The impact of a simulation-based training lab on outcomes of hysterectomy

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Abstract

Objective: To evaluate the impact of a simulation-based training lab on surgical outcomes of different hysterectomy approaches in a resident teaching tertiary care center.

Material and Methods: This retrospective cohort study was conducted at The University of Texas, Department of Obstetrics and Gynecology. In total, 1397 patients who had undergone total abdominal hysterectomy (TAH), vaginal hysterectomy (VH), total laparoscopy-assisted hysterectomy (TLH), or robot-assisted hysterectomy (RAH) for benign gynecologic conditions between 2009 and 2014 were included in the study. The comparison was made according to the year when the surgeries were performed: 2009 (before simulation training) and the combination of 2010-2014 (after simulation training) for each technique (TAH, VH, and LAH). Since a simulation lab for robotic surgery was introduced in 2010 at our institute, the comparison for robotic surgery was made between the combination of 2009-2010 as the control and the combination of 2010-2014 as the study group.

Results: The average estimated blood loss before and after simulation-based training was significantly different in TAH and RAH groups (317±170 mL versus 257±146 mL, p=0.003 and 154±107 mL versus 102±88 mL, p=0.004, respectively), but no difference was found for TLH and VH. The mean of length of hospital stay was significantly different before and after simulation-based training for each technique: 3.7±2.3 versus 2.9±2.2 days for TAH, 2.0±1.2 versus 1.3±0.9 days for VH, 2.4±1.3 versus 1.9±2.5 days for TLH, and 2.0±1.3 versus 1.4±1.7 days for RAH (p<0.01).

Conclusion: Based on our data, simulator-based training may play an integrative role in developing the residents' surgical skills and thus improving the surgical outcomes of hysterectomy. (J Turk Ger Gynecol Assoc 2016; 17: 60-4)

Keywords: Hysterectomy, simulation training, outcomes

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Introduction

Simulator-based training has recently evolved as an effective method in the training of surgeons (1). Developing the necessary eye–hand coordination before hands-on surgical practice may not only shorten the learning curve but also improve patient safety (2). By practicing in a simulation lab, residents can improve their psychomotor and cognitive skills in a risk-free setting (3-6). The benefit of simulator-based training has been increasingly evident since total laparoscopy-assisted hysterectomy (TLH) & robot-assisted hysterectomy (RAH) cases accounted for more than 30% of the total hysterectomies in the United States (7).

Hysterectomy is the most commonly performed gynecological surgical procedure after cesarean section; all residents should master these techniques during resident training (8). While the number of hysterectomies performed annually was 681,234 in 2002, it was calculated as 433,621 in 2010: the number in 2010 was lesser by 247,973 than that in 2002. Benign conditions still comprise the most common indications, with a rate of 90% (9, 10). Moreover, the use of new surgical techniques as well as more access to laparoscopy/robot-assisted approaches for hysterectomy has become more common than the use of abdominal hysterectomy (11-13). As a result, the overall real-case exposure time to perform each approach [total abdominal hysterectomy (TAH), vaginal hysterectomy (VH), TLH, and RAH has been probably compromised to achieve surgical competency. The importance of patient safety as well as limited resident work-hour necessitates new educational techniques for resident training.

Recent literature has shown that the skills gained in the simulation lab for laparoscopic/robotic techniques are transferable to real-case applications (14, 15). However, translation of this to actual clinical outcomes of patients is lacking. In addition, implementing simulation-based training for VH and TAH gains feasibility; however, no available data exist in the current

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literature. The aim of our study was to evaluate the impact of a simulation-based training lab on actual surgical outcomes of different hysterectomy approaches for benign cases in a resident teaching tertiary care center. We also investigated the impact of demographic data on patient selection when hysterectomy is needed.

Material and Methods

Simulator lab

The Mimic Technologies dV-Trainer platform (Mimic Technologies Inc.; Seattle, WA, USA) as a robotic surgery trainer, the 3-Dmed Trainer platform (3-DMEd; Franklin, OH, USA) as a laparoscopy trainer, and the Surgical Female Pelvic Trainer (SFPT) with Advanced Surgical Uterus (Limbs&Things; Bristol, UK) as an open surgery trainer have been used at our institution. All residents proceeded to a structured simulation-based training program implemented in 2009 for TAH, VH, and TLH and in 2010 for RAH. Residents should achieve at least 75% success in training exercises in order to be able to perform surgery on actual cases.

Study design

This retrospective cohort study was approved by the institution review board at The University of Texas Medical Branch. The study population consisted of the patients who had undergone hysterectomy for benign gynecologic conditions (such as leiomyoma, abnormal uterine bleeding, pelvic organ prolapse and/or urinary incontinence, endometriosis, adenomyosis, chronic pelvic pain, and endometrial hyperplasia without atypia) at John Sealy Hospital between 2009 and 2014. Patients with history of gynecological malignancy were excluded from the study. In total, 1397 patients were included in the study.

The patients' age, parity, number of previous surgeries, body mass index (BMI), estimated blood loss (EBL), intraoperative adverse events (IOAE), duration of postoperative hospital stay (HS), number of blood transfusions (BT), and operation room time (ORT) were obtained from the patient's medical records. EBL was calculated in millimeter (mL) and had been recorded during the surgery. IOAE were defined as urinary tract (at least the bladder or ureteral serosa), bowel (at least the bowel serosa), and/or vascular injuries. The length of HS was calculated by subtracting the day of surgery from the day of discharge. The number of BT was calculated in units, which were given to the patient during or following the surgery. ORT was calculated by subtracting the time when patients were taken to the operation room from the time when patients were physically removed after completion of surgery (wheels in and out). Further, the data for TAH, VH, and TLH were stratified according to the year when the surgeries were performed: 2009, which was used as a baseline before the simulation lab was introduced, and the combination of 2010-2014, which was used to assess the impact of the simulation. Since a simulation lab for robotic surgery was introduced in 2010 at our institute, the data for RAH was stratified according to the year when robotic simulation was introduced: 2009-2010 (before simulation) and the combination of 2010-2014 (after simulation). In addition, the postgraduate years (PGY) were later stratified into two groups: PGY2/3 and PGY4. We combined PGY2 and PGY3 because the number of patients on whom PGY2 residents performed surgery was very low to reach a better conclusion.

The outcomes of patients who underwent hysterectomy before simulation-based training were compared with the outcomes of patients who underwent hysterectomy after simulation-based training in terms of EBL, IOAE, length of HS, rate of BT, and ORT for each hysterectomy approach. In addition, the outcomes of hysterectomy performed by PGY2/3 residents were compared with the outcomes of hysterectomy performed by PGY4 residents.

Statistical analysis

SPSS 11.5 software (SPSS Inc.; Chicago, IL, USA) was used for statistical analysis. One-way analysis of variance (ANOVA), Student's t-tests, Mann–Whitney U test, and two-sample z-tests were performed where appropriate. One-way ANOVA was used to compare patient characteristics, and Mann–Whitney U test was used to compare the average EBL, the mean length of HS, the number of BT, and the mean ORT. Two-sample z-test was used to compare the rates of IOAE. A p value of 0.05 was considered as the level of statistical significance. Data are presented as mean±standard deviation (mean±SD) or percentage (%).

Of the 1397 patients, 41% (n=576) underwent TAH, 22% (n=305) underwent VH, 20% (n=272) underwent TLH, and 17% (n=244) underwent RAH. All patients' mean age, BMI, parity, and number of previous surgeries (±SD) were 45.4±9.7 years, 31.4±11.5 kg/m^2, 2.4±1.5, and 1.4±1.4, respectively. The patients who underwent VH were older than other patients (48.1±11.7 years, $p<0.05$). Among patients who underwent hysterectomy, BMI was the highest in patients who underwent RAH (32.9±8.1 kg/m^2, $p<0.05$). Parity, with a mean of 2.9±1.6, was the highest in patients who underwent VH, and a significant difference was found when compared with patients who underwent other types of hysterectomies. The number of previous surgeries was the lowest in the VH group and showed a significant difference in comparison with other groups. Data for the demographics are presented in Table 1.

Table 1. The comparison of demographic data of patients

	TAH	VH	TLH	RAH	p
Age (mean±SD years)	44.9±9.0	48.1±11.7	43.5±8.6	45.3±8.7	<0.05
BMI (mean±SD kg/m^2)	31.9±7.9	29.5±6.2	30.9±6.9	32.9±8.1	<0.05
Parity (mean±SD)	2.2±1.5	2.9±1.6	2.3±1.6	2.1±1.3	<0.05
The number of previous surgery (mean±SD)	1.4±1.4	1.1±1.1	1.6±1.4	1.3±1.2	<0.05

TAH: total abdominal hysterectomy; VH: vaginal hysterectomy; TLH: total laparoscopic hysterectomy; RAH: robot-assisted hysterectomy; BMI: body mass index

Table 2 presents the outcomes of hysterectomy obtained before and after simulation-based training for each hysterectomy technique. The average EBL was 317±170 versus 257±146 mL for TAH, 219±124 versus 180±101 mL for VH, 190±142 mL versus 149±104 mL for TLH, and 154±107 versus 102±88 mL for RAH. The average EBL was lower after simulation-based training for all approaches, but a significant difference was found for only TAH and RAH groups (p=0.003 and p=0.004, respectively). The mean lengths of HS was 3.7±2.3 versus 2.9±2.2 days for TAH, 2.0±1.2 versus 1.3±0.9 days for VH, 2.4±1.3 versus 1.9±2.5 days for TLH, and 2.0±1.3 versus 1.4±1.7 days for RAH. All groups showed a significant difference in terms of the mean lengths of HS obtained before and after simulation-based training (p<0.001 for all groups). Simulation-based training had a favorable impact on the length of HS in all approaches. With regard to the rates of IOAE, none of the groups showed a significant difference before and after simulation-based training. No significant difference was found between TAH and RAH groups in the rates of BT before and after simulation-based training. Because no blood transfusion was needed in VH and LAH groups before simulation-based training in our patient population, a comparison could not be performed for those groups. ORTs were not significantly different for all hysterectomy techniques when the introduction of simulation-based training was accepted as stratifying factor to reveal its impact.

Overall, the outcomes of all types of hysterectomies based on PGY were reported (Table 3). Although the average EBL, rate of IOAE, and rate of BL were less in PGY4 residents, no significant difference was found between PGY2/3 and PGY4 residents. The mean length of HS was shorter in PGY 4 residents than in PGY2/3 residents, and the difference was significant (p<0.001). The mean ORTs before and after simulation-based training were 210±84 versus 195±81 min (p=0.002).

Discussion

Information on evaluation of the impact of a simulator lab on actual hysterectomy outcomes in a tertiary center setting in gynecology is lacking in the literature. Training with simulators has been shown to improve residents' performance on the modules used in robotic and laparoscopic simulators in our previous studies (16, 17). Meanwhile, studies assessing the transferability of laparoscopic and endoscopic simulators to real-time performance have proved to be useful of simulator-based training (14, 15, 18, 19). A VH simulator has been shown to have beneficial effects in learning routine VH (20, 21). Although Greer et al. (21) have shown that structured multiple-component VH education is valid, the impact of VH simulation on surgical competence could be unproven. A pilot study concluded that residents' surgical skills and knowledge were better after simulator education for TAH; no clinical outcomes exist to reach a conclusion about the effectiveness of simulator education (22).

In our study, simulation-based education markedly shortened the outcomes of all hysterectomies in terms of HS. Although the average EBL was also positively influenced by simulation-based training in all techniques, only TAH and RAH showed a significant difference. With regard to the frequency of IOAE, simulation-based training did not seem to make a difference in any hysterectomy technique. Although a partial improvement in the results of ORT was observed in the RAH group, no improvement was observed in the other groups. On the other hand, ORT was better when hysterectomies were performed by PGY4 residents than when hysterectomies were performed by PGY2/3 residents, irrespective of simulation-based training.

In a database study by Igwe et al. (23), the authors found that

Table 2. Comparison of outcomes of each hysterectomy technique obtained before and after simulation-based training in terms of the average estimated blood loss (EBL), duration of postoperative hospital stay (HS), rate of intraoperative adverse events (IOAE), number of blood transfusions (BT), and mean operation room time (ORT)

	TAH (n=576)	VH (n=305)	TLH (n=272)	RAH (n=244)
EBL (mean±SD/mL)	2009 (n=78) 317±170 2010-2014 (n=498) 257±146 p 0.003	2009 (n=36) 219±124 2010-2014 (n=269) 180±101 p 0.054	2009 (n=40) 190±142 2010-2014 (n=232) 149±104 p 0.114	2009-2010 (n=34) 154±107 2011-2014 (n=210) 102±88 p 0.004
HS (mean±SD/day)	2009 (n=78) 3.7±2.3 2010-2014 (n=498) 2.9±2.2 p<0.001	2009 (n=36) 2.0±1.2 2010-2014 (n=269) 1.3±0.9 p<0.001	2009 (n=40) 2.4±1.3 2010-2014 (n=232) 1.9±2.5 p<0.001	2009-2010 (n=34) 2.0±1.3 2011-2014 (n=210) 1.4±1.7 p<0.001
IOAE (%)	2009 (n=78) 9% 2010-2014 (n=498) 10% p 0.345	2009 (n=36) 3% 2010-2014 (n=269) 4% p 0.351	2009 (n=40) 5% 2010-2014 (n=232) 7% p 0.538	2009-2010 (n=34) 5% 2011-2014 (n=210) 2% p 0.044
BT (mean±SD/unit)	2009 (n=78) 0.3±0.7 2010-2014 (n=498) 0.2±0.6 p 0.014	2009 (n=36) 0 2010-2014 (n=269) 0.007±0.1 p n/a	2009 (n=40) 0 2010-2014 (n=232) 0.03±0.2 p n/a	2009-2010 (n=34) 0.02±0.17 2011-2014 (n=210) 0.01±0.13 p>0.05
ORT (mean±SD/min)	2009 (n=78) 185±76 2010-2014 (n=498) 179±74 p 0.523	2009 (n=36) 178±68 2010-2014 (n=269) 168±66 p 0.318	2009 (n=40) 214±74 2010-2014 (n=232) 206±84 p 0.375	2009-2010 (n=34) 281±89 2011-2014 (n=210) 264±77 p 0.141

TAH: total abdominal hysterectomy; VH: vaginal hysterectomy; TLH: total laparoscopic hysterectomy; RAH: robot-assisted hysterectomy

Table 3. Comparison of postgraduate years (PGY) 2/3 and PGY4 in terms of average estimated blood loss (EBL), duration of postoperative hospital stay (HS), rate of intraoperative adverse events (IOAE), number of blood transfusions (BT), and mean operation room time (ORT)

	PGY-2/3 (n=547)	PGY-4 (n=850)	p
EBL (mean±SD/mL)	208±145	193±134	0.098
HS (mean±SD/day)	2.3±2.3	2.1±2.5	<0.001
IOAE (%)	6.4	6.9	0.341
BT (mean±SD/unit)	0.09±0.4	0.07±0.4	0.021
ORT (mean±SD/min)	210±84	195±81	0.002

the mean operative times were longer when a resident joined total laparoscopic hysterectomy (robotic versus conventional laparoscopy), but the duration was shorter when the attending surgeon operated alone. A significant difference was not found between the junior resident (PGY1/2) and senior resident groups (other PGYs) in the same study. In our study, we found that the performance of PGY4 residents with regard to ORT was significantly better than that of PGY2/3 residents for all techniques calculated. One explanation for this significant difference may be that our senior resident group was restricted to only PGY-4 residents in our study. The same study also examined the rates of complications in the attending-alone and the resident-involved groups (5.4% versus 6.8%, p=0.54). In addition, no significant difference existed between the junior resident and senior resident groups. Even when only the attending surgeon performed hysterectomy with a minimally invasive technique, the rates of complication stayed at a similar level in their study. The fact that all surgeries were performed under the direct supervision of a faculty in our study population may explain why we did not observe a significant difference before and after simulation-based education or between PGY2/3 and PGY4 residents in terms of the rate of IOAE. The hysterectomies included in this study were performed for residents' education only, and this may be another reason for the unchanged rate of IOAE before and after simulation-based education or between PGY2/3 and PGY4 residents.

According to our evaluation of patients' demographic data, while patients who underwent VH had the highest mean parity and age, the mean of the number of previous surgeries was the lowest in the VH group. Because age and parity are known to be risk factors for developing pelvic organ prolapse (24), patients with higher parity and older age may have had more advanced pelvic organ prolapse; therefore, this patient population more often underwent a VH procedure. Despite the ACOG opinion (25), the number of previous surgery seemed to be a factor affecting patient selection for the hysterectomy technique. Not surprisingly, it seems that suspected intraabdominal adhesions motivate surgeons to perform an abdominal approach rather than a vaginal approach. Our findings also showed that the patients who underwent RAH had higher BMI than those who underwent other hysterectomies. The robotic surgery technique is known to offer several advantages such as better instrument function without hand tremor and no need to cope with thick abdominal wall in obese patients. These advantages help the surgeon overcome the hardships encountered with traditional laparoscopy and perform surgery on obese patients more confidently. A study conducted by Geppert et al. (26) showed that RAH in obese women was associated with shorter hospitalization, fewer significant complications, and lesser EBL than TAH. Our results may be related to the fact that surgeons working at our institute tend to utilize the robotic technique in performing surgery on patients with higher BMI to reach the best clinical outcomes, which is correlated with the findings revealed by Geppert et al. (26).

One limitation of the study is that control group could not consist of longer consecutive years of data because of physical interruption by the hurricane Ike in 2008 in Galveston. Therefore, we included the data from 2009 and further consecutive years. Another limitation is that the constant shift in hysterectomies from open to minimally invasive hysterectomies throughout the study years may have potential effects on patient outcomes. However, this is a parallel change with nationwide institutions; therefore, it should not affect our overall results.

In conclusion, a simulator lab improves the outcomes of hysterectomy performed at a teaching institution and may play an adjunct role in developing the residents' surgical skills. The skills learned under simulation settings were at least partially transferable to actual surgical cases for all types of hysterectomies according to our results. Actual surgical outcomes of other large institutes using simulator lab will be helpful to reach a more precious conclusion about the impact of implementing simulator-based training on clinical outcomes.

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Informed Consent: *N/A.*

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