Combat readiness for the modern military surgeon: Data from a decade of combat operations

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OBJECTIVE:	Hundreds of general surgeons from the army, navy, and air force have been deployed during the past 10 years to support combat forces, but little data exist on their preparedness to handle the challenging injuries that they are currently encountering. Our objective was to assess operative and operational experience in theater with the goal of improving combat readiness among surgeons.
METHODS:	A detailed survey was sent to 246 active duty surgeons from the army, navy, and air force who have been deployed at least once in the past 10 years, requesting information on cases performed, perceptions of efficacy of predeployment training, knowledge deficits, and postdeployment emotional challenges. Survey data were kept confidential and analyzed using standard statistical methods.
RESULTS:	Of 246 individuals, 137 (56%) responded and 93 (68%) have been deployed two or more times. More than 18,500 operative procedures were reported, with abdominal and soft tissue cases predominating. Many surgeons identified knowledge or practice gaps in predeployment vascular (46%), neurosurgical (29.9%), and orthopedic (28.5%) training. The personal burden of deployment manifested itself with both family (approximately 10% deployment-related divorce rate) and personal (37 surgeons [27%] with two or more symptoms of posttraumatic stress syndrome) stressors.
CONCLUSION:	These data support modifications of predeployment combat surgical training to include increased exposure to open vascular procedures and curriculum traditionally outside general surgery (neurosurgery and orthopedics). The acute care surgical model may be ideal for the military surgeon preparing for deployment. Further research should be directed toward identifying factors contributing to psychological stress among military medics. (*J Trauma Acute Care Surg*. 2012;73: S64 S70. Copyright © 2012 by Lippincott Williams & Wilkins)
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US military forces have been involved in continuous combat operations since 2001, the longest conflict in American history. During the past 10 years, surgeons have performed thousands of cases on US service members, allied nation service members, civilian contractors, enemy combatants, and local nationals. Numerous medical and scientific advances have occurred, such as advancement in tourniquet use, hemostatic dressings, renal replacement therapy, and endovascular techniques in austere environments. Improvement in resuscitation strategies, evacuation models, and the evolution of damage control techniques has also occurred.[1–12] Although data exist on various topics detailing the experience of military medical providers in the theater of operations during the past decade, very little exists on the topic of predeployment training of military surgeons and the efficacy of current models. In a previous study, we compared surgical caseload for a 12-month period at the 31st Combat Support Hospital during the invasion of Iraq to those of graduating chief residents from a military surgical training program and made recommendations for additional training to better prepare them to perform war surgery.[13] Other descriptive studies detail small-unit experience in the deployed setting,[14–17] and some make recommendations for predeployment training for military providers using nonobjective means.[18] No data, however, exist on subjective or objective measures of the efficacy of current predeployment surgical training platforms. In addition, several studies have shown that injury patterns and mechanisms differ in the current conflict compared with previous conflicts, with increased use of improvised explosive devices and unconventional warfare techniques, with notable increased rates of extremity vascular injury.[19–20] In his landmark article "How to Train War Surgery Specialists, Part II," French general and surgeon Daniel P. Rignault noted that to prepare capable military surgeons, predeployment training must involve an analysis of wounds and patterns seen in current operations and must be revised to mirror the injuries seen.[21]

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The purpose of this study was to assess operative and operational experience in the current theater with the goal of improving combat readiness for military surgeons. The results may serve as a basis for the revision and standardization of predeployment surgical training curriculum, which in turn may lead to better prepared war surgeons.

PATIENTS AND METHODS

A three-phase survey of predeployment, deployed, and postdeployment experiences was developed by our study group with collaboration from survey statisticians at the Defense Manpower Data Center (The Pentagon, Washington, DC) and disseminated to all army, navy, and air force active duty surgeons who have been deployed at least once in support of operations in Iraq or Afghanistan. Institutional review board approval was obtained from both the US Army Institute of Surgical Research and the Tricare Management Activity. Final survey licensing and approval was also obtained via the Washington Headquarters Services (WHS) office. E-mail addresses for current general surgeons and subspecialty surgeons who have been deployed in a general surgery billet were provided by each of the service consultants. To preserve anonymity, a third-party research nurse was assigned to disseminate surveys via e-mail, to track responses, to conduct follow-up, and to compile completed surveys. Any personally identifiable information was removed before transfer to the study authors. Surveys were distributed and collected between November 2010 and February 2011.

RESULTS

Of 246 surveys, 127 (52%) were distributed to army surgeons, 86 (35%) to air force surgeons, and 33 (13%) to navy surgeons (Fig. 1). Surveys were also distributed to surgeons in associated surgical subspecialties who have been deployed as general surgeons. Respondent information and demographics are provided in Table 1. Of distributed surveys, 137 were returned for a response rate of 55.7%. Of the respondents, 61

TABLE 1. Respondent Demographics

Respondent Characteristics	Respondents, n (%)
Branch of service	
Army	61 (44.5)
Air Force	43 (31.4)
Navy	33 (24.1)
No. deployments	
1	44 (32.1)
2	46 (33.6)
3	30 (21.9)
4	8 (5.8)
5+	9 (6.6)
Duty status at time of first deployment	
Active	132 (96.4)
Guard or Reserve	5 (3.6)
Years of service at first deployment	Range, 0 28 (median, 7; IQR, 5 12)
Years board-certified at first deployment	Range, 0 26 (median, 2; IQR, 0.5 5)
Fellowship training status*	
Yes	48 (35.0)
No	89 (65.0)
Theater of operations†	
Iraq	136
Afghanistan	154
Level of care (role)†	
2	162
3	133

*Broken down by specialty in Table 2.
†Represents multiple deployments for some individuals.

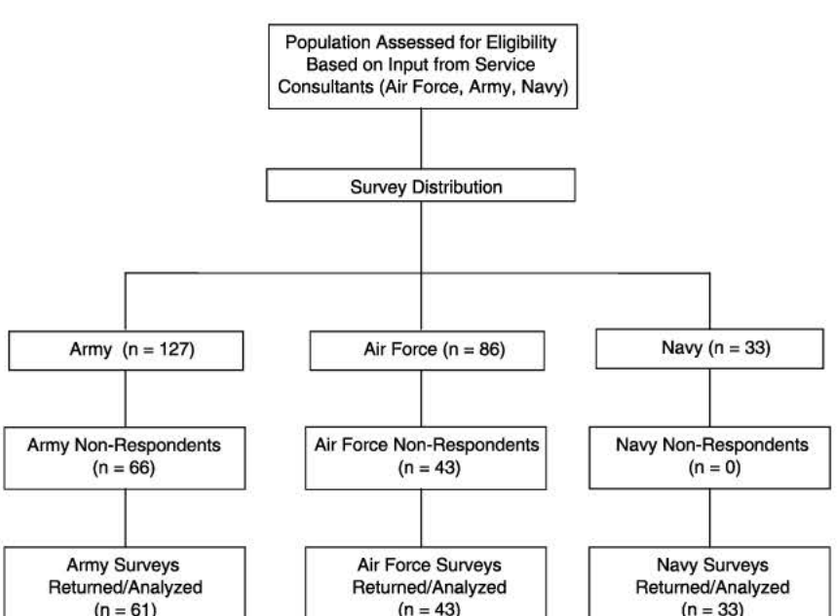

Figure 1. CONSORT diagram.

(44.5%) were in the army, 43 (31.4%) in the air force, and 33 (24.1%) in the navy. Of the respondents, 44 have been deployed one time and 46 have been deployed two times. Forty-seven respondents have been deployed more than two times: 30 were deployed three times, 8 were deployed four times, and 9 were deployed five times. Most respondents (132) were on active duty at the time of their first deployment, but 5 respondents were in the National Guard or Reserve and have since joined active duty. At the time of their first deployment, respondents had a range of 0 to 28 years of active duty service (median, 7; interquartile range [IQR], 5–12%) and a range of 0 to 26 years of practice as a board-certified surgeon (median, 2; IQR, 0.5–5%). Eighty-nine surgeons (65%) had not completed a fellowship at the time of their first deployment, whereas 48 surgeons (35%) had completed postgraduate training. Specialty breakdown is shown in Table 2. Sixteen surgeons completed postgraduate training between the first and the subsequent deployments, with the preponderance of those seeking training in trauma or critical care surgery (9 individuals). Deployment locations varied fairly evenly between Iraq and Afghanistan as well as between Level 2 and Level 3 facilities. The length of deployments ranged from 1 to 15 months (median, 6; IQR, 4–6%).

Predeployment

The first section of the survey detailed predeployment training to include both surgical and military. Of survey participants, 94 (68.6%) graduated from military residency, whereas 43 (31.4%) graduated from civilian programs. Sixty-six (48.2%) of the respondents felt that residency training prepared them very well for deployment, and an additional 48 respondents (35%) felt well prepared. Only six respondents felt that residency prepared them either poorly (five respondents, 3.6%) or very poorly (one respondent, 0.7%). Five of the six who responded either poorly or very poorly trained in military training programs. Less than half of respondents attended a predeployment surgical training course before their first deployment (60 respondents, 43.8%). Courses attended included several different courses and are broken down in Table 3. The most commonly attended course was the Emergency War Surgery course, with 34 respondents attending (24.8% of the total respondents). Of those who attended courses, 44 (73.3%) rated the experience as either very beneficial or beneficial, with 10 respondents neutral about the experience, and only 8 respondents noting that it was not beneficial. Of the respondents, more than 70% had read the Emergency War Surgery text and 80.2% (77 respondents) found it either beneficial or very beneficial. Approximately 90% of respondents were aware of the Joint Theater Trauma System (JTTS) clinical practice guidelines (n = 120, 87.6%). When asked whether they would have liked additional training on specific injuries or injury patterns before their first deployment, approximately 80% (n = 108) of surgeons responded affirmatively. The most commonly requested additional training was in extremity vascular repairs (n = 63, 46%), followed by neurosurgery (n = 41, 29.9%), orthopedics (n = 39, 28.5%), and abdominal vascular repairs (n = 38, 27.7%). The complete breakdown is listed in Table 4.

Regarding predeployment military training, 84 surgeons (61.3%) found their home station military training to be unhelpful. An additional 37 surgeons (27%) found this training only somewhat helpful. This was also true of the 55 surgeons who have been deployed via the CONUS Replacement Center, with most surgeons finding the training either somewhat helpful (n = 23) or unhelpful (n = 29).

TABLE 2. Respondent Subspecialty Training at the Time of First Deployment

Fellowship Training	Respondents, n (%)
None	89 (65.0)
Trauma critical care	21 (15.3)
Vascular	7 (5.1)
Colorectal	6 (4.4)
Cardiothoracic	3 (2.2)
Minimally invasive	3 (2.2)
Surgical oncology	3 (2.2)
Transplant	2 (1.5)
Pediatric surgery	2 (1.5)
Plastic surgery	1 (0.7)

TABLE 3. Predeployment Surgical Training Course Attendance

Course Name	Respondents, n (%)
Emergency War Surgery Course	34 (24.8)
Center for Sustainment of Trauma and Readiness Skills (C-STARS)	13 (9.5)
Army Trauma Training Center	10 (7.3)
Naval Trauma Training Center	9 (6.6)
Combat Extremity Surgery Course	7 (5.1)
Brooke Army Medical Center	6 (4.4)
None	58 (42.3)

TABLE 4. Requested Additional Training Before First Deployment

Surgical Discipline or Injury Type	Respondents, n (%)*
Extremity vascular repairs	63 (46)
Neurosurgery	41 (29.9)
Orthopedics	39 (28.5)
Abdominal vascular repairs	38 (27.7)
Thoracic	32 (23.4)
Burns	30 (21.9)
Ocular trauma	30 (21.9)
None	29 (21.2)
Genitourinary or reproductive	21 (15.3)
Pediatric surgery	14 (10.2)
Critical care	10 (7.3)
Gastrointestinal	2 (1.5)

*Respondents were allowed to check more than one box.

Deployment

Because of the high tempo of operations since 2001, numerous individuals have been deployed more than once. In

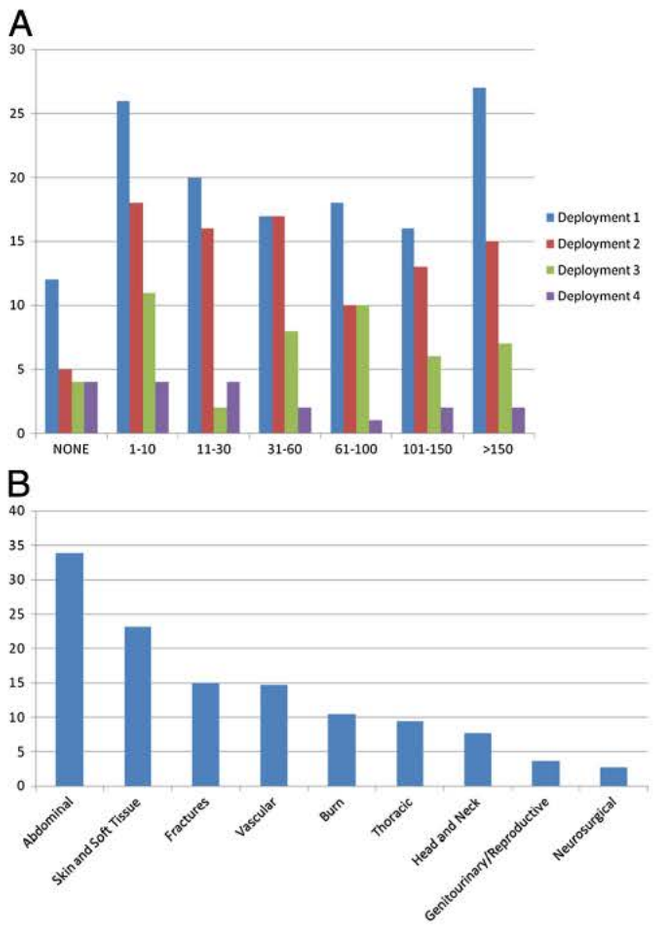

Figure 2. (*A*) Reported caseload ranges by respondents. (*B*) Most common traumatic injuries overall (expressed as mean percentage).

this section, respondents were able to input information for up to four deployments. More than 18,500 cases were reported by all respondents. Respondents were queried on reported caseloads using ranges; the reported data are depicted in Figure 2, *A*. Of surgical patients, US service members were the most common (median, 33.8%; IQR, 20–55%), followed by local nationals (median, 34.3%; IQR, 20–50%), non-US coalition forces (median, 20%; IQR, 10–30%), and enemy combatants (median, 7.5%; IQR, 5–10%). Of surgical case type expressed as a percentage of overall cases, trauma occurred most frequently (median, 87.5%; IQR, 60–95%), followed by acute general surgery (median, 10%; IQR, 5–25%) and elective general surgery (median, 5.1%; IQR, 0–15%). Of the trauma cases performed, the most injuries were abdominal, followed by skin and soft tissue, fractures, vascular, and thoracic injury (Fig. 2, *B*). More than one quarter of deployed general surgeons applied an external fixator without the assistance of an orthopedic surgeon (n = 36, 26.3%), and a similar number (29.3%) acted as the primary surgeon on cases involving fractures. More than 60% of surgeons performed at least one extremity amputation during deployment (n = 85, 62.0%), and approximately 70% of surgeons reported performing at least one fasciotomy (n = 95, 69.3%). Vascular shunt placement was reported by 70 surgeons (51.1%), and 71 surgeons (51.8%) performed at least one primary vascular repair.

It was common for general surgeons, in the deployed setting to perform procedures typically handled by other surgical specialists in the nondeployed setting. Traumatic brain injury was frequently encountered with more than 70% of surgeons reporting treating a patient with traumatic brain injury, and 13.9% (n = 19) of general surgeons reported performing neurosurgical procedures. Ninety-eight surgeons (71.5%) reported treating patients younger than 12 years. Ocular trauma was also encountered frequently, and approximately 20% of surgeons report doing some degree of obstetric and/or gynecologic procedures. Of cases surgeons reported as the most challenging, the vascular cases were by far the most common (extremity and abdominal), followed by neurosurgical, burns, and thoracic (Fig. 2, *B*). Surgeons attributed the difficulty of the previously mentioned cases to various reasons, with the most common being that the cases were not encountered in their nondeployed clinical practice (n = 64) and with the second most common response being a significant time lapse since treating these types of cases (n = 47). Of cases within the standard curriculum of general surgical training, surgeons reported that they would have liked additional experience with mediastinal trauma (n = 59), followed by extremity vascular (n = 52) and mesenteric vascular injury (n = 44) (Table 5). Seventy-five surgeons (54.7%) reported transfusing whole blood while deployed. Seven surgeons (5.1%) reported surgically removing unexploded ordnance.

The survey also included questions detailing the deployed military experience. Forty-five surgeons (32.8%) were the commander of their medical unit. Only five surgeons (3.6%) discharged their weapons in self-defense. Most surgeons (115, 83.9%) took indirect fire while deployed, but only 1 surgeon (0.7%) was injured. These numbers again reflect only respondents and do not include the two general surgeons and one orthopedic surgeon killed in action since 2001. When asked about the optimal length of deployment, with choices ranging from 3 to 12 or more months, almost all surgeons chose either 3 months (39 surgeons, 28.5%), 4 months (44 surgeons, 32.1%), or 6 months (47 surgeons, 34.3%).

TABLE 5. Number of Surgeons Requesting Additional Experience With Injury Types Falling Into Discipline and Traditional Curriculum of General Surgery

Injury Type	Surgeons, n (%)*
Mediastinal trauma	59 (43.1)
Extremity vascular	52 (38.0)
Mesenteric vascular	44 (32.1)
Inferior vena cava injury	38 (27.7)
Pulmonary trauma	38 (27.7)
Retroperitoneal hematoma exploration	35 (25.5)
Liver hemostasis	33 (24.1)
Duodenal injury	28 (20.4)
Pancreatic injury	25 (18.2)
Fasciotomy	20 (14.6)

*Respondents are allowed to choose more than one answer.

Postdeployment

The personal and professional burden of deployment was evident in the survey responses. Approximately 10% (n = 13) underwent a divorce they attributed to the stress of deployment on their marriage, and approximately 40% (n = 53) are considering leaving the military due to deployment-related stressors. When asked about several psychosocial symptoms to include recurring nightmares, mood swings, insomnia, feeling irritable for no reason, recurring images of traumatic patients or experiences, or problems concentrating, 38 surgeons (27%) responded with two or more symptoms, 7 surgeons (3.6%) with four symptoms, and 8 surgeons (5.8%) with five or more of the previously mentioned symptoms. Two surgeons (1.5%) have been clinically diagnosed with posttraumatic stress disorder or another mental illness since returning from deployment. Despite the great personal stress placed on them by deployment, most surgeons (115, 83.9%) felt that deployment was a rewarding experience.

Following the multiple-choice portion of the survey was a free-text section in which respondents were given an opportunity to answer several questions detailing their experience and to make suggestions for the future. Questions asked about surgeon perceptions on improving care in the deployed setting, how to improve combat surgery training, and opinions on increasing surgeon retention. One hundred twenty-one surgeons (88.3%) provided answers in the free-text section. As topics were frequently related and overlapping, results were analyzed by grouping responses into commonly mentioned categories. The most commonly mentioned topics, in order, were as follows: minimize unnecessary training (49 surgeons, 40.5%), improve surgeon utilization in the deployed setting (44 surgeons, 36.4%), shorten deployment time (44 surgeons, 36.4%), improve or increase surgeon compensation (43 surgeons, 35.5%), change CONUS nondeployed practice to be more well-rounded and robust (39 surgeons, 32.2%), improve or standardize predeployment surgical training (36 surgeons, 29.8%), and encourage increased surgeons in command of deployed surgical units and hospitals (27 surgeons, 22.3%).

DISCUSSION

This study represents the first large-scale survey of deployed surgeons after a decade of war. Findings from this survey confirm that surgical case experience during deployments is extensive, requiring a broad range of operative skills. Of injury patterns managed during deployment, vascular trauma was identified as the most challenging and the area in which surgeons would have liked more experience before deployment. Surgeons additionally requested more experience with rare injuries not often seen in training as well as with some injuries that fall outside the traditional general surgical curriculum but will fall under the responsibility of the deployed general surgeon.

Hemorrhage control has been shown by several authors to be the single most important mechanism for mortality prevention in combat-wounded patients in the current conflict.[19,22] In addition, White et al[20] recently published data documenting a vascular injury rate of 12%, approximately five times higher than rates in previous conflicts such as Vietnam. They attributed this finding to a higher percentage of wounding by explosive mechanisms, better armor protection of the torso compared with previous conflicts, and more accurate data collection with the advent of the JTTS or JTTR. This change in injury pattern comes at a time when modern general surgical trainee experience with open vascular procedures is on the decline for several reasons, as detailed in a recent letter by Rasmussen et al[23] in the *Journal of Trauma*. Our data echo the reports from these authors, showing high rates of vascular injury and more than 70% of surgeons performing shunts, primary repairs, and other procedures related to vascular injury such as amputation and fasciotomy. Of the types of additional training requested by surgeons before their first deployment, approximately half of the respondents felt that additional training in extremity vascular trauma would have been helpful, and more than a quarter of respondents also felt that additional abdominal vascular trauma training was also important. Of cases performed downrange, five of the top six most requested injuries for which respondents requested additional training were related to vascular injury (Table 5). Similarly, the cases that respondents reported as the most difficult in the deployed environment were both extremity and abdominal vascular injury, with most respondents noting that their skills in treating such injuries had lapsed because they are not exposed to vascular trauma in their clinical practice or because there have been a significant time lapse since their training in these injuries. This view was also reflected in the free-text question responses: 39 surgeons felt that a more robust, busy clinical practice in the nondeployed setting with more opportunity to moonlight and take trauma call would not only maintain critical trauma-readiness skills but also improve surgeon morale and compensation and improve surgeon retention.

These data also echo the previous article from this study group comparing cases performed in the deployed setting at the 31st Combat Support Hospital to 5 years of graduating residents from a military residency program. We concluded that deploying surgeons need additional experience with injuries rarely seen in clinical practice due to low incidence such as traumatic inferior vena cava and duodenal injuries as well as injuries that fall outside the scope of traditional general surgical curriculum but will be the responsibility of the deployed general surgeon such as damage control neurosurgery and orthopedic techniques.[13] Approximately 30% of respondents requested additional training in neurosurgery and orthopedics.

A great deal of data have been generated about the medical aspects of the combat operations of the past decade. Despite this, very little data have been generated assessing the efficacy of current predeployment surgical training. There is little standardization between services on course attendance and often little standardization between different iterations of the same course In addition, many predeployment courses are taught to physicians as a group rather than being specific to deploying general surgeons. Less than half of surgeons attended predeployment surgical courses, although of those who did, approximately three quarters found them to be beneficial. Course attendance was extremely variable, with six different courses attended, each with a variable curriculum. Until recently, no prospective data have been generated on course attendees documenting course efficacy, and until our current

data set, no data have been generated documenting course utility after attendees have completed their first deployment. This study represents a retrospective attempt to generate such data in an attempt to both improve and standardize predeployment surgical training. Future course curriculum should be surgeon specific, designed in an evidence-based fashion, and standardized among deploying surgeons. In addition, with frequent deployments, a great deal of time is spent away from duty stations and family. Superfluous and unnecessary training should be kept to a minimum. This is reflected in our data showing that approximately 90% of surgeons found their home station or CONUS Replacement Center training to be either unhelpful or only somewhat helpful and in comments in the free-text section from 49 surgeons that eliminating unnecessary training during the predeployment period would be beneficial.

A potential solution to enhancing war surgical skills is to provide additional training using the Advanced Trauma Operative Management and the Advanced Surgical Skills for Exposure in Trauma courses, both currently offered through the American College of Surgeons Committee on Trauma. These courses offer problem-based modules and hands-on surgical skills training using animal models and cadaveric exposures. Our study group recently completed the validation of such a course with military chief residents and surgeons preparing for deployment. We conducted a 2-day course combining Advanced Trauma Operative Management, Advanced Surgical Skills for Exposure in Trauma, and military-specific curriculum such as damage control neurosurgery and orthopedics and an overview of the JTTS clinical practice guidelines. We anticipate the publication of our results soon. In addition, the Acute Care Surgery Fellowship, designed by the American Association for the Surgery of Trauma, allows the fellow an opportunity to concentrate his or her training in areas identified and needed in war surgery. This is an ideal situation because 56% of the respondents who attended a fellowship between their first and second deployments did so in trauma or critical care. This study is not without limitations. Regulatory requirements limited the survey to surgeons who were still on active duty. This requirement excluded surgeons who have been deployed and had since retired or separated from active duty. In addition, the survey populations were identified by general surgery consultants from each respective service via e-mail lists. The 100% response rate from navy participants likely shows that we did not capture all eligible respondents in the initial distribution, as the population of navy surgeons is likely greater than 33. Numbers generated by respondents on the survey device are an approximation of cases and case breakdowns as best remembered by respondents. Given that the survey was administered in 2011 and that some individuals' first deployments were possibly up to 8 years or less, the stated numbers and data represent respondent recollection of their experiences and somewhat limit the accuracy. Similarly, this study represents a retrospective analysis of deployed surgeon experience. Future studies should be completed both to revise and to standardize predeployment surgical training curriculum, with prospective preintervention and postintervention data collected and ultimately with long-term follow-up with participants after their first deployment. Our study group has completed such curriculum generation, and data are currently being collected prospectively. Despite the previously mentioned limitations, this study provides insight into the deployed experience of military surgeons during the last decade of combat operations and, as such, can serve as a basis from which to improve military surgical predeployment training and surgical readiness.

CONCLUSION

Deployed military surgeons are generally well prepared to treat a broad range of injuries. The evidence-based revision and standardization of current predeployment surgical training should be pursued, with the generation of prospective efficacy metrics. With documented increased rates of vascular injury in the current conflict, combined with the diminished role of open vascular repairs in the current training paradigm, particular attention should be given to providing additional vascular surgery training to current predeployment surgical training models. Consideration should also be given to additional training in the treatment of injuries that fall outside traditional general surgery curriculum such as neurosurgery and orthopedics.

AUTHORSHIP

J.A.T., K.D.E., C.E.W., and L.H.B. designed this study. J.A.T., M.L.L., M.M.K., T.E.R., and L.H.B. collected data, which J.A.T., M.M.K., T.E.R., and L.H.R. analyzed. J.A.T., B.E.E., C.E.W., M.M.K., T.E.R., and L.H.B. interpreted the data. All authors participated in writing the article.

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DISCLOSURE

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. The authors declare no conflict of interest.

REFERENCES

1. Beekley AC, Sebesta JA, Blackbourne LH, Herbert GS, Kauvar DS, Baer DG, Walters TJ, Mullenix PS, Holcomb JB; 31st Combat Support Hospital Research Group. Prehospital tourniquet use in Operation Iraqi Freedom: effect on hemorrhage control and outcomes. *J Trauma*. 2008;64:S28 S37; discussion S37.
2. Kragh JF Jr, Wade CE, Baer DG, Jones JA, Walters TJ, Hsu JR, Wenke JC, Blackbourne LH, Holcomb JB. Fasciotomy rates in operations enduring freedom and Iraqi freedom: association with injury severity and tourniquet use. *J Orthop Trauma*. 2011;25:134 139.
3. Wedmore I, McManus JG, Pusateri AE, Holcomb JB. A special report on the chitosan-based hemostatic dressing: experience in current combat operations. *J Trauma*. 2006;60:655 658.
4. Perkins R, Simon J, Jayakumar A, et al. Renal replacement therapy in support of Operation Iraqi Freedom: a tri-service perspective. *Mil Med*. 2008;173:1115 1121.
5. Propper BW, Alley JB, Gifford SM, Burkhardt GE, Rasmussen TE. Endovascular treatment of a blunt aortic injury in Iraq: extension of innovative endovascular capabilities to the modern battlefield. *Ann Vasc Surg*. 2009;23:687.e19 687.e22.
6. Fox CJ, Gillespie DL, Cox ED, Kragh JF Jr, Mehta SG, Salinas J, Holcomb JB. Damage control resuscitation for vascular surgery in a combat support hospital. *J Trauma*. 2008;65:1 9.

7. McLaughlin DF, Niles SE, Salinas J, Perkins JG, Cox ED, Wade CE, Holcomb JB. A predictive model for massive transfusion in combat casualty patients. *J Trauma*. 2008;64:S57 S63.
8. Niles SE, McLaughlin DF, Perkins JG, Wade CE, Li Y, Spinella PC, Holcomb JB. Increased mortality associated with the early coagulopathy of trauma in combat casualties. *J Trauma*. 2008;64:1459 1463.
9. Borgman MA, Spinella PC, Perkins JG, et al. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. *J Trauma*. 2007;63:805 813.
10. Gifford SM, Aidinian G, Clouse WD, et al. Effect of temporary shunting on extremity vascular injury: an outcome analysis from the Global War on Terror vascular injury initiative. *J Vasc Surg*. 2009;50:549 555; discussion 555 556.
11. Murray CK, Griffith ME, Mende K, et al. Methicillin-resistant *Staphylococcus aureus* in wound cultures recovered from a combat support hospital in Iraq. *J Trauma*. 2010;69:S102 S108.
12. Ritenour AE, Blackbourne LH, Kelly JF, McLaughlin DF, Pearse LA, Holcomb JB, Wade CE. Incidence of primary blast injury in US military overseas contingency operations: a retrospective study. *Ann Surg*. 2010; 251:1140 1144.
13. Tyler JA, Clive KS, White CE, Beekley AC, Blackbourne LH. Current US military operations and implications for military surgical training. *J Am Coll Surg*. 2010;211:658 662.
14. Filliung DR, Bower LM, Hopkins-Chadwick D, Leggett MK, Bacsa C, Harris K, Steele N. Characteristics of medical-surgical patients at the 86th Combat Support Hospital during Operation Iraqi Freedom. *Mil Med*. 2010;175:971 977.
15. Lundy JB, Swift CB, McFarland CC, Mahoney P, Perkins RM, Holcomb JB. A descriptive analysis of patients admitted to the intensive care unit of the 10th Combat Support Hospital deployed in Ibn Sina, Baghdad, Iraq, from October 19, 2005, to October 19, 2006. *J Intensive Care Med*. 2010; 25:156 162.
16. Shen-Gunther J, Ellison R, Kuhens C, Roach CJ, Jarrard S. Operation Enduring Freedom: trends in combat casualty care by forward surgical teams deployed to Afghanistan. *Mil Med*. 2011;176:67 78.
17. Peoples GE, Gerlinger T, Craig R, Burlingame B. The 274th Forward Surgical Team experience during Operation Enduring Freedom. *Mil Med*. 2005;170:451 459.
18. Sohn VY, Miller JP, Koeller CA, et al. From the combat medic to the forward surgical team: the Madigan model for improving trauma readiness of brigade combat teams fighting the Global War on Terror. *J Surg Res*. 2007;138:25 31.
19. Kelly JF, Ritenour AE, McLaughlin DF, et al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003 2004 versus 2006. *J Trauma*. 2008;64:S21 S26; discussion S26 S27.
20. White JM, Stannard A, Burkhardt GE, Eastridge BJ, Blackbourne LH, Rasmussen TE. The epidemiology of vascular injury in the wars in Iraq and Afghanistan. *Ann Surg*. 2011;253:1184 1189.
21. Rignault DP. How to train war surgery specialists: Part II. *Mil Med*. 1990; 155:143 147.
22. Martin M, Oh J, Currier H, Tai N, Beekley A, Eckert M, Holcomb J. An analysis of in-hospital deaths at a modern combat support hospital. *J Trauma*. 2009;66:S51 S60; discussion S60 S61.
23. Rasmussen TE, Woodson J, Rich NM, Mattox KL. Vascular trauma at a crossroads. *J Trauma*. 2011;70:1291 1293.