Effects of New Technology on the Operating Room Team

Caroline G.L. Cao [a], and Holly Taylor [b]

[a] Department of Mechanical Engineering, Tufts University, U.S.A.
[b] Department of Psychology, Tufts University, U.S.A.

Abstract. A study was conducted to examine the changes in performance and communication pattern within the OR team as a result of the introduction of a new technology – a remote master-slave surgical robot. A detailed analysis of the information flow during a cholecystectomy procedure with and without the robot revealed large disparities in terms of the amount and type of information required by the surgeon in order to perform the surgical procedure. Adjustments in team communication were necessary to accommodate the novel technology, new procedures, and altered roles of the OR personnel.

Keywords. Technology, Operating room, Team performance.

1. Introduction

Business changes in the US healthcare industry have arisen because of, among other factors, major advances in information technology and biomedical technology, and increased awareness and concern for patient safety and the healthcare system. As a consequence, these changes have created an operating room (OR) environment in which surgical teams work with a multitude of technology under increased uncertainty. The introduction of new technology (such as surgical robots, 3D medical imaging, novel surgical instruments, etc.) has improved the technical performance of surgical procedures, but it has also led to unexpected interactions within the surgical team and new forms of errors, further contributing to levels of uncertainty (Reason, 1990; Cook and Woods, 1994).

Studies of OR team performance have revealed that preventable medical errors are related not to technical competence, but to interpersonal aspects of the OR team functioning (Helmreich and Schaefer, 1994; Zinn, 1995) indicating a need for better communication to improve safety, efficiency and team morale. Few studies to date have been conducted to document OR team communication and how it affects team function, information flow and decision-making. The dynamic and complex socio-technical environment of an operating room where each participant has a tasks to perform and individual expertise relevant to a multitude of tasks underscores its complexity for studying decision making. Moreover, when new technology or regulation which affects work practice in the OR is introduced, adjustments must be made in order to accommodate the changes with greater potential for miscommunication and inefficiency. This is especially critical for addressing the problem of long learning time and high error rates while adapting to new technology or personnel in the operating room. Adjustments in team communication must be made to accommodate the novel technology, new procedures, or altered roles of the OR personnel.

1.1. Common Ground

The theoretical foundation of communication, Common Ground (Clark, 1996, Clark and Schaefer, 1989, Wilkes-Gibbs and Clark, 1992), can be utilized to examine the effect of new technology on the OR team. Common ground is one's working knowledge and or assumptions about what other people within a communication setting know. The level of common ground affects the degree of communication success. With common ground established, communication becomes more efficient (conveys more information in less time/fewer words) and more successful (completes tasks more accurately). Multiple sources contribute to the establishment of common ground, including past and present communications with the same individual(s), knowledge or assumptions about one's conversational partner(s), and general background information. Aspects related to these sources affect when and how common ground can be successfully instantiated, including the role and/or status within the communication and familiarity with the situation or with the communication partners.

The factors affecting common ground have particular relevance for communication within the surgical theater. The role one plays in communication affects one's level of common ground (Schober and Clark, 1989). Within the surgical theater, this plays out in two ways. First, surgery requires multiple participants (surgeon(s), nurses, anesthesiologist). At any given point in a procedure, these individuals are more or less involved. The less involved one is in a communication setting, the more prone to errors and confusion one becomes. Second, some of the surgical team participants have a more central role than others (e.g., the surgeon). This central figure may direct the communication topics while those responding take cues from the on-going situation. Expectations for responses rely on inferences about the knowledge base held by others. These inferences might come from the role one plays in the surgery (surgeon, nurse, anesthesiologist). Familiarity also affects common ground. Greater familiarity with communication partners results from

Report Documentation Page

Form Approved OMB No. 0704-0188

1. REPORT DATE **00 JUN 2004**	2. REPORT TYPE **N/A**	3. DATES COVERED -

4. TITLE AND SUBTITLE **Effects of New Technology on the Operating Room Team**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Department of Mechanical Engineering, Tufts University, U.S.A.; Department of Psychology, Tufts University, U.S.A.**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001766, Work with Computing Systems 2004 (Proceedings of the 7th International Conference). , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**4**	

past opportunities for having developed some common ground. With OR scheduling, surgical teams constantly rotate, resulting in decreased familiarity. Greater familiarity with the situation or procedures also increases the knowledge base on which common ground can be drawn. Thus, surgical teams may have expectations for the more frequent procedures that have not been developed for the less frequent ones.

Critical within the OR is the ability to make decisions that may impact patient outcomes and safety. Accurate information and firming up the idea of common ground to ensure a solid, system wide understanding among surgical team members should improve decision making. Introduction of new technology into the OR impacts many of the factors that affect common ground. Roles change when technology is introduced and people are less familiar with their new roles (as seen with the introduction of a robot). Surgical teams have less familiarity with the technology and procedures using it. For example, in recent years, a great deal of effort has been devoted to the use of telecommunication technology (e.g., email, telephone, and pager systems) for coordinating hospital activities such as preparing patients and managing surgical equipment. It was estimated by one expert that the US healthcare system could save $30 billion a year with improved telecommunications (Little, 1992). However, with each introduction of a communication technology, there is potential for misunderstanding and misuse before the technology can be effective. When new technology is introduced, new forms of errors are possible, as well as interruptions from the use of the technology itself (Coiera and Tombs, 1998; Moss and Xiao, 2004).

Here, we describe a study conducted to examine the changes in performance and communication pattern within the OR team as a result of the introduction of a new technology – a remote master-slave surgical robot, the LaproTek. Being removed from the surgical site, a surgeon does not receive the full range of sensory information normally obtained through vision, audition, the vestibular apparatus, haptics, and the olfactory senses. Rather, most of the available information is received through the visual channel. Even that modality, however, is based on video images of the remote surgical site, which typically provides a restricted field of view and limited depth information from a frequently poor vantage point. Moreover, the physical barrier imposed by the robotic technology also represents a perceptual barrier for the surgeon, increasing the uncertainty regarding the status of the remote system, and increasing information processing demands.

2. Methods

Our observational research was conducted in the operator room of a local teaching hospital. The same surgeon conducted a cholecystectomy using the conventional laparoscopic instruments, and another using the LaproTek robotic system. Both procedures were performed using the minimally invasive approach.

2.1. Data collection

A digital camcorder on tripod was positioned adjacent to the video monitor displaying the endoscopic view to the surgeon. The camera recorded the motions of the surgeon's hands and face at all times. An image from the endoscopic video monitor was recorded simultaneously. These two images were fed into a digital mixer, creating a picture-in-picture effect, then recorded on a Hi-8 tape as one image. All verbal communication was recorded by the microphone on the camera.

2.2. Data analysis

Videotapes were annotated and verbal communication was transcribed. For consistency, the videotapes were analyzed by the same individual. Time and motion analyses of surgical events followed a set of criteria – operationally defined beginnings and endings of events (Cao et al., 1996). Transcription of verbalization was analyzed for communication in establishing common ground, especially as it relates to readiness of surgical instruments.

3. Results and Discussion

Results of our analyses revealed large disparities in terms of the amount and type of information required by the surgeon in order to accomplish the procedure, with and without the robot. When using the robot, there were additional tasks and decisions that the surgeon must make, such as driving the robot in addition to manipulating the tissues at the surgical site. For example, during tool change, the surgeon must put the system on 'pause', to allow the nurse to remove a surgical tool and insert another. Once the new tool was secured in the robotic manipulator, the system could be started again to continue the surgery. Since the slave end of the robotic system was at the operating table (remote site), the surgeon could not directly assess the situation. The OR team relies on verbal exchanges to communicate and coordinate the surgical procedure. Not only did the surgeon need to gather information about the status of the patient and the progress of the surgical procedure, she now had to access information about the status of the robotic manipulator (i.e., the slave end which holds the surgical tool).

Due to the different perspectives of the nurses and surgeons with respect to the patient and the robot, there was a great deal of confusion when communication about the position of the tools had to be established. Although the surgeon was the one in charge of the surgical procedure, critical information was distributed throughout the surgical team and was assimilated from external sources (see Figure 1). Thus, there was significantly more communication within the OR team when using the robot as compared with regular laparoscopic surgery. The potential for error from mis-communication and lack of communication was great.

Even though the surgeon and the nurses have received training on the use of the robot, it was apparent that the presence of the robot added a layer of complexity and resulted in greater uncertainty with regard to the status of the surgical procedure. The introduction of a robotic surgical system into the OR changed the flow of information, as well as the point of access to the information and how that information was shared.

When using a robotic system, the surgeon was also responsible for distributing more information to the surgical team compared to traditional laparoscopic surgery. In laparoscopic surgery, the surgeon's informational output consisted of physically manipulating the tools. In robotic surgery, on the other hand, surgeon was not only responsible for performing the surgery (equivalent of physically manipulating the tools), but he also had to drive the robot, communicate the control state to the nurses, and direct the nurses about where the tool should go when changing instruments (see Figure 2). Thus it was noted that the addition of a robot placed many additional information input and output requirements on the surgeon, increasing the overall communication load on the surgical team.

Since there was no common ground amongst the OR team members with the use of the robot, there was greater uncertainty and confusion. Communication patterns were haphazard, which resulted in increased uncertainty for the surgeon and nurses as to whether it was his/her job to inform or that it was his/her job to ask. In addition, different terminologies were being introduced by the various team members when referring to the robot. Initial confusion further delayed the process in establishing common ground in the team.

In establishing common ground, communication or speech patterns play an important role. Training can also affect team communication and the achievement of common ground. Thus, a shared mental model can be developed by way of a predetermined set of rules and statements and/or the creation of an information visualization system to provide timely information in order to facilitate communication and decision-making in the operating room.

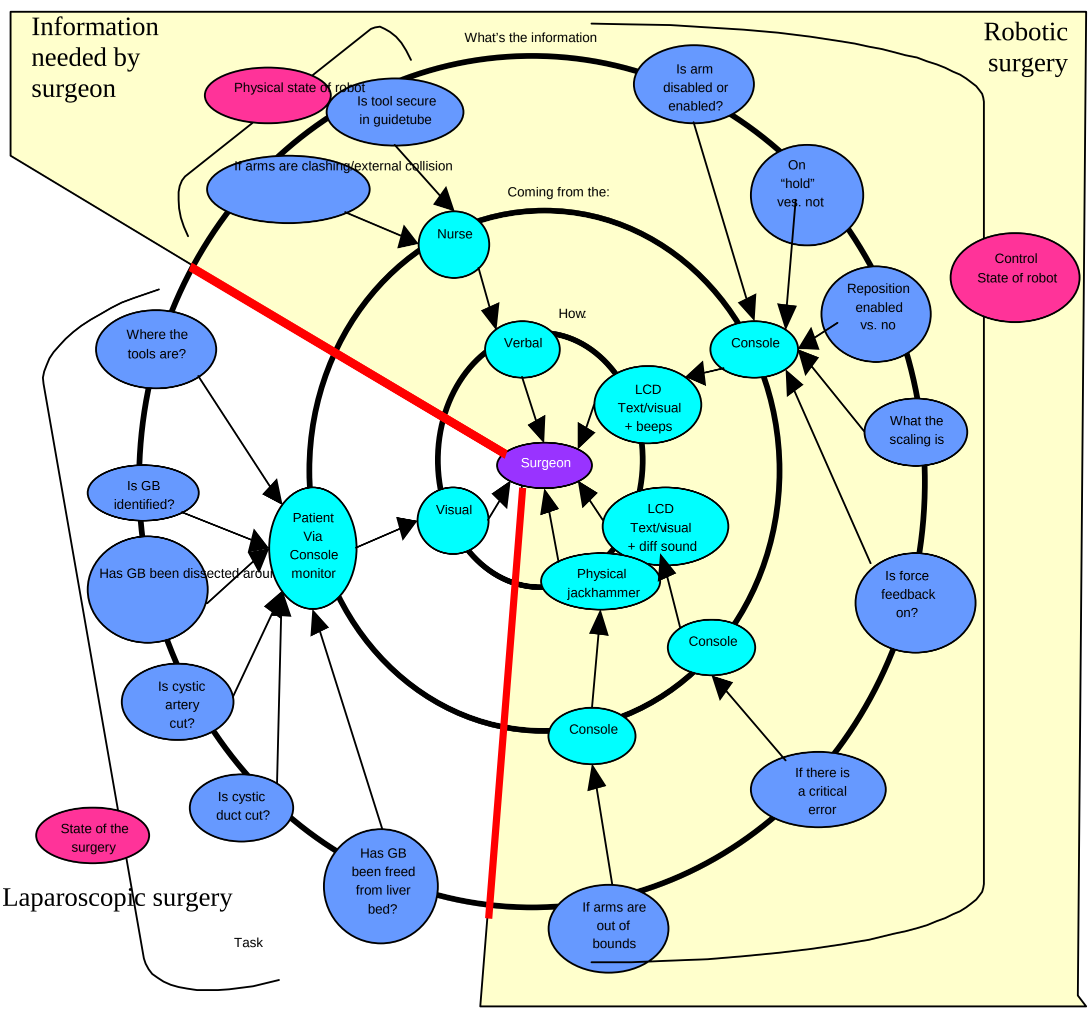

Figure 1. Information need by the surgeon in order to complete the surgery, with and without the robot.

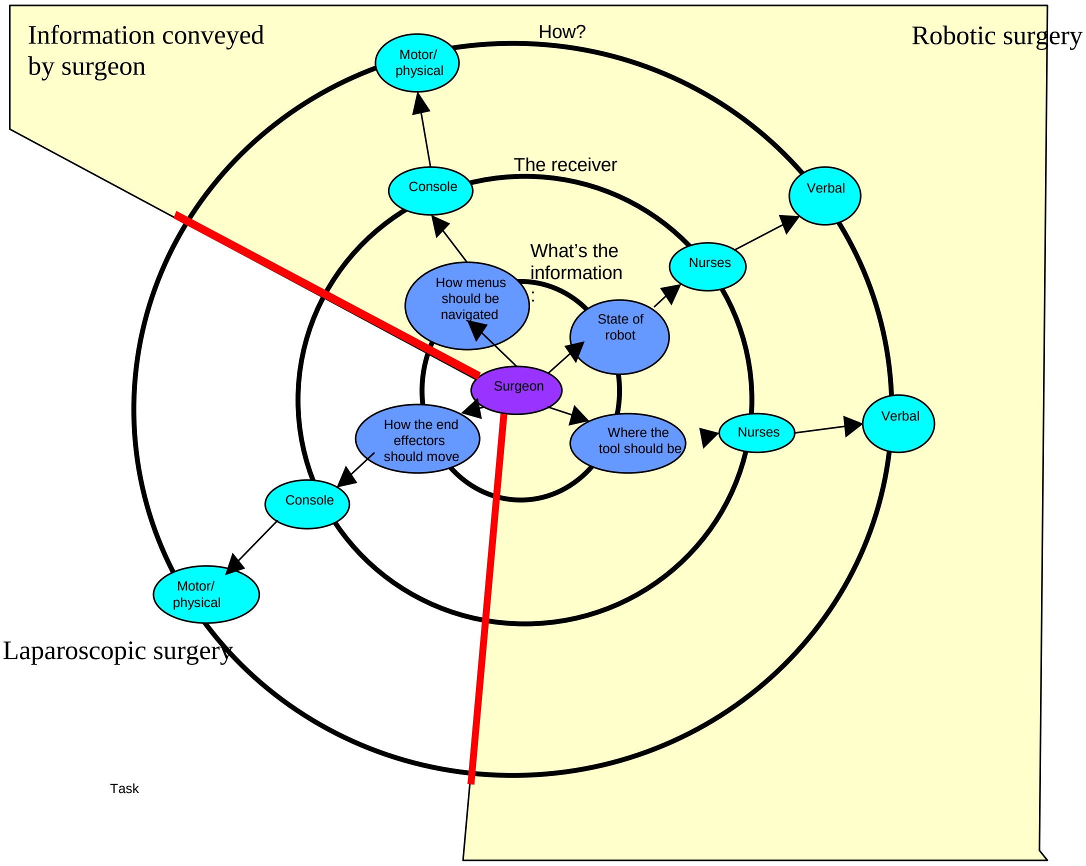

Figure 2. Information communicated by the surgeon to the rest of the OR team with and without the robot.

4. Acknowledgement

This paper is based on work supported by a grant from the National Science Foundation (Grant IIS 0238284). We thank Jessica Webster, Steve Schwaitzberg, the Tufts-New England Medical Center, and endoVia Surgical for their contribution to the study.

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