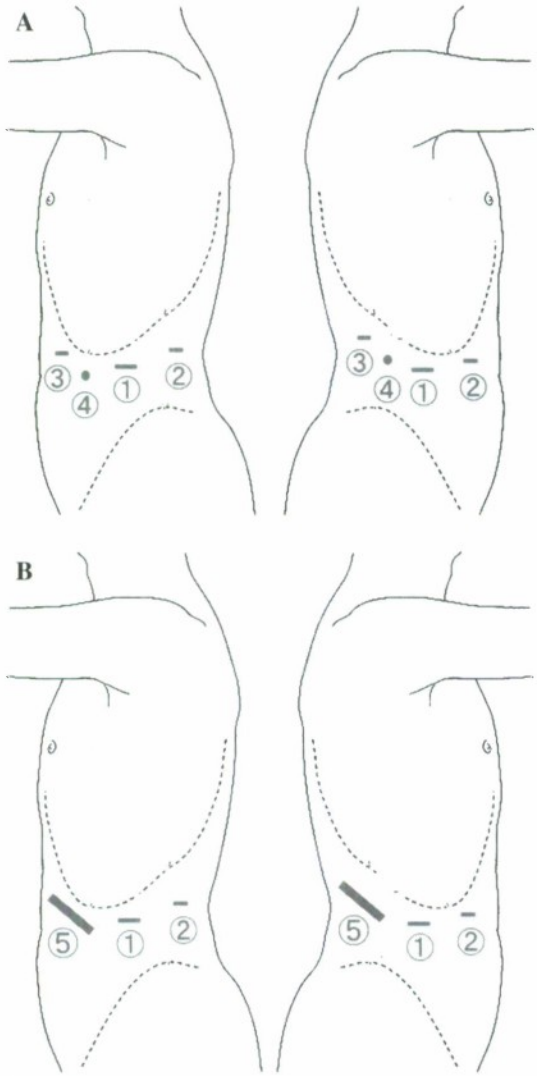

Fig. 1. a Placement of laparoscopic ports: (1) 12 mm port for videoscope, (2 and 3) 5 mm port for tissue manipulators and forceps, (4) 2 mm port for fine forceps. **b** In the conversion to hand-assisted laparoscopic surgery (HALS), an additional 6 cm skin incision (5) was made between the two left trocar incisions.

(Fig. 1a). The first 12 mm trocar for videoscope use was placed just beneath the 11th rib in the midaxillar line. After tissue expansion using a balloon dilator and pneumoretroperitoneum, three additional trocars (two 5 mm and one 2 mm) were inserted for tissue manipulation. Three such cases were converted to HALS.

The decision to convert depended on an assessment made 2 h after the commencement of surgery. The laparoscopic procedure was continued if it appeared that the tumor could be removed within the next hour. Otherwise, surgeons reverted to the HALS approach.

For HALS, a 6 cm skin incision was made between the two left trocar incisions, and the left hand of the surgeon was inserted in an air-tight manner (Fig. 1b). The skin incision was kept as small as possible and extended to the lateral side if necessary for the convenience of the left hand maneuver. Afterward, only the 12 mm trocar for the endoscope and the 5 mm trocar for a manipulator were used for the HALS procedure. The operator stood at the right side of the patient for the right tumor, and at the left side for the left tumor.

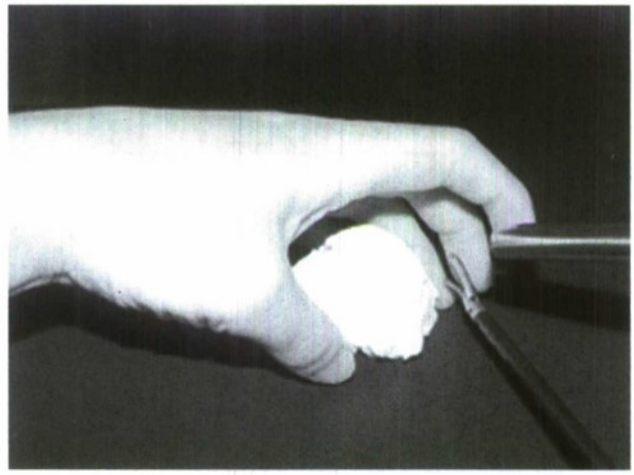

Fig. 2. Use of the surgeon's left fingers and palm. The thumb, ring finger, and little finger are used to hold the tumor; the forefinger and middle finger are used as blunt manipulators and to operate the forceps; and the palm is used as a working area and to create a visual field.

The HALS approach involves two important factors. The movement and positioning of the surgeon's left hand is critical, and the volume of the retroperitoneal space is approximately that of a fist. A key feature of retroperitoneal HALS is that the thumb, ring finger, and little finger are used to hold the tumor, the forefinger and middle finger are used as blunt manipulators and forceps, and the palm is the working area (Fig. 2). The position of the videoscope is adjusted for the use of two fingers to dissect connective tissue and to visualize vessels and the adrenal gland clearly. Small vessels are dissected using a harmonic scalpel, and the central vein and arteries are dissected using surgical clips (Fig. 3a and b).

The HALS technique was completed uneventfully, with no cases of mortality or morbidity. Dissection proceeded promptly and safely. All dissection points were clearly visualized, and tactile sensation resulted in reduction of the surgery time otherwise required. The additional surgery times required for HALS in the three cases were 47, 44, and 51 min, and the postoperative hospitalization times were 4, 6, and 8 days, respectively.

Discussion

The current report describes the use of retroperitoneal HALS in endoscopic adrenalectomy as a rescue procedure for technically or anatomically complicated cases. The HALS technique, a common and established procedure for various laparoscopic operations, provides significant advantages over the purely laparoscopic approach, such as safer and better manipulation, reduced

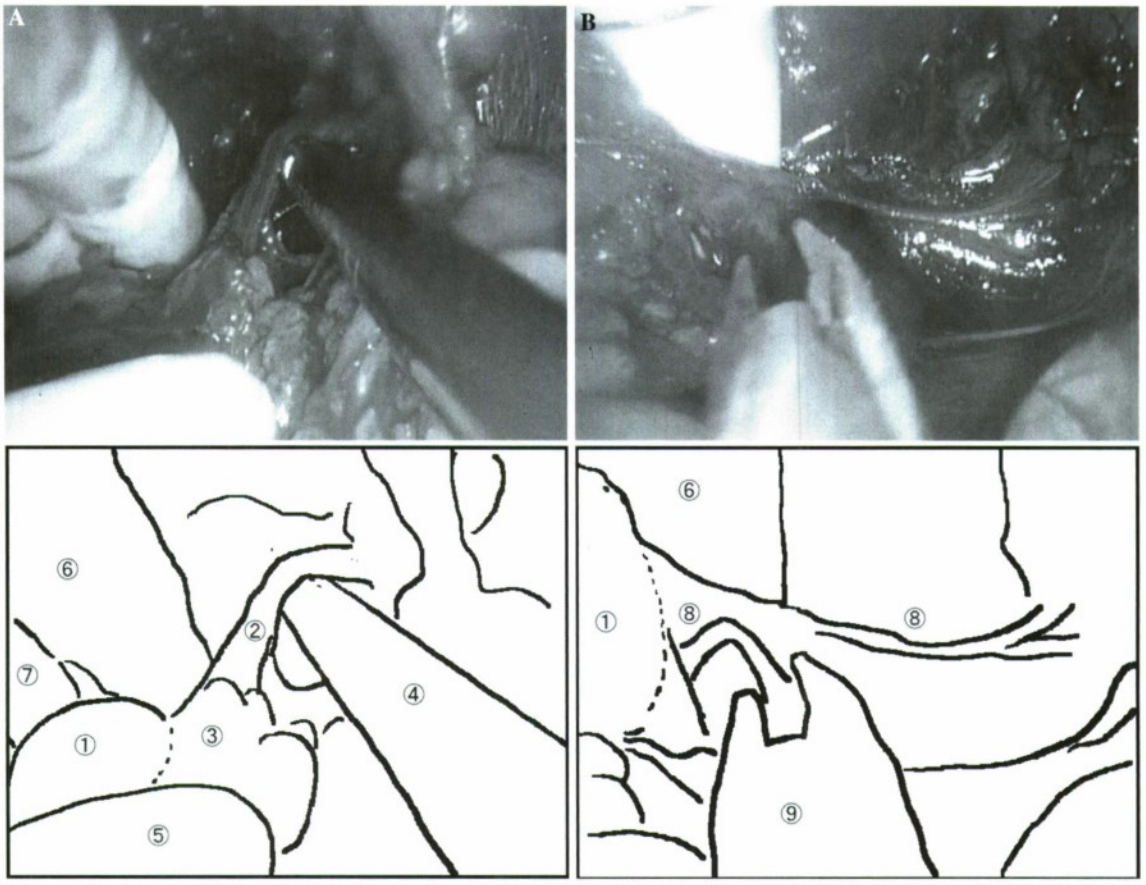

Fig. 3. Intraoperative views during retroperitoneal hand-assisted laparoscopic surgery (HALS) in endoscopic adrenalectomy. **a** Dissection of the central vein. **b** Dissection of the arteries. (1) adrenal adenoma, (2) central vein, (3) adrenal gland, (4) harmonic scalpel, (5) surgeon's thumb, (6) surgeon's middle finger, (7) surgeon's ring finger, (8) adrenal arteries, (9) surgical clip).

time and costs, and minimal additional overload. However, HALS is not commonly used for endoscopic adrenalectomy, especially for retroperitoneal approaches.

Bennett and Ray [2] first reported successful transperitoneal HALS in endoscopic adrenalectomy. They concluded that transperitoneal HALS is a feasible and less invasive alternative procedure for larger tumors and potentially malignant lesions. Although the abdominal cavity is large enough for placement of a hand port and insertion of a hand, the retroperitoneal space was not thought to be suitable for HALS because of its limited working area and visual field.

Retroperitoneal endoscopic adrenalectomy has several advantages over its transperitoneal counterparts. It minimizes intraabdominal adhesions, subsequent bowel obstruction, and injury to the abdominal organs. Several studies have concluded that both methods are equally feasible for removal of adrenal tumors [13, 19, 20]. A very cautious view is that the major disadvantage of retroperitoneal endoscopic adrenalectomy is disorientation, because surgeons can have trouble locating the adrenal gland, which increases stress associated with the procedure.

We found that retroperitoneal HALS provided for easy orientation with tactile sensation, and thus completely compensated for the disadvantages otherwise associated with the retroperitoneal approach. For dissection within a small area, special left hand and finger techniques are required. With complete understanding of the technique, most surgeons can easily perform retroperitoneal HALS.

In the current cases, HALS required approximately 50 additional minutes and did not affect the duration of the postoperative hospital stay. If cases requiring HALS were selected more quickly, operation time could be saved as well as overload to the patients. Intraoperative events, such as location of the kidney and the central vein as well as accidental puncture of the peritoneum, are possible factors that could predict the need for conversion to HALS. Additionally, three-dimensional images of the adrenal gland and surrounding organs generated by preoperative multidetector raw computed tomography (CT) scan would work as a navigator for endoscopic adrenalectomy, possibly predicting the needs of HALS [21, 22].

The major advantage of laparoscopic adrenalectomy over open adrenalectomy is undoubtedly reduced postoperative pain and shorter hospitalization. In our department, a clinical pathway involving 4 days of postoperative hospitalization is applied to endoscopic adrenalectomy. Two of the current patients were discharged as scheduled, and the other patient was discharged on postoperative day 8, mainly because of family and social reasons.

In conclusion, retroperitoneal hand-assisted endoscopic adrenalectomy is feasible and can be used as an aid in the retroperitoneal approach, with intraoperative tactile localization of the adrenal gland. This procedure is especially applicable for anatomically complicated cases and for surgeons unfamiliar with the retroperitoneal route.

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Letters to the editor

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

An alternative gallbladder extraction technique in laparoscopic cholecystectomy

Abstract. In this era of minimally invasive surgery, the challenge remains in finding techniques to reduce access trauma in terms of fewer and smaller size trocar ports. Our new described technique will allow a smaller subxiphoid port to be used to achieve extraction of the gallbladder without the need to change to a 5 mm laparoscope. We believe this method is easy to learn, safe and with no observable complications from our experience.

Key words: Gallbladder extraction — Laparoscopic cholecystectomy

We were very interested to read the recent article by Machado and Herman (Surg Endosc 2004; 18: 1289–1290) on the technique of removing the gallbladder during minilaparoscopic cholecystectomy [4]. We agree that it is a simple and cheap method of extraction using a self-made retrieval bag from a readily available surgical glove. We would like to ask the authors whether it is their usual practice to close the bag prior to delivery under direct vision? If not, should the operating surgeon be concerned with the possibility of spillage of infected bile or stones? We would like to describe our routine method of gallbladder extraction that is also simple to use and avoids the use of a 5-mm laparoscope. This method can be applied in laparoscopic cholecystectomy using the two- or three-trocars technique and can also be used in other laparoscopic procedures requiring specimen extraction, for example; laparosopic appendicectomy.

We perform laparoscopic cholecystectomy (LC) with the standard four-port method—three 5-mm right subcostal ports and one 10-mm subumbilical port. The method of gallbladder resection has been described previously. A manufactured extraction bag (Medical Technical Promotion, Dr. Karl-Storz, Tuttlingen, Germany) is used in cases where the gallbladder is severely inflamed, perforated (spontaneous or iatrogenic), or suspected to be malignant [2]. The use of an extraction bag is to reduce the amount of bile or stone spillage into the peritoneal cavity. It also serves to avoid the well-recognized port-site metastases in cases of malignancy [3].

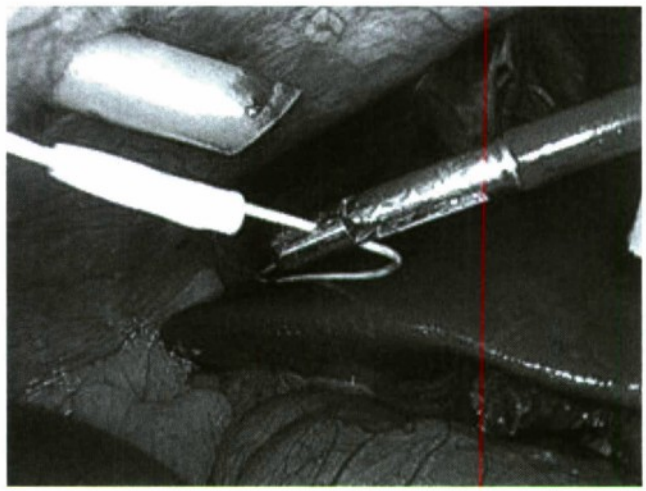

Fig. 1. Closing string of the extraction bag is grasped with forceps introduced from the subxiphoid port.

The retrieval stage consists of first closing the extraction bag intracorporally by tightening the closing string. Then the forceps, inserted via the subxiphoid port, is used to grasp the end of this closing string (Fig. 1). While holding the closing string, the forceps can be advanced in a retrograde direction through the subumbilical port under direct vision by careful alignment (Fig. 2). It is usually easier for a single surgeon to perform this step as shown in the figure. The 10-mm subumbilical port is removed and the specimen can then be safely extracted with or without dilating the wound or extending the incision (Fig. 3).

This alignment technique can be applied to retrieve the gallbladder in uncomplicated elective cases where extraction bags are not necessary. Instead of grasping the closing string of the bag, a lengthened suture (at least 5 cm), used to ligate the cystic duct, can be used to advance through the subumbilical port.

In this era of minimally invasive surgery, the challenge remains in finding techniques to reduce access trauma in terms of fewer and smaller-size trocar ports. Our new described technique will allow a smaller subxiphoid port to be used to achieve extraction of the gallbladder without the need to change to a 5-mm laparoscope. We also recommend the use of a durable

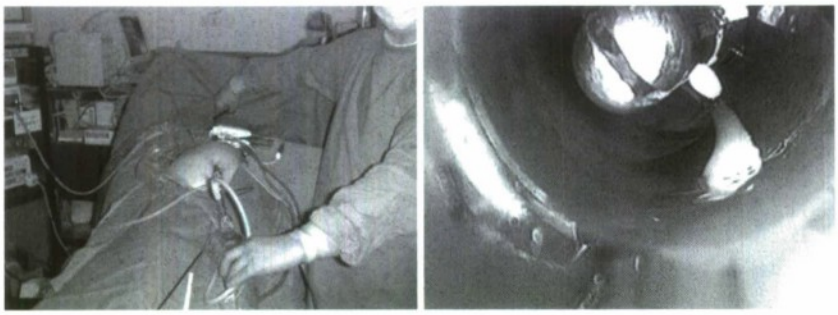

Fig. 2. Alignment of forceps and laparoscope (external view, left). Forceps is advanced through the subumbilical port under direct vision (internal view, right).

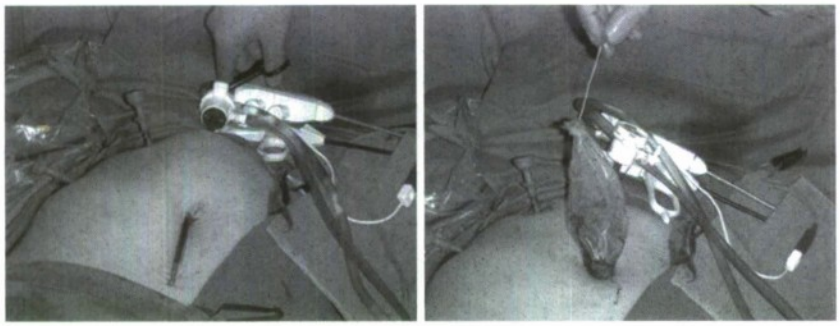

Fig. 3. Subumbilical trocar removed (left). Extraction bag removed (right).

extraction bag, particularly for large stones, so as to allow various fragmentation techniques to be safely employed [1]. We believe this method is easy to learn, safe, and with no observable complications from our experience.

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SURGICAL ENDOSCOPY
and Other Interventional Techniques

A correlation between the shape of the epiglottis and obstructive sleep apnea

Abstract
The incidence of Obstructive Sleep Apnea (OSA) is increasing with the rise in the prevalence of obesity in the population. Upon performing esophagogastroduodenoscopy (EGD) on more than 50 patients with BMI ranging from 21 to 63, we noticed an increase in the concavity of the posterior surface of the epiglottis in correlation with the increase in BMI. Since OSA is caused by collapse of the airways, this same pressure seems to be responsible for the deformity of the epiglottis, which normally has a minimally concave posterior surface. Therefore the shape of the epiglottis reflects the degree of airway collapse and thus the severity of OSA. We recommend that patients with increased concavity of the posterior epiglottal surface seen endoscopically should be tested for OSA.

Key words: Epiglottis — Concavity — Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is a sleep disorder characterized by recurrent episodes of partial or complete closure of the upper airway during sleep [2]. This disease affects 2% to 4% of middle-aged men and 1% to 2% of middle-aged women in Western countries, with the majority of affected individuals remaining undiagnosed. In one survey, as many as 82% to 92% of people with symptoms of moderate to severe OSA were not diagnosed [1].

During sleep, muscle relaxation in the upper airways and diminished reflexes lead to partial airway collapse in all people. In normal individuals, this minor airway collapse has no major effect on the airflow. However, in patients with OSA, the airway collapse can be severe, leading to partial or complete obstruction [6]. In 80% of patients, this airway obstruction involves the retroglottal region. This has been confirmed by magnetic resonance imaging (MRI) and dynamic fiberoptic pharyngoscopy [4]. The compromise of airflow manifests as snoring, apneic episodes, and chronic nighttime hypoxemia, leading to significant complications including systemic and pulmonary hypertension, cor pulmonale, and many other pathologies.

Obstructive sleep apnea should be suspected in patients who exhibit loud snoring; episodes of apnea, choking, or gasping witnessed during sleep; hypertension; a neck circumference of 17 inches or greater; a high body mass index (BMI); and laterally narrowed oropharynxes. The diagnosis of OSA can be established by polysomnography [5].

In an MRI study of patients with OSA, it was found these patients have excess fat deposition, most often located anterolateral to the upper airway, as compared with control subjects [3]. The marked fat deposition in the neck tissues increases pressure on the airways, contributing to the airway collapse seen in patients with OSA [1].

Observation

Normally, the posterior surface of the epiglottis is slightly concave as seen from above [7]. When we performed esophagogastroduodenoscopy on patients with a variety of BMIs ranging from 21 to 63, we noticed a significant correlation between BMI and the degree of concavity of the posterior epiglottal surface. The posterior surface of the epiglottis in patients with normal BMI was minimally concave. However, the extent of concavity increased proportionally with the increase in BMI, to the point at which total closure of the epiglottis was observed in extreme cases (Fig. 1).

The degree of concavity can be estimated visually without difficulty. A numeric value grading the degree of concavity can be obtained by drawing lines cotangent to the posterior lateral surfaces of the epiglottis and then drawing perpendicular lines from the edge points of the epiglottis as shown in picture A. The angle produced by the intersection of these lines will be equal to the arc constituted by the epiglottis. This angle, which we named "alpha," was approximately 100° in a patient with a BMI of 28. The alpha was 360° in another patient with a BMI of 62.

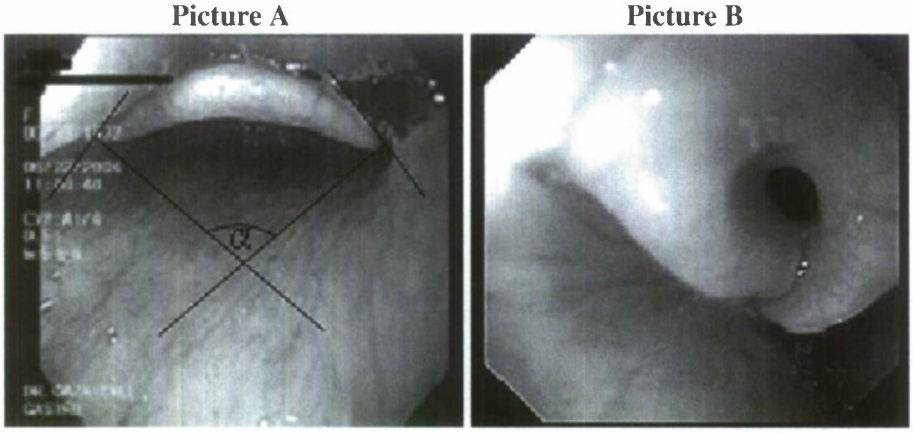

Fig. 1. Comparison between the epiglottis of a patient with a body mass index (BMI) of 28 (**A**) and that of a patient with a BMI of 62 (**B**). The inferior side of the picture represents the posterior pharyngeal wall with the epiglottis anterior to it and the retroglottal space between them.

Conclusion

A positive correlation between high BMI and OSA is well known in the literature [1]. The pressure of the parapharyngeal fat pads and the chronic collapse of the retroglottal airway during sleep create the deformity of the epiglottis observed in patients with OSA. Thus, the shape of the epiglottis seen endoscopically reflects the degree of the chronic airway obstruction. On the basis of this finding, we recommend sleep studies for patients in whom an increased degree of epiglottis concavity is seen during esophagogastroduodenoscopy or nasolaryngoscopy.

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SURGICAL ENDOSCOPY
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The Association of Endoscopic Surgeons of Great Britain and Ireland

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Assistant Professor of Surgery and Co-Director for General Surgery
James Luketich, M.D.
Assistant Professor of Surgery and Co-Director for Thoracic Surgery
The University of Pittsburgh Medical Center
C-800 Presbyterian University Hospital
200 Lothrop Street
Pittsburgh, PA 15213-3221, USA

Geisinger Medical Center Fellowship in Minimally Invasive Surgery

A one-year fellowship in advanced minimally invasive general and thoracic surgery is available at Geisinger Medical Center. The fellowship will involve extensive clinical exposure to UGI, bariatric and thoracic minimally invasive surgery with emphasis on esophageal surgery for benign and malignant disease. Fellows will also participate in clinical outcomes research. Requirements include completion of residency training in general surgery or thoracic surgery. Competitive salary and benefits package including travel allowances are available. Interested candidates are invited to send a letter of inquiry and curriculum vitae to:

Anthony T. Petrick, MD
Director, Minimally Invasive Surgery
Geisinger Medical Center
100 North Academy Avenue
Danville, PA 17821-2111, USA
atpetrick@geisinger.edu

Clinical Fellowship in Laparoscopic Surgery

Mount Sinai School of Medicine, New York, NY, USA
Program Director: Daniel Herron, M.D.

The Mount Sinai Clinical Fellowship in Laparoscopy is a 1-year position offered to two individuals each academic year. Fellows rotate through several clinical rotations, each one emphasizing a different aspect of minimally invasive surgery. During the bariatric rotation, the fellow will gain a broad exposure to laparoscopic gastric bypass, laparoscopic biliopancreatic diversion with duodenal switch and the laparoscopic adjustable gastric band. Additionally, the fellow will learn 2-stage approaches to supermorbid obesity and laparoscopic revisional surgery. In the GI rotation, the fellow joins one of the busiest laparoscopic foregut surgery groups in the East Coast, scrubbing on a large number of fundoplications, paraesophageal hernias, Heller myotomies, and gastroesophageal resections. This rotation also provides a strong experience in laparoscopic partial and subtotal colectomy as well as laparoscopic surgery for Crohn's disease. Solid organ surgery comprises another highlight of the fellowship, with two or more laparoscopic donor nephrectomies performed each week. Fellows will participate in several clinical research projects during the year and will be expected to present their results at a national meeting. Both the Fellowship Director and the Laparoscopic Division Chief have served on the Board of Governors of SAGES and strongly encourage Fellow participation in SAGES courses and committees. Fellows are provided with access to professional-quality video recording and editing equipment, and are formally trained in the use of this equipment to prepare academic video presentations. Numerous opportunities to write review articles and book chapters are available. Fellows will present in both General Surgery and Laparoscopic Surgery Grand Rounds. Fellows play an active role in the education of residents and medical students.

To apply, please visit **www.misfellowshipcouncil.org**.

Advanced Clinical Minimally Invasive Fellowship

Harvard Medical School
Both Israel Deaconess Medical Center
Boston, Massachusetts, USA

Advanced Clinical Minimally Invasive Fellowship with emphasis on Bariatric Surgery, (One-year position begins July 2003). Interested candidates are invited to send curriculum vitae to:

Daniel B. Jones, M.D., F.A.C.S.
Chief, Section of Minimally Invasive Surgery
Harvard Medical School
Beth Israel Deaconess Medical Center
Shapiro TCC 140
330 Brookline Avenue
Boston, MA 02215, USA

Minimally Invasive Surgery Research Fellowships

Mount Sinai Minimally Invasive Surgery Center
Mount Sinai School of Medicine, New York, NY, USA
Center Director: Barry Salky, M.D.

Research fellowships are sponsored by the Mount Sinai MISC for qualified individuals who are interested in an in-residence experience working under the guidance of MISC faculty. The MISC research fellowship program is extremely competitive, and the Center receives numerous applications each year for only a few positions. Applications for research fellowships are accepted up to six months in advance of the expected start date.
For more information on this program (and all Mount Sinai Minimally Invasive Surgery Center activities), please visit www.mssm.edu/misc.

To apply for a research fellowship, contact:

Benjamin Green
Manager
Mount Sinai Minimally Invasive Surgery Center
One Gustave L. Levy Place
Box 1259
New York, NY 10029, USA
E-mail: benjamin.green@mountsinai.org

East Bay (San Francisco Bay Area) Minimal Access Surgery Fellowship

A one-year fellowship starting July 2005 is being offered by the First Surgical Consultants Medical Group, at the Alta Bates Summit Medical Center in Oakland/Berkeley, California, USA. The fellowship

will involve extensive advanced laparoscopic experience as well as clinical research. Approximately 500–550 laparoscopic surgery procedures are performed annually, including bowel resection, hernia surgery, foregut surgery, and solid organ surgery. The fellow will also gain experience in bariatric surgery, use of intraoperative ultrasound, robotic surgery using Da Vinci Robot, as well as open (15–20%) surgery. First Surgical Consultants is an advanced laparoscopic surgery group, in private practice in the East Bay of the San Francisco bay area. The group includes five surgeons and two full-time physician assistants. Requirements for fellowship include completion of surgical residency and California License. Interested candidates are invited to contact:

Ajay Upadhyay, M.D.
Fellowship Co-Director
George Kazantsev, M.D.
Fellowship Co-Director/Medical Director Bariatric Surgery
First Surgical Consultants
365 Hawthorne Avenue, Suite #101
Oakland, CA 94609, USA
Tel.: 510 465 5523
Fax: 510 832 6061
E-mail: Upadhyayak@pol.net

Intensive Courses of Laparoscopic Surgery 2006

Hospital Podlesi
Center of Miniinvasive Surgery
739 61 Trinec, Czech Republic

Contact address:
lada.bystronova@nempodlesi.cz, www.nempodlesi.cz

Head of the course:
Stanislav Czudek, M.D., Ph.D.
24.–26.5.2006
4. –6.10.2006
1. –3.11.2006

1st World Conference on Interventional Oncology

Cernobbio, Italy
12–16 June 2006

Scientific Organizer: Prof. Luigi Solbiati
http://www.wcio2006.com/
Conference Secretariat:
Domm International s.r.l
Via Rossini 1
20122 Milano, Italy
Tel.: +39 02 7779181
Fax: +39 02 76000181

Contact: Stefania Sella, Lorella Filugello

10th World Congress of Endoscopic Surgery
hosted by the EAES and incorporating the
14th International Congress of the European Association for Endoscopic Surgery (EAES)

Berlin, Germany
13–16 September 2006

"Techniques and Technologies for Endoscopic Surgery"

Congress President: Professor Gerhard F. Buess
Congress Secretary: Professor Karl-Hermann Fuchs

Wednesday, 13 September 2006
Postgraduate courses:
Bariatric surgery, Laparoscopic treatment (TAPP-TEP) of inguinal hernia, GERD update 2006, Laparoscopic colorectal surgery, and TEM

Technology symposium:
State of the art systems and process analysis of today's OR, OR systems in practice, Economic constraints, Usability constrains, and OR systems of the future.

Opening ceremony:
Thrusday–Saturday, 14–16 September 2006

IFSES WORLD CONFERENCE SPECIAL TOPIC—LOW BUDGET SURGERY
Featuring a full day symposium focused on "low budget surgery," technologies for developing and emerging countries, surgical procedures, and structures for endoscopic surgery.

TECHNIQUES AND TECHNOLOGIES FOR ENDOSCOPIC SURGERY
Featuring a wide range of topics on the latest information and updates on pathology, surgical techniques, and advances in technologies in endoscopic surgery. Highlighted among these techniques and scientific aspects and technologies and scientific aspects topics will be:

Education topics
Education programmes in MAS around the world: Are training courses helpful in MAS? How can we take the danger out of the surgical learning curve?, and Simulation for training.

Deadlines:
Abstract submission: 1 April 2006
Early Registration: 15 June 2006

Congress Secretariat:
EAES Office
P. O. Box 335
5500 AH Veldhoven
The Netherlands
Tel.: +31 40 252 5288
Fax: +31 252 3102
E-mail: info@eaes.org
Website: www.eaes-eur.org

4th Frankfurter Meeting "Obesity Surgery"
Frankfurter Römer, Frankfurt, Germany
9–10 November 2006

Congress Organization:
Chair: Rudolf A. Weiner, Frankfurt

Congress Secretary:
Sylvia Weiner
Krankenhaus Sachsenhausen
Schulstr. 31
60594 Frankfurt
Tel.: 0049-69-6605-1199 or 1146
Fax: 0049-6605-1510
E-mail: rweiner@khs-ffm.de

Scientific Program includes plenary sessions, conferences, free communications, and live-transmissions from New York and Frankfurt. Advances in all relevant disciplines, such as open and laparoscopic surgery, gastric banding, restriction and bypass, biliopancreatic diversion, gastric stimulation, endoscopy, new and experimental approaches, pre- and postoperative care, long-term results, and clinical, metabolic, and general assistance of morbidly obese surgical candidates will be reviewed.

Program and general information can be found at the website: www.obesity-academy.com

University Postgraduate Course in Laparoscopic Surgery

Victor Babes University of Medicine and Pharmacy Timisoara – Pius Branzeu Center for Laparoscopic Surgery and Microsurgery
Swiss Association for Laparoscopic and Thoracoscopic Surgery
Swiss National Science Foundation

Schedule 2006: October 11–13: Advanced course in digestive surgery
Venue: Timisoara (Romania)
Course's language: English
Course's fees: 800 ECU (accommodations included), with the support of Swiss National Science Foundation
Accreditation: The course is accredited by Romanian College of Physicians and supported by European Association of Endoscopic Surgery (25 credits)

The program of the course includes live demonstrations (held by European experts) and experimental laboratory training in live tissue (pig). All instructors are surgeons with experience in laparoscopic surgery.

For further information please visit our web site (www.umft.ro/pius_branzeu_center) or contact:

Dr Vareus Florian
PB Center for Laparoscopic Surgery and Microsurgery
Piata E. Murgu Nr. 2
RO 300041, TIMISOARA
Tel. 0040724 7444 19, 0041 789 125 349
Email: vareusflorian@yahoo.com

Asia Pacific Hernia Congress

New Delhi, India
6–8 October 2006

The Asia Pacific Hernia Congress & Live Workshop - Second Congress of Asia Pacific Hernia Society in conjunction with Indian Association of Gastrointestinal Surgeons (IAGES) is scheduled to be held in New Delhi from 6–8 October 2006. The Congress is being organized by the Department of Minimal Access Surgery, Sir Ganga Ram Hospital, New Delhi (India)
Speciality sessions will include:

- Pathogenesis of hernia
- Aetiology of recurrent hernias
- Polymers and Biomaterials: Advantages, short comings - present and future
- Biologieal Prosthesis: Indications and Expectations
- Industry Role: Progress towards better patient care
- Evolution in hernia repair: comparison of surgieal techniques
- Abdominal wall closure
- Hernia repairs (Conventional and Endoscopie)
- Inguinal
  - Ventral – primary
  - Ventral – incisional
  - Recurrent hernias

Live Surgical Workshop will include:

- Hiatus hernias
- Diaphragmatic hernias
- Primary tissue repairs
- Mesh based groin hernia repairs
- Recurrent hernia repairs
- Endoscopic hernia repairs
- Laparoscopic IPOM repair for ventral / incisional hernias
- Laparoscopic Peritoneal flap repairs for ventral / incisional hernias
- Difficult hernias

Pre-Congress Master Class & Hands-on training in Endohernia Surgery on 5th October 2006.

For further inquiry, please contact the Congress Secretariat or visit our website www.aphs06.com
Dr. Pradeep Chowbey - Organizing Chairman
AYUSHMAN, Douhle Storey Market, R-Block, New Rajinder Nagar, New Delhi–110060 (India)
Tel.: +91-11-25868768 / 25748085 * Fax.: 91-11-25748085 / 26519935
e-mail.: chowhey1@vsnl.com / info@aphs06.com
wehsite: www.chowbey.com / www.aphs06.com

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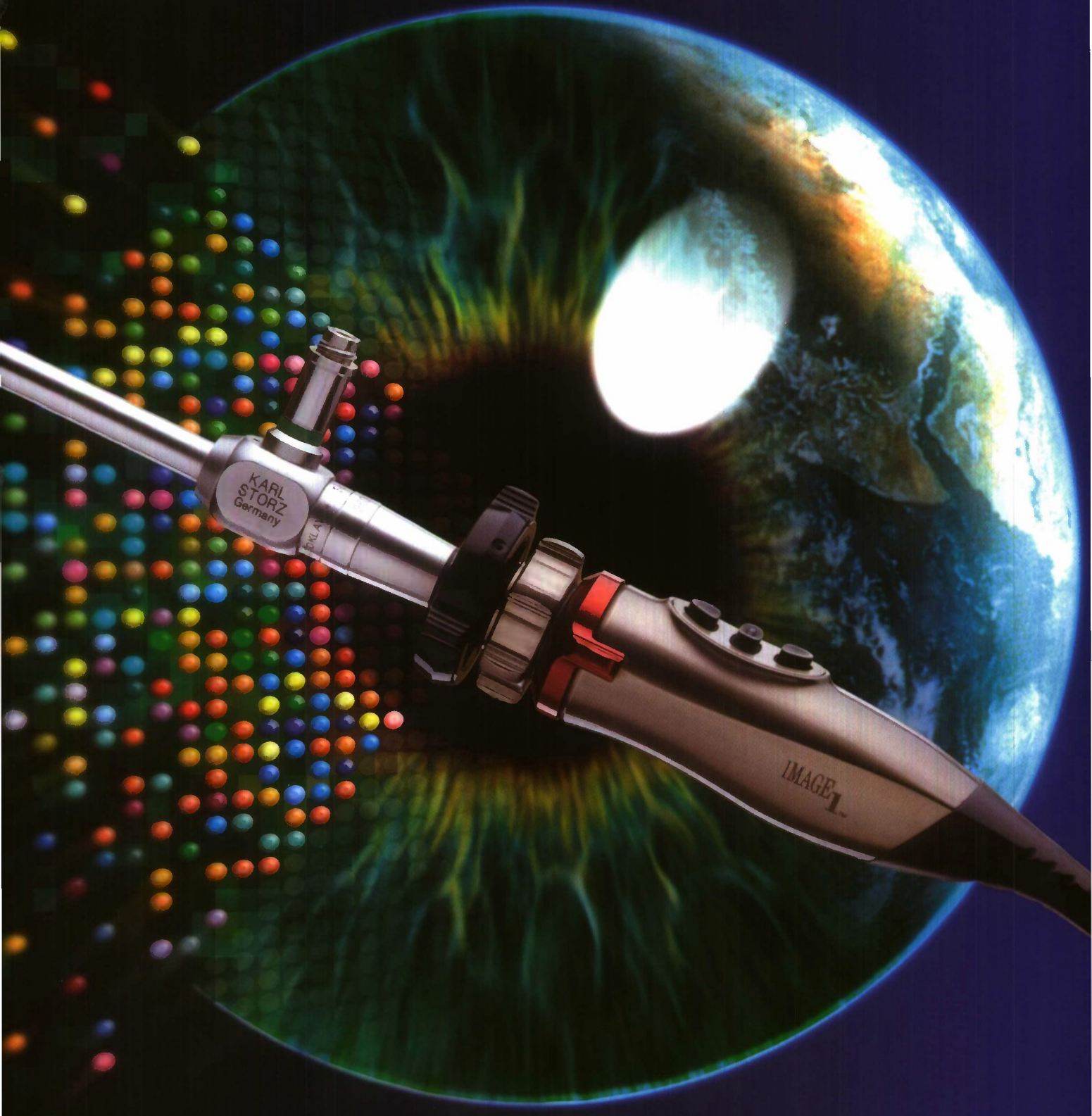

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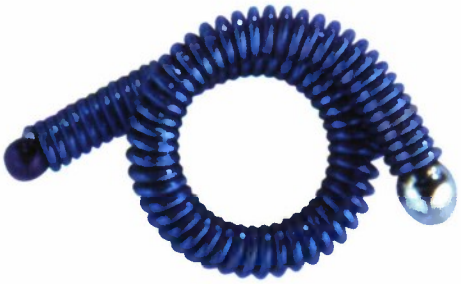

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