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Proficiency-based training and credentialing can improve patient outcomes and decrease cost to a hospital system

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ABSTRACT

Background: While proficiency-based robotic training has been shown to enhance skill acquisition, no studies have shown that training leads to improved outcomes or quality measures.
Methods: Board-certified general surgeons participated in an optional proficiency-based robotic training curriculum and outcomes from robotic hernia cases were analyzed. Multivariable analysis was performed for operative times to adjust for patient and surgical variables.
Results: Six out of 16 (38%) surgeons completed training and 210 robotic hernia cases were analyzed. Longer operative times were associated with bilateral repairs (observed-to-expected operative time ratio [OTR] = 1.41, $p < 0.001$) and incarceration (OTR = 1.24, $p = 0.006$), while female patients (OTR = 0.87, $p = 0.001$) and increasing chronologic case order (OTR = 0.94, $p < 0.001$) were associated with shorter operative times. Surgeons who completed robotic training achieved shorter OTRs than those who did not ($p = 0.03$). Comparing non-risk adjusted hospital costs, trainees had an average of $1207 in savings (20% reduction) per robotic hernia case.
Conclusions: A structured proficiency-based robotics training curriculum is an effective way to reduce operative times and costs.

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Introduction

Recent landmark evidence has demonstrated that better intraoperative technical skill leads to improved patient outcomes.[1] One successful strategy for improving surgeon technique focuses on video review and surgical coaching.[2,3] Many effective robotic training curriculums have been described,[4,5] and proficiency-based training has been shown to enhance skill acquisition. However, many of these studies use skill-based endpoints measured during inanimate tasks that may not necessarily translate to the operating room.[6–8] Therefore, no studies have shown that a proficiency-based training curriculum is capable of improving objective clinical outcomes, leaving the impact of robotic training on quality measures still undetermined.

With the rise and expansion of robotic surgery, several common general surgery operations are now performed with robotic assistance.[9] In particular, abdominal wall hernias which require over a half-million operations in the United States every year,[10] is expected to occupy a greater market share of robotic surgeries.[11,12] With rising public interest in robotically performed surgeries,[13,14] there is an increased demand for robotically-trained surgeons; however, there are no standards and few solutions for optimal training. The challenge for hospitals is to reconcile the pressure of performing more robotic operations while recuperating the high cost of the surgical robot and ensuring safe implementation of new technology throughout surgeons' proficiency curves.[15–17]

Due to the frequency and precipitous rise in volume of robotic inguinal hernia repairs being performed nationwide, the impact of surgeon training on patient outcomes and cost can have great implications on hospital systems. An optimized training paradigm for credentialing and privileging surgeons will affect how we train robotic novices, and potentially the adoption of any new surgical

Abbreviations: OTR, Observed-to-expected operative time ratio.

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technology. The aim of this study was to evaluate the impact of a structured proficiency-based robotic training curriculum on objective clinical outcomes and hospital costs for the robotic inguinal hernia repair in a system where there was increasing surgeon demands for robotic privileges. We hypothesized that surgeons who complete a standardized robotics training program will have decreased operative times leading to cost savings.

Methods

This was a retrospective collaborative quality improvement project between the University of Pittsburgh Medical Center (UPMC) Division of Surgical Oncology, the Wolff Center at UPMC, and the UPMC Center for Advanced Robotics Training (CART). All surgeons across UPMC interested in performing robotic inguinal hernia repairs were offered the opportunity to complete an institutional robotic training curriculum.[6,8,18] Participants were solicited through an online webinar offered to all surgeons requesting privileges that outlined the institutional robotic training program. Because this study was a quality improvement initiative, surgeons were not randomized to training, and participation was optional.

Robotic training curriculum

The structured, multi-step proficiency-based training curriculum broadly consisted of three stages: virtual reality simulation, inanimate biotissue simulation, and live proctorship. The sequence was part of a previously-described novel strategy to credential surgeons seeking to gain privileges for a new surgical technology using video review.[19] This pathway differentiates surgeons into three categories: beginner, intermediate, and experienced.

The virtual reality simulation program is composed of 24 modules of increasing difficulty completed on either the da Vinci® Skills Simulator (Intuitive Surgical Inc., Sunnyvale, CA) or the Mimic dV-Trainer® (Mimic Technologies Inc, Seattle, WA). Based on pre-and-post-completion test scores among general surgery board-certified fellows, the program demonstrated skill acquisition reflected in overall score improvement.[6]

The inanimate biotissue model is a three-dimensional replica of the inguinal hernia anatomy including bony landmarks, vascular structures, peritoneum, and pre-peritoneal fat using a commercial model supplied by Covidien (Medtronic; Minneapolis, MN). In an analogous model replicating the three anastomoses of the pancreaticoduodenectomy, a biotissue curriculum improved objective technical performance and reduced errors among surgical oncology fellows.[8]

In total, simulation training required approximately 5–8 h to complete: 4–6 h on the virtual reality simulator and 1–2 h on the inanimate hernia model. Surgeons were given feedback on their scores. In certain cases, additional suturing or inanimate model use was recommended. Following simulation, surgeons received live OR proctorship during three robotic hernia cases with expert feedback or video review prior to operating independently.

Data collection

All consecutive robotic hernias performed at UPMC between December 2015 and March 2017 were reviewed. Retrospective chart reviews were conducted to collect reported details on patient presentation and post-operative follow-up. Hospital records were queried using administrative databases for intraoperative details, post-operative emergency room visits, and readmissions. This study was approved by the Institutional Review Board at the University of Pittsburgh (PRO15040497).

Operative (OR) time was defined as the elapsed time between the first incision and closure of the last incision. *Resident Present* was defined as the attendance of a surgery resident (general surgery or surgical sub-specialty) or fellow in the operating room; non-surgical residents, physician assistants, medical students, and other students were not included. *Resident level* was defined as the post-graduate year (PGY) level of the most senior-ranking surgical resident present; PGY 1–3 was classified as a junior resident and PGY 4–5 or above was classified as a senior resident. *Case order* was defined as the chronologic robotic inguinal hernia case number performed by a single surgeon since the beginning of the study period, regardless of elapsed time between cases. *Incision Time* was defined as the number of hours elapsed since 07:00 which is when each day's first elective case is scheduled.

Total costs were allocated to each hernia case using an activity-based costing methodology that applies costs either directly, or by activity drivers that represent resource utilization, such as time in the operating room. The cost analysis focuses on three main expense categories: hospital variable expenses, anesthesia provider expenses, and support expenses. All cost data were sourced from UPMC institutional financial records.

Statistical analysis

Surgeons were classified into two groups: one that completed the proficiency-based robotic training curriculum (trainees), and one that did not (non-trainees). Patient demographics, clinical presentation, intra-operative details, post-operative outcomes, and operation costs were compared between trainees and non-trainees using likelihood-ratio chi-squared tests, Mann-Whitney U tests, and Spearman correlation coefficients.

A multivariable analysis of operative time was conducted evaluating the following pre-and-intra-operative risk factors: patient age, sex, BMI, history of any abdominal surgery, hernia type (bilateral vs. unilateral), incarceration, recurrence or reoperation, surgeon case order, incision time, and presence of resident. Using a significance threshold of $\alpha = 0.05$, significant risk factors were included in a multivariable model to determine risk-adjusted observed-to-expected operative time ratios (OTR) for each surgeon. OTRs were then compared between trainees and non-trainees. A post-hoc non-risk-adjusted operative cost comparison was conducted between the two groups. All analyses were completed using Stata® 14.2 (StataCorp LLC, College Station, Texas).

Results

Between December 2015 and March 2017, 16 board certified general surgeons performed 210 robotic inguinal hernia repairs across seven UPMC hospitals. Five (71%) of these hospitals were teaching hospitals with general surgery residents from two separate residency programs.

Surgeon cohort

Of 16 surgeons, six (38%) completed the previously-described robotics training curriculum: five surgeons completed the full beginner pathway and one surgeon with prior robotic experience completed the abbreviated intermediate pathway. No differences were found in surgeon or surgeon hernia practice demographics between the two cohorts (Table 1). The median time in practice was 17 years (range 0–29, $p = 0.446$). The median total volume of *open* inguinal hernia repairs prior to performing robotic cases was 44 cases (range 1–964, $p = 0.415$), and median prior total volume of *laparoscopic* inguinal hernia repairs was 3 cases (range 0–628; $p = 0.275$).

Table 1
Baseline surgeon characteristics.

Characteristic		Total (N = 16)	Curriculum Completed		p[b]
			No (N = 10)	Yes (N = 6)	
Age (yrs.); Mean (S.D.)		49.7 (6.8)	51.1 (6.3)	47.3 (7.6)	0.356
Male; N (%)		16 (100)	16 (100)	6 (100)	1.000
Years in Practice; Median (Range)		17 (0–29)	18 (5–29)	16 (0–21)	0.446
Fellowship Completed; N (%)		10 (62.5)	6 (60.0)	4 (66.7)	0.789
Total Volume of Inguinal Hernia Repairs[a]; Median (Range)	Open	44 (1–964)	242 (1–964)	24.5 (4–129)	0.415
	Laparoscopic	3 (0–628)	7 (0–211)	1.5 (0–628)	0.275
Volume of Inguinal Hernia Repairs in 2015[a]; Median (Range)	Open	13.5 (0–101)	32.5 (0–101)	12.5 (0–55)	0.663
	Laparoscopic	1.5 (0–55)	1.5 (0–33)	1.5 (0–55)	0.782

[a] Excludes robotic hernia repairs.
[b] Bolded denotes $p < 0.05$.

Clinical presentation and peri-operative course

Baseline patient clinical presentation characteristics were similar between the trainee and non-trainee groups (Table 2), including mean age (56.0 vs. 59.5 years, $p = 0.086$), BMI (26.9 vs. 26.6, $p = 0.582$) and reported median length of symptoms (3 vs. 2 months, $p = 0.206$). These groups also saw similar rates of patients with recurrent and incarcerated hernias. Trainees had a significantly greater rate of patients with a history of previous abdominal surgery than non-trainees (29.8% vs. 15.8%, $p = 0.018$).

Unadjusted mean operative time was 86.1 (SD 30.9) minutes for the trainee group vs. 122.0 (SD 37.9) minutes for the non-trainee group. There were very few differences in intra-operative complications between the two groups (0% vs. 2.1%, $p = 0.074$): only the

Table 2
Pre-operative characteristics, intra-operative details, and post-operative outcomes.

Variable		Total (N = 210[a])	Curriculum Completed		p[f]
			No (N = 95[a])	Yes (N = 115[a])	
Pre-operative Characteristics					
Age (yrs.); Mean (S.D.)		57.6 (14.1)	59.5 (13.7)	56.0 (14.3)	0.086
Male; N (%)		193 (91.9%)	86 (90.5%)	107 (93.0%)	0.507
BMI, (kg/m^2); Mean (S.D.)		26.8 (4.4)	26.6 (4.6)	26.9 (4.3)	0.582
Obesity [BMI $\geq$ 30]; N (%)		37 (17.6%)	14 (14.7%)	23 (20.0%)	0.316
Surgery Type; N (%)	Unilateral, Left	50 (23.8%)	16 (16.8%)	34 (29.6%)	0.083
	Unilateral, Right	88 (41.9%)	45 (47.4%)	43 (37.4%)	
	Bilateral	72 (34.3%)	34 (35.8%)	38 (33.0%)	
Symptomatic; N (%)		186 (97.9%)	94 (100%)	92 (95.8%)	**0.019**
Length of Symptoms (months); Median (IQR)		3 (4)	2 (2)	3 (5)	0.206
Recurrence/Reoperation; N (%)		29 (14.3%)	17 (17.9%)	12 (11.1%)	0.168
Incarcerated Hernia; N (%)		13 (6.3%)	8 (8.4%)	5 (4.5%)	0.242
History of Abdominal Surgery; N (%)		46 (23.1%)	15 (15.8%)	31 (29.8%)	**0.018**
Intra-operative Details					
Operative Time (min.); Mean (S.D.)		102.3 (38.6)	122.0 (37.9)	86.1 (30.9)	< **0.001**
Incision Time[b]; Mean (S.D.)		3.15 (2.58)	3.49 (2.49)	2.86 (2.62)	**0.037**
Type of Hernia; N (%)	Direct Only	38 (22.6%)	22 (24.7%)	16 (20.3%)	0.298
	Indirect Only	96 (57.1%)	46 (51.7%)	50 (63.3%)	
	Both Direct and Indirect	34 (20.2%)	21 (23.6%)	13 (16.5%)	
Incidental Hernia; N (%)	Femoral	7 (3.3%)	7 (7.4%)	0 (0%)	**0.001**
	Obturator	0 (0%)	0 (0%)	0 (0%)	1.000
Intra-operative Complication[c]; N (%)		2 (1.0%)	2 (2.1%)	0 (0%)	0.074
Resident Present[d]; N (%)	Junior Resident[e] (PGY 1–3)	24 (11.4%)	17 (17.9%)	7 (6.1%)	**0.007**
	Senior Resident[e] (PGY 4–5 and above)	62 (29.5%)	39 (41.1%)	23 (20.0%)	**0.001**
Post-operative Outcomes					
Follow-up; N (%)		145 (69.0%)	62 (65.3%)	83 (72.2%)	0.281
Length of Follow-up (days); Mean (S.D.)		17.6 (5.9)	19.4 (6.2)	16.3 (5.4)	**0.001**
Readmission within 30 Days after Discharge; N (%)		0 (0%)	0 (0%)	0 (0%)	1.000
Emergency Room Visit within 10 Days after Discharge; N (%)		13 (6.2%)	5 (5.3%)	8 (7.0%)	0.610
Any Post-operative Complication; N (%)		33 (22.1%)	12 (18.8%)	21 (24.7%)	0.383
Surgical Site Infection; N (%)		0 (0%)	0 (0%)	0 (0%)	1.000
Urinary Retention; N (%)		10 (6.7%)	4 (6.3%)	6 (7.1%)	0.845
Seroma/Hematoma; N (%)		4 (2.7%)	1 (1.6%)	3 (3.5%)	0.449
Inguinodynia; N (%)		5 (3.4%)	3 (4.7%)	2 (2.4%)	0.436
Hernia Recurrence; N (%)		0 (0%)	0 (0%)	0 (0%)	1.000
Scrotal Swelling; N (%)		9 (6.0%)	2 (3.1%)	7 (8.2%)	0.179

Abbreviations: S.D. = Standard deviation; IQR = Interquartile range.
[a] Some variables had unknown values.
[b] Elapsed hours since 07:00 clock time.
[c] One sigmoid serosal tear, one excessive blood loss, and no conversions-to-open.
[d] Includes residents and fellows (excludes medical students, physician assistant students, and physician assistants).
[e] Highest-level trainee present (PGY of one trainee was unknown).
[f] Bolded denotes $p < 0.05$.

trainee group experienced one sigmoidal serosal tear and one case of excessive blood loss. No conversions-to-open occurred in either group. Curriculum non-trainees were significantly more likely to have a surgical resident assistant present during their cases (41.1% vs. 20.0%, p = 0.001).

Post-operative follow-up was available for 145 (69.0%) patients and mean length of follow-up was slightly longer for the non-trainee group (19.4 vs. 16.3 days, p = 0.001). The two groups experienced similar rates of patients admitted to the emergency room within 10 days of operation (7.0% vs. 5.3%, p = 0.610) whereas no patients in either group were readmitted within 30 days of their operation. The most common post-operative complications were urinary retention (6.7%), scrotal swelling (6.0%), and inguinodynia (3.4%), with no significant differences between the two groups. No hernia recurrences were reported in either group within the study period.

Risk adjusted operative time

Univariable analysis (Table 3) indicated that operative time was correlated with surgery type, incarceration, history of abdominal surgery, presence of residents, case order, and incision time. Using multivariable analysis to determine independent predictors of operative time (Table 3), longer operative times were associated with bilateral repairs (OTR = 1.41, p<0.001) and incarceration (OTR = 1.24, p = 0.006), while shorter operative times were associated with female sex (OTR = 0.87, p = 0.001) and increasing chronologic case order (OTR = 0.94, p<0.001).

Non-adjusted operative times by hernia chronologic case order are displayed in Fig. 1A stratified by curriculum completion status. After controlling for surgery type, sex, and incarceration, estimated operative times by hernia case order are displayed in Fig. 1B. A typical curriculum-trainee had an estimated operative time of 100.8 min for their first case vs. 131.4 min for a typical non-trainee, a 30.6-minute difference. A typical non-trainee would need approximately 28 cases to match the expected operative time of a typical trainee on their first case.

Following risk-adjustment, individual surgeon analysis was performed and showed that surgeons who completed the curriculum achieved significantly lower OTRs than those who did not (p = 0.030; data not shown). Upon examining individual surgeon performances (Fig. 2), five out of six (83%) surgeons who completed the curriculum achieved shorter-than-expected average operative times during the study period (OTR < 1.0) whereas only one out of ten (10%) surgeons who did not complete the curriculum achieved a shorter-than-expected average.

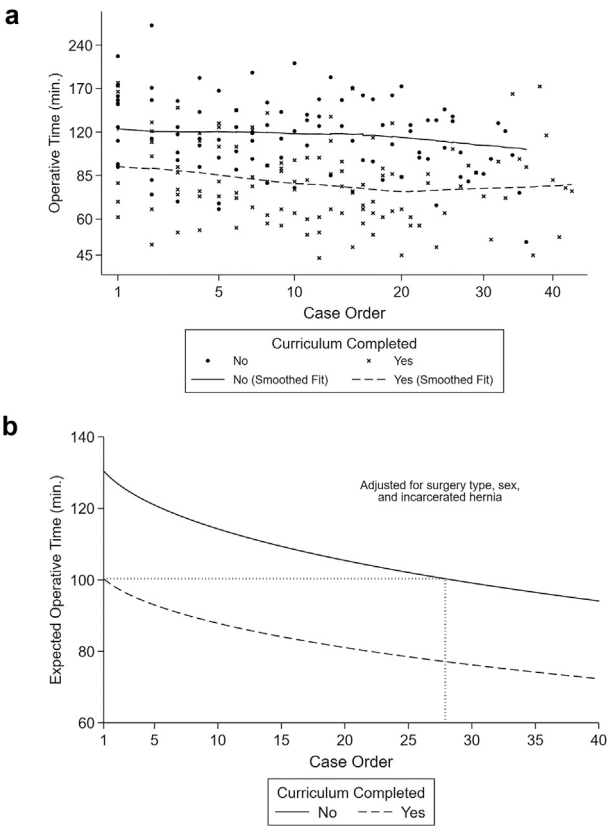

Fig. 1. A: Operative Time by Case Order and Curriculum Completion Status
Each point represents a single robotic hernia case performed by a single surgeon who completed (×) or did not complete (•) training. Cases are in chronologic order as performed by a single surgeon since the beginning of the study period.
B: Expected Operative Time by Case Order and Curriculum Completion Status
Expected operative times are adjusted for surgery type (bilateral vs. unilateral), patient sex, and hernia incarceration. Curriculum non-trainees (solid line) required an estimated 28 additional cases to match the starting proficiency of trainees (dashed line).

Table 3
Operative time univariable and multivariable analyses.

Variable	Category	N	Univariable		Multivariable	
			Operative Time (min.): Mean (S.D.) or Spearman Correlation Coefficient	p[b]	OTR (95% C.I.)	p[b]
Surgery Type	Unilateral	138	88.7 (32.1)	< **0.001**	1.0 (N/A)	< **0.001**
	Bilateral	72	128.4 (36.8)		1.409 (1.336, 1.485)	
Sex	Male	193	103.0 (38.4)	0.262	1.0 (N/A)	**0.001**
	Female	17	94.9 (41.2)		0.872 (0.807, 0.943)	
Incarcerated Hernia	No	194	99.7 (35.8)	**0.001**	1.0 (N/A)	**0.006**
	Yes	13	144.8 (55.8)		1.239 (1.064, 1.443)	
Recurrence/Reoperation	No	174	101.2 (36.3)	0.117		
	Yes	29	116.4 (49.5)			
History of Abdominal Surgery	No	153	106.0 (35.4)	**0.046**		
	Yes	46	98.4 (47.9)			
Resident Present	No	123	99.9 (41.8)	**0.044**		
	Yes	87	105.7 (33.6)			
Case Order[a]	N/A	210	−0.210	**0.002**	0.940 (0.928, 0.953)	< **0.001**
Age (years)	N/A	210	−0.030	0.665		
BMI	N/A	210	−0.060	0.388		
Incision Time	N/A	210	0.176	**0.011**		

Abbreviations: S.D. = Standard deviation: OTR = Observed-to-expected operative time ratio; BMI = Body mass index.
[a] Square-root transformation.
[b] Bolded denotes p < 0.05.

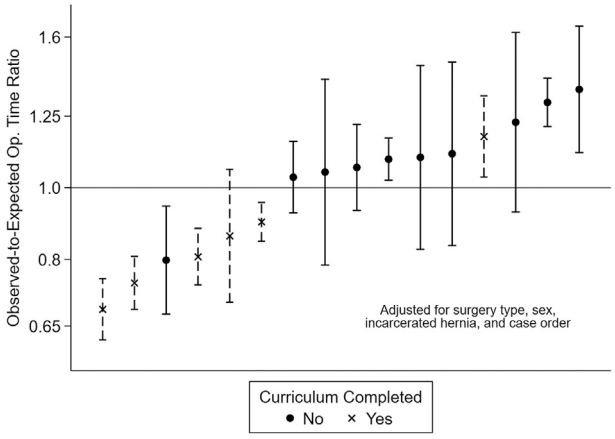

Fig. 2. Individual Surgeon Observed-to-Expected Operative Time Ratios by Curriculum Completion Status
Each vertical data point represents an individual surgeon who completed (×) or did not complete (•) training. Surgeons are displayed in increasing Observed-to-expected operative time ratios (OTR) from left to right, which are adjusted for surgery type (bilateral vs. unilateral), patient sex, and hernia incarceration. Horizontal line represents OTR = 1.0 or expected average operating time. Shorter-than-expected operative times (OTR<1.0) was achieved by 5/6 surgeons who completed the curriculum (×) vs. 1/10 surgeons who did not complete the curriculum (•).

Analysis was repeated removing the intermediate surgeon and removing surgeries with residents present. With removal of the intermediate surgeon ($p = 0.05$) and removal of resident involved/attended cases ($p = 0.012$), there was a persisting significance between the trainee and the non-trainee cohorts.

Cost comparison

Surgeons who completed the curriculum had lower hospital variable expenses, anesthesia provider expenses, and support expenses per robotic inguinal hernia case (Table 4). Overall, the average total hospital cost per case for a trainee was $4802.23 USD vs. $6009.42 for a non-trainee, for an average difference of $1207.19 (20.1%) per robotic inguinal hernia case.

Discussion

This was a retrospective study analyzing outcomes for robotic inguinal hernia repair in a multi-hospital university system performed by robotic novices who completed a voluntary structured robotics training curriculum compared to robotic novices who did not. In our study, we showed that surgeons who completed a voluntary structured robotics training curriculum had shorter estimated risk-adjusted operative times by 31 min (23%) and an average cost savings of $1207 (20%) per robotic hernia case.

Prolonged operative time has been demonstrated to be independently associated with adverse post-operative outcomes including rates of complications, length of hospital stay, and readmissions.[20–22] Fortunately, studies analyzing the learning curve for complex robotic procedures have expectedly identified a reduction in operative time as surgeons perform more cases and become more technically proficient.[23,24] Therefore, it has been suggested that improving surgeon efficacy in the operation room can reduce operative time and improve patient outcomes.[22] However, optimizing performance through live robotic surgery or deliberate simulation practice has shown that operative time is the most difficult parameter to improve.[8,23]

Previous studies have shown the impact of training curriculums on improving objective performance in the operation room,[25] but none have evaluated the link between surgeon training and improved quality measures such as OR time and cost. Asoglu et al. studied patient outcomes following robotic, laparoscopic, and open hysterectomies before and after simulation-based training was enforced amongst *residents* and found improvements in estimated blood loss and length of hospital stay.[26] Regarding costs, Rehman et al. conducted a cost analysis of time spent on a robotic surgical training console (RoSS) and its resulting loss of live OR time and revenue.[27] A total of 361 h on the robotic simulator spent by 105 trainees was equivalent to 72 robotic-assisted radical prostatectomies. After considering the cost of the RoSS, operating room console and estimated loss of revenue per patient, the authors concluded that the RoSS prevented a potential loss of $600,000. While this study provides support for a robotic simulator, it uses hypothetical and indirect cost estimates. Furthermore, the study only shows that OR time is replaced by training time, and not necessarily improved by training.

We estimate that curriculum non-trainees require an estimated 28 additional cases on average to match the starting proficiency of a curriculum trainee. Based on the median frequency of 0.5 robotic inguinal hernias per month (IQR 0.38–1.0) performed by non-trainees in our cohort, this learning gap would have required over 55 months to surpass. To our knowledge, this is the first study of its kind to identify an evidence-based gap in operative cases between board-certified attending surgeons who completed and did not complete a training program. We assert that the time commitment of 5–8 h to complete the robotic simulation curriculum compares favorably with this learning gap that could take more than 4 years of live surgery and over $168,000 to close per surgeon. Therefore, investing a relatively short time period to acquire robotic proficiency prior to embarking on live surgery can have major implications on a hospital system over several years.

This study had several limitations; an inherent limitation of this study is that it is a retrospective study where surgeons were not randomized to curriculum completion and instead offered voluntary participation which introduces selection bias. A second limitation was that results are limited to a small cohort of surgeons

Table 4
Robotic hernia repair costs by curriculum completion.

Cost Pool	Total (N = 210)	Curriculum Completed		Cost Variance (%)	p[d]
		No (N = 95)	Yes (N = 115)		
Hospital Variable Expense[a]	$3589.38	$3861.35	$3364.72	-$496.63 (−12.9%)	**0.002**
Anesthesia Provider Expense[b]	$1013.25	$1208.25	$852.16	-$356.09 (−29.5%)	< **0.001**
Support Expense[c]	$745.71	$939.82	$585.35	-$354.47 (−37.7%)	< **0.001**
Total Expenses	$5348.34	$6009.42	$4802.23	-$1207.19 (−20.1%)	< **0.001**

[a] Includes total direct expenses (supplies, drugs, and blood) and total salaries (OR staff and nursing staff).
[b] Includes physician anesthesiologist and nurse anesthesiologist salaries.
[c] Includes unit supporting expenses.
[d] Bolded denotes $p < 0.05$.

from varying baseline experiences which were not significant but could have been underpowered to show significance. Additionally, the non-trainee cohort had a higher percentage of residents; however, this was not a significant factor on multivariable analysis and the results maintained significance when the resident cases were removed. Given that attendings surgeons were new to the robotic platform and/or operation it is unknown how many residents physically participated in the operation from the surgeon console. This finding does advocate for curriculum completion by resident trainees as well. Our institution has 100% compliance by our surgical oncology fellows due to mandatory enforcement; however, only 18% of our general surgery residents complete a voluntary curriculum.[28] Lastly, the upfront cost of obtaining simulation equipment and training materials may be prohibitively expensive for many hospitals. However, we have attempted to show that the investment of time and resources deliver high returns in the long run. Despite these limitations, this study shows that safe outcomes can be achieved by robotic novices, and proficiency can be optimized by a structured training curriculum prior to performing independent operations. Finally, we believe that the results of this study should not persuade institutions to screen, or exclude less-proficient surgeons from performing robotics. Instead, we assert that a structured curriculum is a necessary tool for all novice robotic surgeons to expedite their learning curve and maximize proficiency.

In conclusion, the results of this study show that a structured proficiency-based training curriculum for robotic surgery is an effective way to reduce operative times and costs and may also reduce the learning curve for robotic inguinal hernia repairs. This training pathway offers a potential solution for health care systems undergoing increased requests from surgeons for robotic privileges in a health care climate that wants to contain costs. However, minimizing cost and maximizing quality while rolling out a robotic training program will require oversight and continuous scrutiny of outcomes. By mandating a proficiency-based credentialing pathway for surgeons, hospital systems have the potential to reduce costs and improve patient outcomes following a variety of operations.

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Conflict of interest

The authors do not have any conflicts of interest to declare.

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