Surgical simulation supplements reproductive endocrinology and infertility fellowship training

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Objective: To assess if a surgical boot camp improves laparoscopic skill among reproduction endocrinology and infertility (REI) fellows and increases fellow desire to incorporate surgical skills into practice and to examine whether fellowship in vitro fertilization (IVF) volume correlates with surgical efficiency.
Design: Prospective evaluation.
Setting: Simulation Center.
Patient(s): Forty REI fellows.
Intervention(s): Fellows were timed before and after training in laparoscopic suturing and knot tying and while using virtual simulators. Fellows were surveyed before boot camp on prior experience with IVF and reproductive surgery, and immediately and 1 month after boot camp on their desire to incorporate surgical skills into practice.
Main Outcome Measure(s): Efficiency of laparoscopic suturing and knot tying before and after boot camp; likelihood and persistence of incorporating surgical skills into practice immediately and 1 month after boot camp; and correlation between fellowship IVF volume and fellow surgical efficiency.
Result(s): Fellows experienced significant improvement in laparoscopic suturing (44 sec), intracorporeal knot tying (82 sec), and extracorporeal knot tying (71 sec). Fellows reported being more likely to incorporate operative hysteroscopy (89%), operative laparoscopy (87%), and laparoscopic suturing (84%) into practice immediately following boot camp with no difference 1 month later. Fifty-four percent of fellows reported being more likely to perform robotic surgery after the boot camp, increasing to 70% 1 month later. There were weak correlations between IVF case volume and efficiency in laparoscopic suturing or hysteroscopic polypectomy (Spearman correlation coefficients, -0.14 and -0.03).
Conclusion(s): An intensive surgical boot camp enhances surgical skill among REI fellows. (Fertil Steril Rep® 2020;1:154–61. ©2020 by American Society for Reproductive Medicine.)
Key Words: Surgical education, fellowship, reproductive surgery, laparoscopy, robotic surgery

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Surgical simulation has emerged as a potential means of effectively training surgeons in a nonclinical setting, but simulation programs frequently are limited by lack of resources, cost, and time constraints in busy academic centers (1). The concept of a short, intensive boot campapproach to surgical skills training has emerged within the last decade and has been well documented in orthopedic (2–5), neurosurgical (6, 7), otolaryngology (8, 9), cardiothoracic (10–13), and general surgery (14) literature, where it has been shown to improve technical skills and confidence for up to 6 months after its completion (15). A similar approach has been described in obstetrics and gynecology (OBGYN) (16), where it is of particular interest given the shorter training of OBGYN residents relative to their counterparts in general surgery (17–23).

The field of reproductive endocrinology and infertility (REI) has evolved dramatically in the last several decades (24). Some have suggested that advanced hysteroscopy and gynecologic laparoscopy have a more limited role in infertility treatment with advances in assisted reproductive technologies and in vitro fertilization (IVF), a trend that is reflected in the composition and priorities of many REI fellowship training programs. Given inherent differences in surgical skill among graduating OBGYN residents and the heterogeneous training in reproductive surgery among REI fellowship programs, a surgical boot camp may be useful as a means to standardize surgical skill for REI fellows; this may be of particular importance for fellows at programs with high IVF volume due to perceived detraction from surgical training.

We describe our experience with a 2-day, intensive boot camp for REI fellows focusing on minimally invasive reproductive surgery. The primary study objectives were to assess the efficacy of a surgical boot camp in improving REI fellow performance of timed surgical tasks, determine whether a surgical boot camp results in an increased likelihood of REI fellows incorporating select surgical skills into their practice and whether this persisted over time, and evaluate for correlation between a training program's IVF case volume and the surgical skill of the REI fellow. A secondary aim was to compare the surgical performance and attitudes of first-year fellows with their second- and third-year counterparts.

MATERIALS AND METHODS

All United States REI fellows were invited to participate in an intensive, 2-day boot camp for the purpose of advancing surgical principles and technical skills inherent to minimally invasive reproductive surgery. The fifth annual boot camp took place in January 2019 at the Methodist Institute of Technology, Innovation and Education in Houston, Texas, and was cosponsored by the American Society for Reproductive Medicine's Society for Reproductive Endocrinology and Infertility and Society of Reproductive Surgeons. The course was taught by a group of invited faculty educators and reproductive surgeons from the fields of REI and urology.

The format of the boot camp included pre–boot camp video lectures and both 15-min didactic lectures as well as hands-on wet and dry laboratory instruction. The day was equally divided into didactic instruction on surgical concepts in REI and minimally invasive surgery with dedicated hands-on practice of hysteroscopy, laparoscopic suturing, robotic tubal anastomosis, and embryo transfer using a combination of low- and high-fidelity simulators. Specific course objectives included reviewing pelvic anatomy in didactic sessions as well as cadaveric dissections, exploring a variety of techniques for diagnostic and operative hysteroscopy, performing laparoscopic suturing and knot tying using box trainers and cadaveric models, attempting robotic tubal anastomosis using cadaveric models, and practicing embryo transfer using the American Society for Reproductive Medicine Embryo Transfer Simulator (VirtaMed).

Prior to the start of the boot camp, all fellows were asked to complete a precourse survey characterizing: demographics, career aspirations, perceived competency with concepts and procedures in reproductive surgery, and prior surgical experience and simulation training in both IVF and reproductive surgery. During the boot camp, fellows were timed before and after training in laparoscopic suturing, intracorporeal knot tying, and extracorporeal knot tying using the box trainers. Fellows also were timed while performing laparoscopic needle loading, suturing, and knot tying in cadaveric models as well as while performing various hysteroscopic tasks including hysteroscope assembly and virtual hysteroscopic polypectomy. Following the boot camp, fellows were surveyed about incorporating select surgical skills into clinical practice based on a 5-point Likert scale (much more likely, slightly more likely, neutral, slightly less likely, and much less likely). This survey was administered immediately after the boot camp and again 1 month later to assess the longevity of any changes. The study was approved by the Institutional Review Board at Penn State Health Milton S. Hershey Medical Center.

Descriptive statistics were generated with continuous data reported as median (interquartile range [IQR]) and categorical data reported as n (%). Fellow level of training was dichotomized as first year versus upper year due to fewer second- and third-year fellow participants. Signed-rank tests were used to assess improvement in laparoscopic suturing tasks for a given fellow. Wilcoxon rank-sum tests were used to compare the improvement between first-year and upper-level fellows. The 5-point Likert scale for the post–boot camp survey was dichotomized as more likely versus neutral/less likely. Once dichotomized, generalized estimating equations with a logit link, an extension of logistic regression that accounts for correlated data per fellow (25), were used to assess differences in the post–boot camp survey responses with effect sizes quantified based on odds ratios and 95% confidence intervals. Associations between two continuous variables were examined via the Spearman correlations coefficient.

RESULTS

Forty REI fellows participated in the boot camp, representing 72% of the 50 REI fellowship training programs in the United States. One first-year fellow did not complete the demographic portion of the survey and was excluded from

TABLE 1

Demographics of boot camp participants.

Variable	Data
Age (y), mean ± SD	32.6 ± 3.1
Female	28 (71.8)
Race	
White	20 (51.3)
Asian	11 (28.2)
African American	3 (7.7)
Other	3 (7.7)
Unknown	2 (5.1)
Year of fellowship	
1	25 (62.5)
2	11 (27.5)
3	4 (10.0)
Career goal	
Academic practice	9 (23.1)
Private practice	3 (7.7)
Hybrid practice	18 (46.2)
Undecided	9 (23.1)

Note: Data presented as n (%), unless noted otherwise. SD = standard deviation.

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subsequent analyses. Most of the fellows were female (72%) and in their first year of fellowship training (63%). Fifty-one percent identified as white and 28% as Asian. Almost half of the fellows (46%) reported a desire to enter a hybrid academic-private practice after graduation (Table 1).

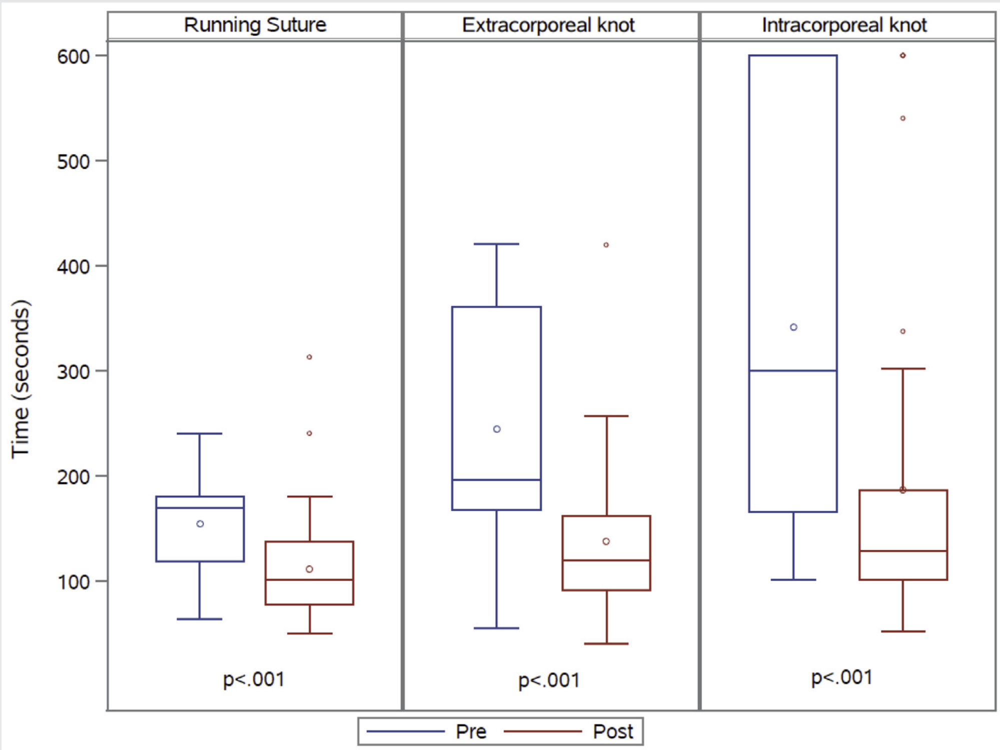
Prior to the boot camp, most fellows felt prepared to perform operative hysteroscopy (100%), open surgery (85%), and operative laparoscopy (82%), but only a minority felt prepared to perform laparoscopic suturing (33%), robotic surgery (28%), or tubal anastomosis (10%). Fellows reported engaging in a median of 2 simulation hours for hysteroscopy (IQR 0–10), 8 simulation hours for laparoscopy (IQR 2–20), and 4 simulation hours for robotic surgery (IQR 2–10) prior to attending the boot camp. Reported surgical experience in fellowship training varied greatly between participants. Fellows reported performing a median of 30 operative hysteroscopies (IQR 17–64), 17 operative laparoscopies (IQR 10–30), and three abdominal myomectomies (IQR 1–7) during their fellowship training to date. A minority (38.5%) of fellows reported having performed robotic laparoscopy in their fellowship. Seventy-nine percent of fellows had not performed a tubal anastomosis; those fellows who had reported performing this procedure noted having participated in approximately 1 to 5 procedures each. The median number of surgeries performed in the month prior to boot camp was 11.0 (IQR 5–18) for first-year fellows and 2.0 (IQR 0–5) for upper-year fellows. The median number of surgeries performed overall thus far during fellowship was 73 (IQR 40–118) for first-year fellows and 140 (IQR 90–163) for upper-year fellows. In the pre–boot camp survey, a majority of fellows reported they were likely to perform hysteroscopic surgery (100%), operative laparoscopy (87%), and open surgery (71%) after fellowship, whereas only 32% felt they were likely to perform robotic surgery.

During the boot camp, fellows experienced significant improvement in laparoscopic suturing skill. Using the box trainers, fellows had a median 44-second improvement (IQR 15–70 sec) in running suture placement, an 82-second improvement (IQR 25–298 sec) in intracorporeal knot placement, and a 71-second improvement (IQR 32–154 sec) in extracorporeal knot placement (Fig. 1; $P<.001$ for all comparisons). First-year fellows demonstrated a 60-second improvement (IQR 19–76 sec) in running suture times as compared with their upper-level peers who improved by 28 seconds (IQR 3–50 sec; $P=.04$). No significant differences were found between first- and upper-year fellows in the degree of improvement for intracorporeal and extracorporeal knot tying. There were similarly no differences between first- and upper-year fellows in the efficiency of cadaveric laparoscopic suturing, robotic placement of 6-0 suture for tubal anastomosis, or in hysteroscope assembly or hysteroscopic polypectomy ($P>.15$ for all comparisons, data not shown).

The post–boot camp survey aimed to assess if the boot camp changed their desire to perform certain procedures by using a less likely to more likely Likert scale. Results from the post–boot camp survey, analyzed as more likely versus neutral/less likely, are summarized in Table 2. A majority of fellows reported being more likely to incorporate operative hysteroscopy (89%), operative laparoscopy (87%), and laparoscopic suturing (84%) into their practice after attending the boot camp, a finding that persisted when reassessed 1 month later ($P>.30$ for all comparisons of 1 month versus immediately after boot camp). Fifty-four percent of fellows reported being more likely to perform robotic surgery after attending the boot camp, which significantly increased to 70% 1 month later (odds ratio 2.10; 95% confidence interval 1.09–4.05; $P=.03$). Only 50% of fellows reported they felt more likely to perform tubal anastomosis immediately after attending the boot camp, decreasing to 43% 1 month later, although not a statistically significant decrease ($P=.41$). After attending the boot camp, first-year fellows felt more likely to incorporate surgical techniques into their practice when compared with upper-year fellows. Specifically, 96% of first-year fellows felt they were more likely to incorporate laparoscopic suturing into future practice, compared with 60% of upper-level fellows ($P=.02$) and, similarly, 96% of first-year fellows versus 64% of upper-year fellows ($P=.03$) felt more likely to incorporate operative hysteroscopy into their future practice.

Correlations between the number of IVF cycles performed per year and fellow efficiency at laparoscopic suturing or virtual hysteroscopic polypectomy are shown in Figure 2. There was a very weak correlation between the IVF case volume and the surgical skill of the fellow as assessed based on these two tasks (Spearman correlation coefficients -0.14 for laparoscopic suturing and -0.03 for hysteroscopic polypectomy). To examine whether the residency program training may have impacted the results, the same correlations of IVF volume versus surgical skills were run separately by fellowship year. Using upper-year fellows only, there were still no strong associations (absolute values of Spearman correlation coefficients <0.20). Efficiency at laparoscopic suturing or hysteroscopic polypectomy similarly were weakly correlated with

FIGURE 1



Laparoscopic suturing times before and after boot camp. Box plots represent laparoscopic suturing times before and after the boot camp. Signed-rank tests were used to assess improvement in laparoscopic suturing tasks for a given fellow. *Borders of the box* indicate the interquartile range (Q1–Q3); *horizontal lines* depict the median; *open dots* depict the mean; *whiskers* indicate minimum and maximum values; and *closed dots* reflect outliers.

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hours of prior simulation training or the numbers of prior procedures performed in fellowship (all absolute values of Spearman correlation coefficients <0.24). There was no correlation between IVF case volume and number of surgical cases performed in the month prior to boot camp (Spearman correlation coefficient of 0.25), nor with the total number of surgical procedures performed during fellowship (Spearman correlation coefficient of -0.02).

DISCUSSION

Because surgical morbidity has been directly linked to surgeon experience (17), national organizations such as the American Association of Gynecologist Laparoscopists have suggested concentrating gynecologic surgery in the hands of fewer practitioners who can maintain higher operative volumes (18). It has been shown previously that higher-volume surgeons have better operative outcomes and decreased surgical complication rates (19, 20). Particularly in the case of minimally invasive gynecologic surgery, additional practice or training may be required for an individual to achieve comfort or perceived competency (20, 21). Advanced gynecologic procedures, therefore, increasingly may be performed by the approximately 12% of OBGYN residency graduates who chose to pursue fellowship training in a gynecologic subspecialty, including the 4% who pursue REI (22).

Although incoming REI fellows report widespread exposure to hysteroscopic, basic laparoscopic, and open procedures, comfort and training in advanced laparoscopy and robotic reproductive surgery are more limited and inconsistent. The reasons for this lack of exposure are likely multifactorial and may relate to scope of practice, resource availability, and referral patterns within fellowship training programs. The nature of surgical practice for the reproductive endocrinologist has changed dramatically with the advent and improvement of IVF. Although surgery may have a more limited role in the treatment of infertility related to endometriosis or tubal pathology, the scope of reproductive surgery has expanded to include not only the correction of abnormal pathology but also techniques that preserve fertility or enhance the outcome of IVF treatment with a focus on minimally invasive techniques (1, 24, 26, 27) that remain critical to a patient's reproductive care (28). Although REI physicians were among the first gynecologists to embrace minimally invasive surgical techniques, time constraints and economic pressures have caused many to curtail or abandon surgical practice (29). These practice changes likely have impacted fellowship training in REI, although the effect

TABLE 2

Reported desire to perform a given surgical procedure after boot camp.

Procedure	Immediately, n (%)	1 mo, n (%)	OR (95% CI)	*P* value
Operative hysteroscopy	33 (89.2)	31 (83.8)	0.60 (0.23, 1.56)	.30
Operative laparoscopy	33 (86.8)	32 (86.5)	0.81 (0.32, 2.05)	.65
Laparoscopic suturing	31 (81.6)	31 (83.8)	1.13 (0.54, 2.37)	.75
Robotic surgery	20 (54.1)	26 (70.3)	2.10 (1.09, 4.05)	.03
Tubal anastomosis	19 (50.0)	16 (43.2)	0.78 (0.44, 1.40)	.41

Note: The 5-point Likert scale for the post–boot camp survey was dichotomized as "more likely" versus "neutral/less likely." Once dichotomized, generalized estimating equations with a logit link were used to assess differences in likelihood of incorporating skills into practice. CI = confidence interval; OR = odds ratio.

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previously has not been quantified. Interestingly, IVF case volume at a fellow's training program was not correlated with surgical case volume nor with surgical skill as measured by performance on laparoscopic suturing or hysteroscopic polypectomy. These findings may suggest retention of essential surgical skills gained during residency training as well as a potential role for surgical simulation in the maintenance and expansion of skill. It is unlikely that the entirety of this effect was due to retention of surgical skill from residency training because the lack of correlation persisted when examined solely among upper-level fellows, although this subanalysis was limited by sample size.

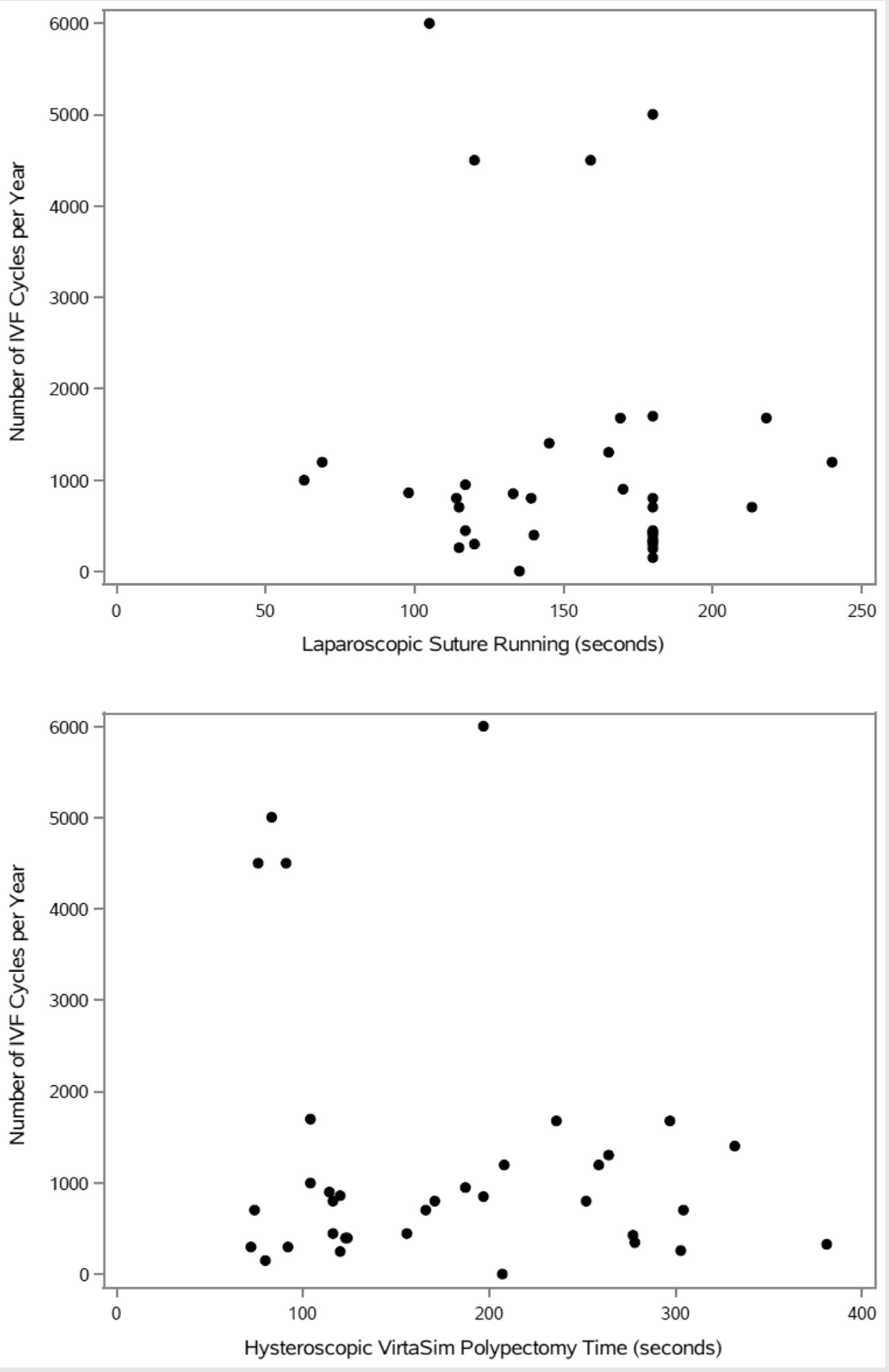
Significant improvement in the efficiency of laparoscopic suturing ranging from 15 sec to nearly 5 min was seen across fellows at all levels of training during the boot camp. This increase in efficiency can translate to reduced operative times, resulting in significant cost savings (28, 30, 31) as well as improved perioperative outcomes from reduced anesthetic exposure (32). It is notable that first-year fellows had the fastest baseline times in all laparoscopic suturing tasks and showed greater improvement following the boot camp in comparison with upper-level fellows. One explanation for these findings is the proximity of first-year fellows to residency training with its higher surgical case volume. One may expect further improvement in baseline laparoscopic suturing skill with the new American Board of Obstetrics and Gynecology requirement that residents graduating after 2020 successfully complete the Fundamentals in Laparoscopic Surgery course as a prerequisite for board certification. Although completion of Fundamentals in Laparoscopic Surgery consistently has been shown to improve surgical skill and reduce operative times among general surgery residents (33, 34), its validity has been only recently established in gynecology where studies are more limited (35). DeStephano et al. (36) called for a more standardized approach for surgical simulation within OBGYN graduate medical education for which a surgical skills boot camp may be beneficial. Greater baseline competence in laparoscopic suturing among incoming REI fellows may enable surgical simulation training to focus on advanced skills necessary for reproductive surgery, including multilayer myomectomy closure, retroperitoneal dissection, and use of fine suture for tubal pathology.

In the present study, most fellows reported being more likely to incorporate surgical techniques into clinical practice after attending the boot camp. This finding was most significant among first-year fellows, highlighting the importance of early surgical and/or simulation exposure to reinforce and develop skills acquired in residency. Maintenance and development of surgical practice through volume of exposure has been linked directly to decreased surgical complications (17–21). High- and low-fidelity surgical simulation have been similarly well-studied as a means to develop muscle memory and practice surgical decision making in a nonclinical setting. In gynecology, effective simulation models have been described for a variety of advanced procedures including laparoscopic ureteral dissection (19), vaginal hysterectomy (37), trans-vaginal tape placement (38), sacrospinous ligament fixation, and radical hysterectomy (29, 39). Use of brief, intensive surgical boot camps has been validated to prepare medical students for an OBGYN residency (40) and to reinforce basic procedural skills for junior residents (39, 41) but has yet to be described for advanced reproductive surgery.

A key strength of this study is its wide reach, with representation from more than 70% of the REI fellowship programs in the country. Moreover, the study provides empiric data to quantify the improvement in key surgical tasks following a short, intensive period of simulation training. However, certain limitations should be considered when interpreting this data. First, the descriptive portions of the study rely on self-reporting to assess surgical training and exposure and could not be confirmed by empiric data from fellowship programs. Second, surveys were designed to assess the longevity of fellows' comfort with reproductive surgical skills following the boot camp, but conclusions cannot be reached about the impact of the boot camp on persistent changes in knowledge or surgical performance. There is literature to suggest that simulation-based curricula may be beneficial to learn psychomotor skills but continued coaching may be necessary for maintenance of skill (41). Because most surgeries in our cohort were performed during the first year of fellowship, REI fellows may benefit from more evenly distributed clinical time throughout all 3 years. Potentially useful strategies to maintain surgical skill could include competency-based curricula (42) with benchmarks to monitor progress and encourage growth (43), use of personalized surgical video feedback (44), and continued formal surgical mentorship or repeated attendance at the surgical boot camp.

Given the heterogeneous training in advanced reproductive surgery among REI fellowship programs, a surgical boot camp

FIGURE 2



Correlation between in vitro fertilization (IVF) cycles performed in fellowship and surgical simulation efficiency. The scatter plots represent the correlation between the number of IVF cycles performed in fellowship and efficiency with laparoscopic suturing and hysteroscopic polypectomy simulation. Associations between surgical skills and the number of IVF cycles performed per year were examined via Spearman correlations.

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appears to be useful in enhancing surgical skill among REI fellows. The empiric increases in surgical efficiency demonstrated among REI fellows during the boot camp, as well as the sustained improvements in perceived competency after its completion, are both reassuring. However, subsequent study is required to quantify the longevity of this impact on surgical skill. If brief, intensive, boot-camp style simulation sessions can indeed impact long-term surgical knowledge and competency among REI fellows, they may provide a mechanism for practitioners to obtain and retain the skills required to maintain ownership of patients' reproductive surgical needs.

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REFERENCES

1. Gargiulo AR, Nezhat C. Robot-assisted laparoscopy, natural orifice transluminal endoscopy, and single-site laparoscopy in reproductive surgery. Semin Reprod Med 2011;29:155–68.
2. Zevin B, Aggarwal R, Grantcharov TP. Surgical simulation in 2013: why is it still not the standard in surgical training? J Am Coll Surg 2014;218:294–301.
3. Sonnadara RR, Van Vliet A, Safir O, Alman B, Ferguson P, Kraemer W, et al. Orthopedic boot camp: examining the effectiveness of an intensive surgical skills course. Surgery 2011;149:745–9.
4. Sonnadara RR, Garbedian S, Safir O, Nousiainen M, Alman B, Ferguson P, et al. Orthopaedic Boot Camp II: examining the retention rates of an intensive surgical skills course. Surgery 2012;151:803–7.
5. Sonnadara RR, Garbedian S, Safir O, Mui C, Mironova P, Nousiainen M, et al. Toronto Orthopaedic Boot Camp III: examining the efficacy of student-regulated learning during an intensive, laboratory-based surgical skills course. Surgery 2013;154:29–33.
6. Selden NR, Origitano TC, Burchiel KJ, Getch CC, Anderson VC, McCartney S, et al. A national fundamentals curriculum for neurosurgery PGY1 residents: the 2010 Society of Neurological Surgeons boot camp courses. Neurosurgery 2012;70:971–81.
7. Shao X, Yuan Q, Qian D, Ye Z, Chen G, le Zhuang K, et al. Virtual reality technology for teaching neurosurgery of skull base tumor. BMC Med Educ 2020;20:3.
8. Molin N, Chiu J, Liba B, Isaacson G. Low cost, easy-to-replicate myringotomy tube insertion simulation model. Int J Pediatr Otorhinolaryngol 2020;131: 109847.
9. Milner TD, Okhovat S, McGuigan M, Clement WA, Kunanandam T. Feasibility of ovine and porcine models for simulation training in parotid surgery and facial nerve dissection. Eur Arch Otorhinolaryngol 2020;277:1167–75.
10. Schieman C, Ujiie H, Donahoe L, Hanna W, Malthaner R, Turner S, et al. Developing a national, simulation-based, surgical skills bootcamp in general thoracic surgery. J Surg Educ 2018;75:1106–12.
11. Kenny L, Booth K, Freystaetter K, Wood G, Reynolds G, Rathinam S, et al. Training cardiothoracic surgeons of the future: the UK experience. J Thorac Cardiovasc Surg 2018;155:2526–38.e2.
12. Bierer J, Memu E, Leeper WR, Fortin D, Fréchette E, Inculet R, et al. Development of an in situ thoracic surgery crisis simulation focused on nontechnical skill training. Ann Thorac Surg 2018;106:287–92.
13. Macfie RC, Webel AD, Nesbitt JC, Fann JI, Hicks GL, Feins RH. "Boot camp" simulator training in open hilar dissection in early cardiothoracic surgical residency. Ann Thorac Surg 2014;97:161–6.
14. Ferguson CM. Effects of a surgical skills boot camp. J Am Coll Surg 2010; 211:691–2.
15. Singh P, Aggarwal R, Pucher PH, Hashimoto DA, Beyer-Berjot L, Bharathan R, et al. An immersive "simulation week" enhances clinical performance of incoming surgical interns improved performance persists at 6 months follow-up. Surgery 2015;157:432–43.
16. Moulder JK, Louie M, Toubia T, Schiff LD, Siedhoff MT. The role of simulation and warm-up in minimally invasive gynecologic surgery. Curr Opin Obstet Gynecol 2017;29:212–7.
17. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. N Engl J Med 2003;349:2117–27.
18. Worldwide AAMIG. Guidelines for privileging for robotic-assisted gynecologic laparoscopy. J Minim Invasive Gynecol 2014;21:157–67.
19. Yousuf AA, Frecker H, Satkunaratnam A, Shore EM. The development of a retroperitoneal dissection model. Am J Obstet Gynecol 2017;217: 483.e1–3.
20. Einarsson JI, Sangi-Haghpeykar H. Perceived proficiency in minimally invasive surgery among senior OB/GYN residents. JSLS 2009;13:473–8.
21. Wohlrab K, Jelovsek JE, Myers D. Incorporating simulation into gynecologic surgical training. Am J Obstet Gynecol 2017;217:522–6.
22. Rayburn WF, Gant NF, Gilstrap LC, Elwell EC, Williams SB. Pursuit of accredited subspecialties by graduating residents in obstetrics and gynecology, 2000-2012. Obstet Gynecol 2012;120:619–25.
23. Raff M, DeCherney A. Reproductive surgery and in vitro fertilization: the future reevaluated. Fertil Steril 2019;112:197–202.
24. Tulandi T, Marzal A. Redefining reproductive surgery. J Minim Invasive Gynecol 2012;19:296–306.
25. Zeger SL, Liang KY, Albert PS. Models for longitudinal data: a generalized estimating equation approach. Biometrics 1988;44:1049–60.
26. Estes SJ, Waldman I, Gargiulo AR. Robotics and reproductive surgery. Semin Reprod Med 2017;35:364–77.
27. Goldberg JM, Falcone T, Diamond MP. Current controversies in tubal disease, endometriosis, and pelvic adhesion. Fertil Steril 2019;112:417–25.
28. Childers CP, Maggard-Gibbons M. Understanding costs of care in the operating room. JAMA Surg 2018;153:e176233.
29. Evans SKL, Myers EM, Anderson-Montoya B, Vilasagar S, Tarr ME. A cadaveric simulation model to teach suture placement during sacrospinous ligament fixation. Female Pelvic Med Reconstr Surg 2020. Online ahead of print. https://doi.org/10.1097/SPV.0000000000000805.
30. Holloran-Schwartz MB, Gavard JA, Martin JC, Blaskiewicz RJ, Yeung PP. Single-use energy sources and operating room time for laparoscopic hysterectomy: a randomized controlled trial. J Minim Invasive Gynecol 2016;23: 72–7.
31. Avondstondt AM, Wallenstein M, D'Adamo CR, Ehsanipoor RM. Change in cost after 5 years of experience with robotic-assisted hysterectomy for the treatment of endometrial cancer. J Robot Surg 2018;12:93–6.
32. Harris M, Chung F. Complications of general anesthesia. Clin Plast Surg 2013;40:503–13.
33. Sroka G, Feldman LS, Vassiliou MC, Kaneva PA, Fayez R, Fried GM. Fundamentals of laparoscopic surgery simulator training to proficiency improves laparoscopic performance in the operating room-a randomized controlled trial. Am J Surg 2010;199:115–20.
34. American Board of Obstetrics and Gynecology. Fundamentals of laparoscopic surgery- FAQs for residency. Available at: https://www.abog.org/about-abog/faqs/faqs-for-fundamentals-of-laparoscopic-surgery-residents. Accessed May 5, 2020.
35. Zheng B, Hur HC, Johnson S, Swanström LL. Validity of using Fundamentals of Laparoscopic Surgery (FLS) program to assess laparoscopic competence for gynecologists. Surg Endosc 2010;24:152–60.
36. DeStephano CC, Nitsche JF, Heckman MG, Banks E, Hur HC. ACOG Simulation Working Group: a needs assessment of simulation training in OB/GYN residencies and recommendations for future research. J Surg Educ 2020;77: 661–70.
37. Kerbage Y, Cosson M, Hubert T, Giraudet G. Multiparous ewe as a model for teaching vaginal hysterectomy techniques. Obstet Gynecol 2017;130: 1276–8.

38. Chong W, Downing K, Leegant A, Banks E, Fridman D, Downie S. Resident knowledge, surgical skill, and confidence in transobturator vaginal tape placement: the value of a cadaver laboratory. Female Pelvic Med Reconstr Surg 2017;23:392–400.
39. Geoffrion R, Suen MW, Koenig NA, Yong P, Brennand E, Mehra N, et al. Teaching vaginal surgery to junior residents: initial validation of 3 novel procedure-specific low-fidelity models. J Surg Educ 2016;73:157–61.
40. Lerner V, Higgins EE, Winkel A. Re-boot: simulation elective for medical students as preparation bootcamp for obstetrics and gynecology residency. Cureus 2018;10:e2811.
41. Elessawy M, Skrzipczyk M, Eckmann-Scholz C, Maass N, Mettler L, Guenther V, et al. Integration and validation of hysteroscopy simulation in the surgical training curriculum. J Surg Educ 2017;74:84–90.
42. Krajewski A, Filippa D, Staff I, Singh R, Kirton OC. Implementation of an intern boot camp curriculum to address clinical competencies under the new Accreditation Council for Graduate Medical Education supervision requirements and duty hour restrictions. JAMA Surg 2013;148: 727–32.
43. Leijte E, Claassen L, Arts E, de Blaauw I, Rosman C, Botden SMBI. Training benchmarks based on validated composite scores for the RobotiX robot-assisted surgery simulator on basic tasks. J Robot Surg 2020. Online ahead of print. https://doi.org/10.1007/s11701-020-01080-9.
44. Aljamal Y, Saleem H, Prabhakar N, Abhishek C, Farley DR. Group video feedback is an effective and efficient tool for enhancing skills of surgical interns. J Surg Res 2020;251:248–53.