Surgery at Sea: Exploring the Training Gap for Isolated Military Surgeons

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OBJECTIVE: Newly-graduated military general surgeons often find themselves isolated at sea, solely responsible for all surgical care of several thousand sailors, regardless of the surgical specialty training required for any individual procedure. This educational need assessment explored trends in afloat surgical care over the last 25 years, and assessed trainees' preparedness for their expected role as an isolated surgeon.

DESIGN: A sample of deidentified US Navy Ship's Surgeon case logs were reviewed to determine afloat case load trends in 5 common afloat case categories (urologic/gynecologic, anorectal, hernia, appendectomy, and hand/orthopedic/trauma) from 1990s to 2017. Individual procedures were mapped to American College of Surgeons/Military Health System Knowledge, Skills, and Attitudes line items to ensure afloat-relevant skills were identified. Recent military resident case logs were then compared with afloat cases to evaluate relevant trainee experience.

SETTING: US Navy ships at sea from 1995 to 2017.

PARTICIPANTS: US Navy afloat-deployed surgeons, totaling 1340 cases within the study period.

RESULTS: Case log analysis of 1340 surgeries, comprising >200 months at sea, reflected 46 named procedures; 34 of 46 (74%) correlated to an intraoperative knowledge, skills, and attitudes item. The most common surgeries were vasectomy, (304 of 1340, 23%). No difference in case mix was apparent comparing pre- and post-2000 deployments (representing afloat laparoscopic integration) in 4 of 5 categories, while hernias proportionally declined. Case volume per deployment markedly declined overall ($p < 0.001$) and in each category. Resident case log analysis from 2012 to 2016 showed experience was limited in urologic/gynecologic, orthopedic, and open appendectomy categories.

CONCLUSIONS: No formal case repository exists for afloat surgery, making detailed analysis problematic. Current training provides excellent surgical education but minimal exposure to rare-but-real cases expected on deployments, which may not translate to competency for the isolated, afloat surgeon. Military surgical leadership should embrace training for these cases and assertively invest in the development of the military's newest surgeons. (J Surg Ed 76:1139−1145. Published by Elsevier Inc. on behalf of Association of Program Directors in Surgery.)

KEY WORDS: Isolated surgeon, surgical education, military, surgery resident

COMPETENCIES: Patient Care, Medical Knowledge, Practice-Based Learning and Improvement

INTRODUCTION

"Ship's Surgeon" is a unique and longstanding title within the Navy that brings heavy responsibility. Newly-graduated Navy general surgeons routinely find themselves with limited surgical resources, deployed as the sole surgeon in the middle of the ocean, responsible for 5000 to 6000 sailors and marines spread across a squadron of ships and aircraft.[1-3] Similar to our isolated rural civilian counterparts as described by Halverson and Sachdeva, Navy surgeons must be prepared to independently handle any surgical emergency that arises, regardless of specialty.[4,5] Radiologic capabilities are limited. Ships typically carry no computed tomography, no magnetic resonance imaging, and no fluoroscopy. Afloat surgeons must interpret their own x-rays and perform and

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interpret their own ultrasound exams. Phone or email consultation is often severely hampered by bandwidth constraints and mission security, onboard equipment is limited, and resupply chains are lengthy or sometimes completely disrupted by military operational concerns.[3] The newly-graduated, deployed surgeon's role represents a decidedly different paradigm than the role of the typical US general surgery residency graduate.

Trainees, both military and civilian, have adapted as the last 3 decades brought revolutionary applications of minimally invasive techniques in surgery. As laparoscopic experience grew, the Navy pushed minimally-invasive surgery to ships in the late 1990s, with Cubano describing the first laparoscopic hernia repair at sea in 1997.[6] Laparoscopy afloat brings unique challenges, including the need to tie down the laparoscopic tower for surgery in rough seas, need for the ship's machinists to sometimes hand-make required instruments, and insufflation gas resupply difficulties intrinsic to naval operations.[2,3] The potential for surgeon isolation reinforces the need for newly-graduated military general surgeons to be trained in domains that may not be adequately emphasized in the current Patient Care and Procedural Skills training requirements of the Accreditation Council on Graduate Medical Education (ACGME) or American Board of Surgery (ABS).[7,8] Recognizing the importance of sustaining surgical readiness, the Military Health System Strategic Partnership with the American College of Surgeons (MHSSPACS) conducted a formal job-task analysis to identify the trauma-centric knowledge, skills, and attitudes (KSAs) required for surgeons in the expeditionary environment.[9,10] However, the training gap between ACGME requirements and the unique requirements of a Ship's Surgeon has not been previously explored.

The purpose of this evaluation is to conduct an education and training needs assessment[11] through review of ships' surgeons operative experience over the past several decades and to compare this experience to current military resident operative training. We sought to describe the scope of shipboard surgery and any constitutive changes over the last 30 years, and to compare current requirements to military surgery graduates' experience in common afloat procedures.

METHODS

Since no Department of Defense-wide, Navy-wide, or numbered-Fleet case repository currently exist, case data collection was accomplished through numbered Fleet and U.S. Navy Surgical Specialty Leader email distributions, and through personal contact by the authors. Deidentified Ship's Surgeon logs from the 1990s through 2017 was solicited from current and former afloat-deployed US Navy surgeons. Records were extracted from work by Fontana et al. and Lin et al.,[1,2] to add historical context. Minor procedures which are inconsistently logged, such as simple lacerations or nonanorectal/gynecologic incision and drainage procedures which are typically within an enlisted corpsman's scope of practice while deployed were excluded, using only ABS-defined surgical procedures for analysis. Procedures were then mapped to individual KSA line items, based on the current MHSSPACS working documents (e-appendix 1), to ensure that all afloat-pertinent KSAs had been identified.

Defined procedures were iteratively grouped into 5 general categories for comparison: urologic/gynecologic (e.g. vasectomy, scrotal abscess, testicular torsion, Bartholin cyst drainage); anorectal (e.g. perirectal/perianal abscess, hemorrhoid, pilonidal abscess); hernia (inguinal, umbilical/ventral); appendectomy; and hand/orthopedic/other trauma (e.g. complex laceration/amputation, exploratory laparotomy, and thoracotomy). Case totals were normalized to a 7-month deployment period for ease of comparison. Data from US Navy hospital ships, *USNS MERCY* and *COMFORT* were specifically excluded, as these platforms execute constitutively different missions than the warfighting platforms (e.g. aircraft carriers), are staffed with multiple senior physicians, and possess state-of-the-art surgical suites and radiologic capabilities.[12]

To evaluate training of military surgery residents germane to the afloat case load, deidentified ACGME case logs of graduates from a tertiary-care military treatment facility were reviewed from 2012 to 2016. ACGME-defined cases approximating the afloat categories above were averaged over the analysis period. Chief Resident case numbers were examined as a proxy for emerging surgical competency, under the assumption the resident was performing as the lead surgeon in the categories above. Unpaired student's *t*-test was used to compare mean absolute case numbers and percentage of total cases per deployment before and after the year 2000 (reflecting the Fleet-wide, late 1990s implementation of shipboard laparoscopy) for each of the 5 afloat case categories. Analysis was performed using SPSS 24.0 (IBM Corporation), with statistical significance defined as $p < 0.05$. This evaluation was designated as an exempt project by the institutional review board of Walter Reed National Military Medical Center.

RESULTS

Logs were returned from multiple deployments aboard 4 amphibious assault ships (3 Landing, Helicopter, Dock [LHD], and 1 Landing Platform, Helicopter [LPH]) and 3 Aircraft Carriers, Nuclear (CVN), plus previously

published work,[1,2] comprising more than 200 months at sea. Deployment length ranged from 6 to 11 months. Analysis yielded 1748 logged procedures from 1990 to 2017, 1340 of which met inclusion criteria. The 10 most common procedures at sea are highlighted in Table 1.

Analysis yielded 46 distinct procedures. Thirty-four procedures (74%) correlated to at least one specific intraoperative KSA item; 12 (26%) had no correlating KSA (e-appendix 2). Nonmatched procedures typically comprised nontrauma general surgery procedures (e.g. inguinal

TABLE 1. Comparison of Individual Case Absolute and Proportional Volume, 1990s vs 2000s *(n [sd])*. Highest Volume Cases Highlighted *(NFI=No Further Information—laparoscopic vs open approach not reported.)*

Case	Total Cases Examined	Total 1990s Cases	Cases per 1990s Deployment	Total 2000s Cases	Cases Per 2000s Deployment
Inguinal hernia (NFI)	39	0	0.0 (0.0)	39	1.8 (1.9)
Open inguinal hernia	171	153	25.4 (11.2)	18	1.1 (2.7)
Lap inguinal hernia	0	0	0.0 (0.0)	0	0.0 (0.0)
Umbilical/Ventral Hernia	49	35	5.8 (2.9)	14	0.6 (1.2)
Lap umbilical/ventral hernia	0	0	0.0 (0.0)	0	0.0 (0.0)
Appendectomy (NFI)	33	0	0.0 (0.0)	33	1.7 (2.1)
Appendectomy, open	87	87	14.4 (5.8)	0	0.0 (0.0)
Appendectomy, laparoscopic	17	0	0.0 (0.0)	17	0.8 (1.4)
Cholecystectomy, open	4	2	0.3 (0.3)	2	0.1 (0.3)
Cholecystectomy, laparoscopic	6	0	0.0 (0.0)	6	0.4 (0.8)
Incision & drainage	20	0	0.0 (0.0)	20	0.9 (2.0)
Exploratory laparotomy	8	2	0.3 (0.2)	6	0.3 (0.6)
Diagnostic laparoscopy	4	0	0.0 (0.0)	4	0.2 (0.5)
Percutaneous tube cholecystostomy	2	0	0.0 (0.0)	2	0.1 (0.4)
Neck trauma/exploration	1	0	0.0 (0.0)	1	0.1 (0.2)
Thoracotomy	1	1	0.2 (0.1)	0	0.0 (0.0)
Chest tube	2	1	0.2 (0.1)	1	0.04 (0.2)
Urologic minor (scrotal abscess, cyst, etc.)	43	12	2.0 (1.0)	31	1.9 (7.7)
Circumcision	78	63	10.5 (5.1)	15	0.8 (3.3)
Vasectomy	304	171	28.5 (14.0)	133	4.8 (7.2)
Testicular torsion	2	0	0.0 (0.0)	2	0.1 (0.3)
Breast, nongynecomastia	4	0	0.0 (0.0)	4	0.2 (0.7)
Gynecomastia	24	7	1.1 (0.1)	17	0.8 (1.8)
Gynecologic incision & drainage	3	0	0.0 (0.0)	3	0.1 (0.3)
Closed reduction, percutaneous pinning (CRPP)	1	0	0.0 (0.0	1	0.04 (0.2)
Colonoscopy	54	27	4.5 (2.2)	27	1.3 (2.5)
Esophagogastroduodenoscopy (EGD)	12	0	0.0 (0.0)	12	0.3 (0.5)
Pilonidal abscess	100	49	8.1 (2.2)	51	2.4 (3.3)
Perirectal abscess	47	28	3.5 (1.8)	19	0.8 (1.2)
Internal hemorrhoidectomy	8	4	0.6 (1.4)	4	0.1 (0.3)
External hemorrhoidectomy	7	1	0.1 90.4)	6	0.2 (0.7)
Fistulotomy	7	0	0.0 (0.0)	7	0.2 (0.4)
Sphincterotomy	1	0	0.0 (0.0)	1	0.1 (0.3)
Fasciotomy	1	0	0.0 (0.0)	1	0.04 (0.1)
Finger laceration, complicated	1	0	0.0 (0.0)	1	0.01 (0.3)
Other orthopedic procedure (hand, dislocation, fracture, etc.)	36	19	3.2 (1.6)	17	1.0 (1.7)
Joint aspiration	1	0	0.0 (0.0)	1	0.01 (0.04)
Neck abscess/mass	2	0	0.0 (0.0)	2	0.1 (0.3)
Lymph node biopsy	9	0	0.0 (0.0)	9	0.3 (0.6)
Lipoma	75	2	0.3 (0.2)	73	3.5 (8.0)
Deep abscess/hematoma	19	1	0.2 (0.1)	18	1.0 (2.0)
Complicated wound/laceration	17	6	1.0 (0.1)	11	0.5 (1.1)
Dental	8	0	0.0 (0.0)	8	0.3 (1.5)
Implantable birth control extraction	11	0	0.0 (0.0)	11	0.1 (0.5)
Implantable birth control insertion	12	0	0.0 (0.0)	12	0.1 (0.5)
Foreign body removal	1	0	0.0 (0.0)	1	0.01 (0.04)
Oropharynx	1	0	0.0 (0.0)	1	0.1 (0.2)

TABLE 2. Comparison of Common Case Category Proportional and Absolute Volume, 1990s vs 2000s

	% 1990s Case Load	% 2000s Case Load	p Value	Cases Per 1990s Deployment *n (sd)*	Cases Per 2000s Deployment *n (sd)*	p Value
Urologic/gynecologic	31.4	17.9	0.16	41.0 (20.1)	7.7 (11.0)	<0.001
Anorectal	18.0	12.4	0.33	13.5 (2.3)	3.7 (3.8)	<0.001
Hernia	26.2	15.3	0.004	31.3 (14.0)	3.5 (2.8)	0.005
Appendectomy	13.3	15.6	0.56	14.4 (5.8)	2.5 (1.9)	0.003
Orthopedic/hand/ other trauma	2.9	7.4	0.05	3.8 (1.9)	1.7 (1.8)	0.02

herniorrhaphy or gynecomastia excision) or nontrauma, nongeneral surgery procedures (e.g. oropharyngeal/dental or joint aspiration). One hundred nineteen KSAs were classified as "universally-applicable," comprising topics such as standard perioperative care, accurate identification of injuries, communication throughout the longitudinal pathway of care, etc.

The most common surgery performed overall was vasectomy, totaling 23% of operations (304 of 1340), nearly doubling open inguinal hernia, the second-most frequent (13%, 171 of 1340). Vasectomy strongly contributed to Urologic/Gynecologic cases being the largest category in both 1990s and 2000s cases (31.4% vs 17.9%). No statistically significant difference in case mix was apparent comparing pre- and postlaparoscopy-integrated deployments in 4 of 5 categories (Table 2): urologic/gynecologic, anorectal, and appendectomy; hand/orthopedic/other trauma trended toward significance ($p = 0.05$). Hernia cases showed the only statistically-discernible decrease in proportional volume. Interestingly, overall case volume markedly declined from an average of 111.5 (±42.6) cases per deployment prior to 2000 down to 29.2 (±23.7) cases per deployment after 2000 ($p < 0.001$). Case load per deployment significantly declined in all 5 categories (Table 2).

Analysis of ACGME case logs from 2012 to 2016 yielded data of 34 graduates, comprising more than 32,000 total resident cases (946 ± 41 per resident), with an average of 181 (±8) cases logged as Chief Resident. Experience in ACGME case categories is listed with comparable afloat procedures in Table 3. Highlighting the most common afloat case category, general surgery residents averaged only 0.24 (±0.17) urologic procedures during Chief year.

DISCUSSION

This evaluation represents a needs assessment based on operative experience for the austere practice environment of the afloat-deployed surgeon. It is not a comment on the surgical proficiency of military residents.[11] However, this report highlights 2 important aspects of shipboard surgery: (1) newly graduated military surgeons

TABLE 3. Comparison of Selected At-Sea Cases with Military Surgical Resident Experience *(n [sd])*

Case	Average # Cases Per 7-month Deployment		Average # Resident Cases	
	1990s	2000s	Chief year (mean = 181 ± 8)	Full residency (Mean = 946 ± 41)
Appendectomy	14.4 (5.8)	2.5 (1.9)	Open 0.5 (0.3) Lap 5.3 (1.8)	Open 4.8 (2.3) Lap 46.2 (4.4)
Anorectal	13.5 (2.3)	3.7 (3.8)	6.9 (2.3)	31.3 (4.3)
Inguinal hernia	22.7 (12.1)	2.7 (2.6)	Open 6.8 (1.5) Lap 17.6 (1.7)	Open 43.6 (4.5) Lap 36.5 (2.6)
Cholecystectomy, open	0.3 (0.3)	0.1 (0.3)	1.3 (0.5)	5.2 (0.8)
Cholecystectomy, laparoscopic	0.0 (0.0)	0.3 (0.7)	13.6 (1.8)	64.2 (4.0)
Urologic/gynecologic	41.0 (20.1)	7.7 (11.0)	0.4 (0.4)	4.0 (1.8)
Ortho/hand	2.8 (1.6)	1.0 (1.6)	0.04 (0.09)	0.4 (0.3)

may not currently receive the necessary experience in residency to cover the breath of cases required for the afloat surgeon, and (2) at-sea surgical volume appears to have markedly decreased over time, but no registry mechanism exists to provide holistic data for ongoing analysis. Accredited training programs throughout the Department of Defense continue their tradition of world-class surgical training within the ABS and ACGME paradigm, often attaining ABS first time certification at higher rates than many academic or community program peers.[13] The unique responsibilities shouldered by uniformed surgeons expected to perform as young, solo practitioners likely require additional programmatic considerations beyond ABS/ACGME requirements. Regardless of average case volume for any individual procedure, the breadth of afloat cases found here dictates that training requirements remain the same—deploying general surgeons clearly require an expanded skillset beyond current graduation requirements.

Recognizing the unique requirements of military surgeons, in 2014 the American College of Surgeons and the Department of Defense formally created an ongoing partnership designated as the MHSSPACS.[10] One major goal of this partnership is defining the trauma-centric KSAs required for expeditionary surgeons, with a particular goal of optimizing predeployment preparations for surgeons and measuring surgeon competency.[9] The most common nonelective procedures identified in our analysis match well with the consensus-driven KSAs, particularly within the "Expeditionary Unique" domain. While 1/3 of the procedures found in our convenience sample had no specific intraoperative KSA correlate, these procedures were heavily nontrauma, core general surgery (e.g., inguinal hernia repair, gynecomastia excision) of which basic competence is presumed for the board-certified general surgeon. Nontrauma, nongeneral surgery procedures (e.g., dental, oropharynx, and joint aspiration) represent a true training gap and reveal expansion possibilities for the MHSSPACS KSA working groups. This buoys our observations that afloat surgery requires an impressive variety of procedural competency and provides analytical support to the applicability of both projects.

The surgical knowledge and skills required to provide this breadth of care remain constant, though the emphasis in training programs has appropriately evolved with the widespread integration of technological advances and specialization of surgical care. The minimally-invasive surgery revolution ushered in a shift from completely open surgery to mostly laparoscopic approaches for common cases (e.g. appendectomy). Every patient undergoing these procedures in a minimally-invasive fashion is counseled on the possibility of conversion to open, but conversion rates remain low, and planned-open approaches for these procedures remain the distinct minority of cases.[14]

Urologic and gynecologic cases warrant specific discussion. Vasectomy stood out as the most common individual defined procedure throughout the span of this investigation. This is, by definition, a completely elective procedure whether in port or at sea. Surgeons choose individually whether to offer or decline this procedure while afloat and—as with all elective cases involving service members—must receive Commanding Officer approval prior to completion. The choice to offer this elective procedure should remain with the surgeon, but if offered, the surgeon should have sufficient familiarity with the procedure to perform it safely and effectively, with appropriate reflections in privilege documents. Relatedly, other male urologic procedures (scrotal abscess, testicular torsion, and pelvic trauma) represent urgent or emergent cases which require experience operating on the urogenital system that many general surgeons lack. Similar statements may be made regarding necessary gynecologic cases of Bartholin cyst management, ovarian torsion or cyst rupture, caesarian section, ectopic pregnancy, pelvic trauma, etc.[15] Twelve individual urologic and gynecologic line items were identified as critical competencies in the KSA partnership,[16] reiterating their importance to the deployed surgeon. Expertise in these rare but real scenarios may not be practically achievable during general surgery residency, but curricula should be developed to adequately prepare the expeditionary surgeon prior to deployment.

Specialty-bridging experience germane to the afloat surgeon may be found through multiple pathways, requiring varying levels of time and financial investment by individuals, programs, and the Department of Defense. Cadaveric, manufactured, or virtual simulation models are already available for many procedures.[17] Case sharing among residents has been proposed to increase cross-service cooperation while simultaneously satisfying ACGME requirements for Chief Resident Teaching Assistant case numbers.[8,18] This may be untenable to programs, however, as sharing creates the understandable tension of residents "losing" training cases to another service. En route training or professional development short courses exist for trauma disciplines, such as Emergency War Surgery (EWS— https://health.mil/Training-Center/Defense-Medical-Readiness-Training-Institute/Emergency-War-Surgery-Course). Some courses (e.g. Advanced Trauma Operative Management [ATOM], Advanced Surgical Skills for Exposure in Trauma [ASSET]) include active resident participation and have even been piloted for medical students[17,19-22]; revamping such courses to include afloat surgery modules

would be a plausible first step. These courses utilize surgical simulation to provide standardized training in low-risk environments, without the logistic uncertainties of waiting for a given case to present to clinic. Well-outfitted surgical simulation centers already exist at major centers in the Department of Defense, along with the large Department of Veterans Affairs center in Tampa; academic cadaver labs exist in similarly-accessible locations, including the Uniformed Services University. Standardized curricular options would also benefit the numerous residents training outside the military residency paradigm,[23] as well as the many Navy Reserve surgeons who deploy. Similar opportunities would likely benefit civilian surgeons in isolated, rural, or underserved locations. Creating a repository of afloat techniques as reference material for the at-sea surgeon (e.g., The Borden Institute's *Emergency War Surgery* textbook[24]) would front-load any time or monetary investment but yield long-lasting material easily distributed to a widely-dispersed audience.

LIMITATIONS

A few limitations to this report deserve mentioning. There is no centralized registry for surgery performed at sea. We obtained afloat case logs from data request respondents as a convenience sample. While this does not comprise a true random sample, in the absence of any official curated data we propose these are representative of general trends in surgery at sea, particularly the robust recent data from multiple platforms. Logs analyzed in this review more than triple the published data on surgical care afloat. The possibility exists for unaccounted data reflecting goal-deployed task forces (e.g. humanitarian/natural disaster response, mass-casualty or assault support) or unique-event occurrences (e.g. aircraft disaster, ship collision) to individually alter the cases of any given deployment, however, the baseline expectations continue to be grossly unchanged across deployment platforms, locations, and time frames. Qualifying data reflecting these operational considerations was not available in our logs. Military leadership should reflect these factors in any prospectively-maintained data repository.

Multiple, anecdotal contributing factors for the observed decline in overall deployment case numbers have been proposed, including airspace dominance leading to robust intercontinental medical evacuation capabilities, but are beyond the scope of this needs assessment. Lack of a service- or military-wide case log repository makes detailed analysis difficult.

The ACGME case logs providing resident procedure data reflect only a single military training program. While programmatic differences may exist, and examination of the limited number of military surgery residents may be feasible, this sample of 34 residents, totaling more than 32,000 procedures both in and out of the Military Health System at all levels of care, varied little year-to-year, and illustrates the general state of newly-trained surgeons entering uniformed service. Data also represent only those cases logged by the resident; incorrectly-coded or missing cases could affect the conclusions drawn above.

CONCLUSIONS

Current curricula and operative practices provide graduating residents with minimal exposure to specific cases expected on deployments, which may not translate to competency for the afloat surgeon. Military leadership, residency program directors, and surgical trainees should embrace training pipelines for these unique afloat experiences, evaluating current curricula for reasonable training opportunity improvements while maintaining ACGME and ABS program integrity, develop afloat-ready resources for well-trained but isolated surgeons, and assertively invest in the development of the military's newest surgeons. An unexpected finding was a marked decrease in at-sea operations, which requires further analysis. A formal, curated registry of afloat case logs—inclusive of all procedures performed afloat—should be developed, or included in the Department of Defense Trauma Registry to quantify and to ensure quality surgical care is being delivered at sea.

DISCLAIMER

The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the views of the Department of Defense, the Uniformed Services University of the Health Sciences, or any other agency of the US Government.

REFERENCES

1. Fontana M, et al. Surgery aboard ship: is it safe? *Mil Med*. 1999;164:613–615.
2. Lin H, et al. Surgery in expeditionary strike group. *Mil Med*. 2009;174:241–244.
3. Thoman DS. Laparoscopy at sea: overcoming unique challenges. *Bull Am Coll Surg*. 2004;89:12–17.
4. Halverson AL, et al. Evaluation of a blended learning surgical skills course for rural surgeons. *Am J Surg*. 2014;208:136–142.

5. Harris JD, Hosford CC, Sticca RP. A comprehensive analysis of surgical procedures in rural surgery practices. *Am J Surg*. 2010;200:820–825. discussion 825-6.

6. Cubano MA, Luther JH, Antosek LE. First laparoscopic hernia repair onboard an aircraft carrier at sea. *Mil Med*. 1997;162:219–220.

7. Surgery ABo. The American Board of Surgery Booklet of Information Surgery. 2017. [cited 2017 Nov 1]; Available from: http://www.absurgery.org/xfer/BookletofInfo-Surgery.pdf.

8. Education ACoGM. ACGME program requirements for graduate medical education in general surgery. 2017. [cited 2017 Nov 1]; Available from https://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/440_general_surgery_2017-07-01.pdf.

9. *Military Health System Clinician Readiness*. General Surgery Pilot Report. 2017:66. Department of Defense.

10. Knudson MM, et al. A shared ethos: the military health system strategic partnership with the American College of Surgeons. *J Am Coll Surg*. 2016;222:1251–1255.

11. Thomas PA, et al. Curriculum development for medical education : a six-step approach. 3rd ed. Baltimore: Johns Hopkins University Press; 2016:300. xii.

12. Information, U.S.N.C.o. *Hospital Ships—T-AH*. 2017. Available from: http://www.navy.mil/navydata/fact_display.asp?cid=4625&tid=200&ct=4.

13. Falcone JL, Charles AG. Military and academic programs outperform community programs on the American Board of Surgery Examinations. *J Surg Educ*. 2013;70:613–617.

14. Masoomi H, et al. Laparoscopic appendectomy trends and outcomes in the United States: data from the Nationwide Inpatient Sample (NIS), 2004-2011. *Am Surg*. 2014;80:1074–1077.

15. Garland FC, Garland CF, Gorham ED. A model of the expected occurrence of adverse pregnancy outcomes aboard U.S. Navy ships. *Mil Med*. 2000;165:691–697.

16. Hennings SS. MHSSPACS General Surgery Tasks Blueprint. In: Ritter EM, ed. 2018.

17. Tyler JA, et al. Current US military operations and implications for military surgical training. *J Am Coll Surg*. 2010;211:658–662.

18. Education, ACoGM. Case log information for urology programs. 2013. [cited 2018 Feb 2]; Available from: http://www.acgme.org/portals/0/pfassets/programresources/480-urology-case-log-info_.pdf.

19. Mueller G, et al. Intensive skills week for military medical students increases technical proficiency, confidence, and skills to minimize negative stress. *J Spec Oper Med*. 2012;12:45–53.

20. Edwards MJ, et al. Saving the military surgeon: maintaining critical clinical skills in a changing military and medical environment. *J Am Coll Surg*. 2016;222:1258–1264.

21. Truitt MS, et al. Civilian and military trauma: does civilian training prepare surgeons for the battlefield? *Am Surg*. 2011;77:19–21.

22. Tyler JA, et al. Combat readiness for the modern military surgeon: data from a decade of combat operations. *J Trauma Acute Care Surg*. 2012;73 (2 Suppl 1):S64–S70.

23. Babcock JA. Integrated military and civilian surgical residency: a review of one program, its development, and future trends. *J Surg Educ*. 2014;71:774–776.

24. Emergency war surgery. Fourth United States revision. ed. Washington, DC: Borden Institute (U.S.); 2013.

SUPPLEMENTARY INFORMATION

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