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Robotic Technology in Emergency General Surgery Cases in the Era of Minimally Invasive Surgery

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IMPORTANCE Although robotic surgery has become an established approach for a wide range of elective operations, data on its utility and outcomes are limited in the setting of emergency general surgery.

OBJECTIVES To describe temporal trends in the use of laparoscopic and robotic approaches and compare outcomes between robotic and laparoscopic surgery for 4 common emergent surgical procedures.

DESIGN, SETTING, AND PARTICIPANTS A retrospective cohort study of an all-payer discharge database of 829 US facilities was conducted from calendar years 2013 to 2021. Data analysis was performed from July 2022 to November 2023. A total of 1 067 263 emergent or urgent cholecystectomies (n = 793 800), colectomies (n = 89 098), inguinal hernia repairs (n = 65 039), and ventral hernia repairs (n = 119 326) in patients aged 18 years or older were included.

EXPOSURE Surgical approach (robotic, laparoscopic, or open) to emergent or urgent cholecystectomy, colectomy, inguinal hernia repair, or ventral hernia repair.

MAIN OUTCOMES AND MEASURES The primary outcome was the temporal trend in use of each operative approach (laparoscopic, robotic, or open). Secondary outcomes included conversion to open surgery and length of stay (both total and postoperative). Temporal trends were measured using linear regression. Propensity score matching was used to compare secondary outcomes between robotic and laparoscopic surgery groups.

RESULTS During the study period, the use of robotic surgery increased significantly year-over-year for all procedures: 0.7% for cholecystectomy, 0.9% for colectomy, 1.9% for inguinal hernia repair, and 1.1% for ventral hernia repair. There was a corresponding decrease in the open surgical approach for all cases. Compared with laparoscopy, robotic surgery was associated with a significantly lower risk of conversion to open surgery: cholecystectomy, 1.7% vs 3.0% (odds ratio [OR], 0.55 [95% CI, 0.49-0.62]); colectomy, 11.2% vs 25.5% (OR, 0.37 [95% CI, 0.32-0.42]); inguinal hernia repair, 2.4% vs 10.7% (OR, 0.21 [95% CI, 0.16-0.26]); and ventral hernia repair, 3.5% vs 10.9% (OR, 0.30 [95% CI, 0.25-0.36]). Robotic surgery was associated with shorter postoperative lengths of stay for colectomy (−0.48 [95% CI, −0.60 to −0.35] days), inguinal hernia repair (−0.20 [95% CI, −0.30 to −0.10] days), and ventral hernia repair (−0.16 [95% CI, −0.26 to −0.06] days).

CONCLUSIONS AND RELEVANCE While robotic surgery is still not broadly used for emergency general surgery, the findings of this study suggest it is becoming more prevalent and may be associated with better outcomes as measured by reduced conversion to open surgery and decreased length of stay.

Invited Commentary

Supplemental content

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The use of minimally invasive surgical (MIS) techniques is well established in various general surgery subspecialties. Previous work has reported improved outcomes when a laparoscopic or robotic approach is undertaken rather than an open approach in the surgical management of benign and malignant diseases.[1-6] Compared with open surgery (OS), MIS was associated with less postoperative pain, shorter hospital length of stay (LOS), and lower risk of infection or mortality.[7-10]

While MIS has historically been referred to as laparoscopic surgery (LS), further distinction has been made to distinguish between laparoscopic and robotic techniques. Robotic surgery (RS) has been associated with equivalent or even improved postoperative outcomes in comparison with laparoscopic outcomes.[11-13] One of the most consistent outcome advantages associated with robotics is lower rates of conversion to OS across specialties and procedures.[11] Given their equivalent and improved outcomes, RS in many centers has become more prevalent than laparoscopy for elective cases. Annual RS volume in the US exceeded 600 000 cases in 2017, which represents a 3-fold increase.[12,13] The increase in RS paralleled a decrease in hospital use of LS as well as minor reductions in OS.[13]

While OS and LS are the status quo for many emergency general surgery (EGS) procedures, RS has been slowly yet increasingly adopted for specific EGS procedures, including cholecystectomies,[14,15] colectomies,[16-18] hiatal hernia repairs,[19,20] and abdominal hernia repairs.[21] This expansion has prompted the World Society of Emergency Surgery to publish its first position paper, outlining guidance on specific situations in which robotic approaches may be preferred.[22] However, there is no RS requirement in fellowship and as such there remains wide variation in MIS training and experience among acute care surgeons. To our knowledge, a large-scale study to evaluate the use of RS in EGS has not been performed.[23,24]

For this reason, we performed a retrospective cohort study to evaluate temporal trends in the use of MIS approaches in common EGS procedures and compared outcomes between RS and LS. We hypothesized that the use of RS has increased over time and may be associated with improved surgical outcomes with decreased conversion to OS and LOS.

Key Points

Question Do outcomes for emergency general surgery vary by surgical approach?

Findings In this cohort study of more than 1 million procedures, robotic surgery was more prevalent for emergency general surgery between 2013 and 2021. Robotic surgery, compared with laparoscopic surgery, is associated with decreased conversion to open surgery and decreased postoperative length of stay in commonly performed urgent and emergent procedures.

Meaning The findings of this study suggest that robotic surgery may be associated with better surgical outcomes in emergent general surgery, similar to previous findings in elective operations.

Methods

Data Source and Study Population

The PINC AI Healthcare Database (PHD, formerly known as the Premier Healthcare Database) was used for this study. The PHD is a discharge database that collects data from 829 US facilities (eTable 1 in Supplement 1).[25] The database includes a diverse group of nonprofit, nongovernmental, community, and teaching hospitals and health systems from rural and urban areas. The PHD includes nearly 8 million inpatient admissions per year, representing approximately 25% of annual US inpatient admissions.[25] Additionally, outpatient visits to emergency departments, ambulatory surgery centers, and alternate sites of care are included, with more than 71 million visits per year.[25] As an all-payer database, 35% of the encounters are commercial insurance, 33% Medicare, and 19% Medicaid.[25]

This study used aggregated, deidentified patient data. Institutional review board approval and patient consent were not required per Common Rule (45 CFR §46). This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.[26]

Adult patients (age ≥18 years) who underwent emergent or urgent cholecystectomy, colectomy, inguinal hernia repair, or ventral hernia repair between calendar years 2013 and 2021 were included in the analysis. These procedures were chosen because they are among the most common EGS procedures and have a well-adopted robotic approach in the elective setting.[22,27] Emergent and urgent procedures are categorized in the PHD using the uniform billing form (UB-04). Emergent procedures include patients requiring immediate intervention for a life-threatening or potentially disabling condition. Urgent procedures include patients requiring immediate attention, prioritizing their care as first available. We excluded elective procedures, which include patients whose condition permitted time to schedule their case as available. Urgent and emergent procedures may have been performed as an inpatient or outpatient. Outpatient procedures in PHD include up to 23 hours of observation. We used *International Classification of Diseases, Ninth Revision, Procedure Classification System* (*ICD-9-PCS*) codes, *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Procedure Classification System* (*ICD-10-PCS*) codes, *Current Procedural Terminology* codes, and hospital billing text fields (eTable 2 in Supplement 1) to define eligible cases and surgical modality. We classified patients as undergoing either OS or MIS, and MIS was further divided into LS or RS approaches.

Exposure

The study exposure was surgical approach. We classified patients as undergoing OS, LS, or RS. Patients who underwent conversion to OS during an MIS procedure were counted as intention-to-treat by the originally planned approach.

Outcomes

The primary outcome was the temporal trend in use of each surgical approach. Secondary outcomes included conversion to OS during an MIS procedure and LOS. Conversion to OS was identified by *ICD-9-PCS* and *ICD-10-PCS* diagnosis codes for

conversion (eTable 2 in Supplement 1). Length of stay was measured as both total LOS (days from admission to discharge) and postoperative LOS (days from surgery to discharge).

Study Covariates

We evaluated patient, hospital, and surgeon characteristics for patients who underwent emergency surgery. Patient characteristics included age, gender, race and ethnicity, admission type (emergent or urgent), inpatient or outpatient status, insurance type (commercial, Medicaid, Medicare, or self-pay/other), Charlson Comorbidity Index, body mass index category (underweight, normal, overweight, and obese), year of surgery, and underlying diagnosis. Based on the literature, race and ethnicity is a confounding variable and needs to be controlled in the model. Demographic data were missing in 3.7% of the cohort. These cases were excluded from the analytic models, as it comprised less than 5% of the cohort. Hospital characteristics included rurality (rural or urban), type (teaching or nonteaching), geographic region (Midwest, Northeast, South, or West), bed number (<300, 300-399, 400-499, and ≥500), and volume. All models were adjusted for clustering by facility to account for different practice patterns.

We calculated the annual procedure numbers (elective, urgent, and emergent) of each hospital and used tertial cutoffs to generate low-, medium-, and high-volume categories. Surgeon characteristics included specialty and volume. Surgeon specialty was classified as critical care/trauma, general, colorectal, or other. We calculated procedure and approach-specific surgeon volume during the prior year.

Statistical Analysis

Data analysis was performed from July 2022 to November 2023. We evaluated the overall use of OS, LS, and RS for cholecystectomy, colectomy, inguinal hernia repair, and ventral hernia repair across the study period. We then measured change in the use of RS for each operation over time, between 2013 and 2021. Two analytic approaches were then used to address the stated study objectives.

First, we characterized the trend in the use of each surgical approach over time for EGS procedures. We reported raw proportions of each surgical approach annually and calculated the change for each surgical approach over time by dividing the proportional use of the approach in 2021 by its proportional use in 2013. We then used linear regression to estimate the mean annual increase or decrease in the proportional use of each approach. The assumption of normal distribution was verified using the Shapiro-Wilk test for all data, except for laparoscopic ventral hernias. As such, the annual rates for the laparoscopic ventral hernia repairs should be interpreted with caution. In this analysis, study years were considered as a continuous variable. Annual change per year was obtained from the β coefficient and its 95% CI.

Second, we performed a propensity score-matched analysis to evaluate whether MIS surgical approach (LS or RS) was associated with the secondary outcomes (conversion to OS and LOS). Baseline differences in patient, hospital, and surgeon characteristics were compared between patients who underwent LS vs RS. Continuous variables were compared using the Wilcoxon rank sum test, while frequencies were compared using the χ^2 test. Propensity score matching was then used to minimize confounding due to patient selection.[28] The propensity for each patient to receive RS was estimated using multivariable logistic regression adjusted for patient, hospital, and surgeon characteristics and hospital cluster. Patients in the RS group were then matched to patients in the LS group using a 1:1 nearest neighbor matching algorithm without replacement. We used standardized differences with a threshold of less than 10% to indicate a good balance of covariates between matched RS and LS groups (eTable 3 in Supplement 1). Logistic regression was then used to estimate the odds ratio (OR) and 95% CI for conversion to OS associated with RS vs LS. We used 0-inflated Poisson regression to estimate the mean difference in LOS between RS and LS groups. A 2-sided *P* value <.05 was used to determine statistical significance.

Statistical analyses were performed using R, version 4.1.3 (R Foundation for Statistical Computing).

We aimed to capture the clinical practice of acute care surgeons by including inpatient and outpatient emergent and urgent procedures. To address the possibility that patients undergoing elective procedures were misclassified and included in the cohort, we conducted a sensitivity analysis of inpatient emergent cases only. The conversion to OS and postoperative LOS results were unchanged. The differences in total LOS for ventral hernia and inguinal hernia were no longer statistically significant. The results reported herein are of the primary analysis. The sensitivity analysis results are available in eTable 4 in Supplement 1.

Results

We identified a total of 1 067 263 emergent or urgent surgeries: 793 800 cholecystectomy, 89 098 colectomy, 65 039 inguinal hernia repair, and 119 326 ventral hernia repair cases from PHD between 2013 and 2021. During the study period, MIS was the predominant approach for cholecystectomy (98.5%), while OS was more common for colectomy (69.8%), inguinal hernia repair (72.2%), and ventral hernia repair (68.6%) (**Figure 1**). The use of RS increased for all procedures between 2013 and 2021: from 2.5% to 8.8% with a 0.7% increase per year for cholecystectomy, from 1.4% to 8.8% with a 0.9% increase per year for colectomy, from 0.4% to 15.3% with a 1.9% increase per year for inguinal hernia repair, and from 0.7% to 9.6% with a 1.1% increase per year for ventral hernia repair (**Figure 2**; **Table 1**).

Increased use of RS corresponded with a decrease in OS for all procedures: 0.1% decrease per year for cholecystectomy, 0.7% decrease per year for colectomy, 1.9% decrease per year for inguinal hernia repair, and 1.6% decrease per year for ventral hernia repair (Table 1). There was also a corresponding decrease in LS for cholecystectomy (0.6% decrease per year) and colectomy (0.3% decrease per year) (Table 1). There was no significant change in LS for inguinal hernia repair and an increase in LS for ventral hernia repair (0.4% increase per year) (Table 1).

Figure 1. Use of Operative Approach for Emergency General Surgery Between 2013 and 2021

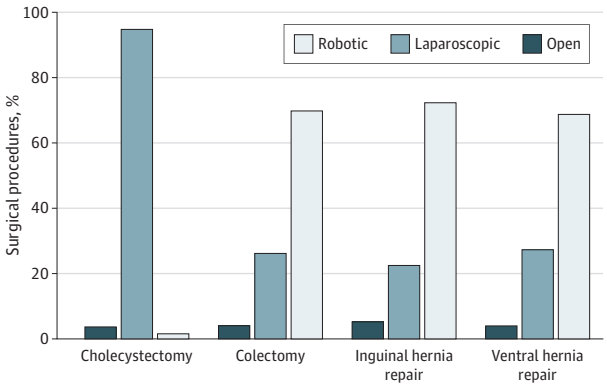
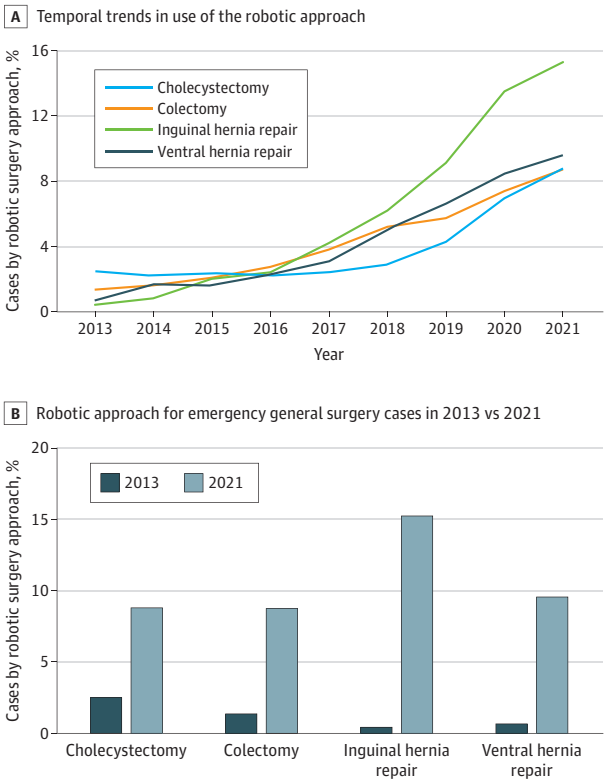


Figure 2. Temporal Trends and Robotic Approaches in the Use of Robotic Emergency General Surgery, 2013-2021



A, Trends in the use of robotic emergency general surgery. B, Proportion of robotic emergency general surgery use in 2013 compared with 2021.

Within each procedure, patients who underwent RS were older (excluding cholecystectomy), had more comorbidities, and were more often overweight or obese compared with those who underwent LS. Robotic procedures were more likely to be done in the South (excluding inguinal hernia repair), an urban setting, and hospitals with 500 or more beds (excluding cholecystectomy) (eTable 5 in Supplement 1). Robotic cholecystectomy and robotic ventral hernia repair were more likely to be performed by general surgeons, whereas colorectal surgeons performed more robotic colectomy cases (eTable 5 in Supplement 1).

After PSM analysis, RS was associated with a significantly lower risk of conversion to OS compared with LS, regardless of the procedure: cholecystectomy, 1.7% vs 3.0% (OR, 0.55 [95% CI, 0.49-0.62]); colectomy, 11.2% vs 25.5% (OR, 0.37 [95% CI, 0.32-0.42]); inguinal hernia repair, 2.4% vs 10.7% (OR, 0.21 [95% CI, 0.16-0.26]); and ventral hernia repair, 3.5% vs 10.9% (OR, 0.30 [95% CI, 0.25-0.36]) (**Table 2**). A robotic approach was associated with a decreased total LOS for both inguinal hernia repair (mean difference, −0.12 [95% CI, −0.24 to −0.003]) and colectomy (mean difference, −0.21 [95% CI, −0.36 to −0.06]), but increased LOS for cholecystectomy (mean difference, 0.19 [95% CI, 0.14-0.23]) (Table 2). Additionally, there was a significant decrease in postoperative LOS for RS colectomy (mean difference, −0.48 [95% CI, −0.60 to −0.35]), inguinal hernia repair (mean difference, −0.20 [95% CI, −0.30 to −0.10]), and ventral hernia repair (mean difference, −0.16 [95% CI, −0.26 to −0.06]) compared with LS (Table 2).

Discussion

Our study provides a comprehensive evaluation of temporal trends of MIS in 4 common EGS procedures over the past decade. The use of robotic techniques significantly increased for all 4 procedures by 2-fold in the final 3 years of the study, which paralleled the decrease in OS approaches. The laparoscopic approach decreased only for cholecystectomies and colectomies. These findings emphasize the increasing uptake of RS in EGS procedures, which is concordant with previous work.[13] Compared with LS, patients who underwent RS were older, had more comorbidities, and were more often overweight or obese. After PSM, RS was associated with a significantly lower risk of conversion to OS for all 4 procedures. Robotic surgery was also associated with a shorter postoperative LOS compared with LS for colectomies, ventral hernia, and inguinal hernia repairs. These data suggest that, while RS is still used in the minority of EGS cases, it is becoming more prevalent with a corresponding decrease in OS.

To our knowledge, this is the first study to directly compare the outcomes between LS and RS propensity score-matched cohorts for a typical caseload found in the EGS setting. This study design directly addresses the first research priority of the World Society of Emergency Surgery position statement: to identify the applications of RS and compare outcomes with open and laparoscopic approaches using observational data.[22] We found that RS has a lower risk of conversion to OS than LS and was associated with an expedited postoperative course. In several randomized clinical trials, RS has had equivocal or improved outcomes relative to LS.[29] No significant differences in the rates of conversion to OS between the approaches have been identified in randomized clinical trials for prostatectomies, cholecystectomies, and Roux-en-Y gastric bypasses, while RS had lower conversion to OS for rectal surgery and hysterectomies.[29] Procedures such as hiatal hernia repairs, ventral suturing, mesh fixations, colonic

Table 1. Annual Rate of Change for Emergency General Surgery by Surgical Approach, 2013-2021

	Open		Laparoscopic		Robotic	
Surgery type	Annual rate, % (95% CI)	*P* value	Annual rate, % (95% CI)	*P* value	Annual rate, % (95% CI)	*P* value
Cholecystectomy	−0.11 (−0.16 to −0.07)	<.001	−0.61 (−1.1 to −0.17)	.01	0.73 (0.29 to 1.2)	.01
Colectomy	−0.65 (−1.0 to −0.33)	.002	−0.29 (−0.54 to −0.04)	.03	0.94 (0.77 to 1.1)	<.001
Inguinal hernia repair	−1.9 (−2.3 to −1.5)	<.001	−0.01 (−0.56 to 0.54)	.97	1.9 (1.4 to 2.4)	<.001
Ventral hernia repair[a]	−1.6 (−1.7 to −1.4)	<.001	0.42 (0.13 to 0.72)	.01	1.1 (0.88 to 1.4)	<.001

[a] All the data except ventral hernia repair laparoscopic annual rates are under the assumption of normal distribution. The results of ventral hernia repair laparoscopic annual rates therefore need to be interpreted with caution.

Table 2. Propensity Score–Matched Adjusted Outcomes: Laparoscopic vs Robotic Emergency General Surgery

	Conversion, %			LOS, d				Postoperative LOS, d			
Outcome	No. (%)	Odds ratio (95% CI)	*P* value	Median (IQR)	Mean (SD)	Adjusted difference (95% CI)	*P* value	Median (IQR)	Mean (SD)	Adjusted difference (95% CI)	*P* value
Cholecystectomy											
Laparoscopic surgery	800 (3.0)	1 [Reference]	NA	2.00 (0.00 to 4.00)	2.87 (3.64)	1 [Reference]	NA	1.00 (0.00 to 2.00)	1.63 (2.65)	1 [Reference]	NA
Robotic-assisted surgery	450 (1.7)	0.55 (0.49 to 0.62)	<.001	2.00 (0.00 to 4.00)	3.05 (4.20)	0.19 (0.14 to 0.23)	<.001	1.00 (0.00 to 2.00)	1.65 (3.16)	0.03 (−0.002 to 0.05)	.07
Colectomy											
Laparoscopic surgery	860 (25.5)	1 [Reference]	NA	9.00 (6.00 to 13.00)	10.26 (7.30)	1 [Reference]	NA	5.00 (4.00 to 8.00)	6.91 (5.87)	1 [Reference]	NA
Robotic-assisted surgery	379 (11.2)	0.37 (0.32 to 0.42)	<.001	8.00 (5.00 to 13.00)	10.05 (8.31)	−0.21 (−0.36 to −0.06)	.01	5.00 (3.00 to 7.00)	6.44 (6.69)	−0.48 (−0.60 to −0.35)	<.001
Inguinal hernia repair											
Laparoscopic surgery	357 (10.7)	1 [Reference]	NA	1.00 (0.00 to 3.00)	2.17 (3.85)	1 [Reference]	NA	0.00 (0.00 to 2.00)	1.76 (3.48)	1 [Reference]	NA
Robotic-assisted surgery	80 (2.4)	0.21 (0.16 to 0.26)	<.001	1.00 (0.00 to 3.00)	2.05 (4.71)	−0.12 (−0.24 to −0.003)	.045	0.00 (0.00 to 2.00)	1.56 (4.28)	−0.20 (−0.30 to −0.10)	<.001
Ventral hernia repair											
Laparoscopic surgery	497 (10.9)	1 [Reference]	NA	2.00 (0.00 to 4.00)	3.23 (4.63)	1 [Reference]	NA	1.00 (0.00 to 4.00)	2.54 (4.00)	1 [Reference]	NA
Robotic-assisted surgery	161 (3.5)	0.30 (0.25 to 0.36)	<.001	2.00 (0.00 to 4.00)	3.18 (5.01)	−0.05 (−0.16 to 0.08)	.48	1.00 (0.00 to 3.00)	2.38 (4.23)	−0.16 (−0.26 to −0.06)	.002

Abbreviations: LOS, length of stay; NA, not applicable.

suturing, strictureplasties, and dissection of inflamed gallbladder or colon are difficult to complete laparoscopically and frequently result in conversion to OS. Features of robotic platform, such as deep magnification, stereoscopic vision, motion scaling, and better ergonomics, may facilitate the ability to perform these procedures optimizing outcomes.[30] With many surgeons not having spent dedicated time training in laparoscopy, the robotic technology may enhance the ability to adopt the necessary skill set to perform MIS.

Appropriate patient selection undoubtedly contributes to outcomes. In this study, patients undergoing RS were older and had more comorbidities than those undergoing LS. The conventional OS approach is recommended for patients with unstable and frail status who require time-critical surgery. However, prior reviews suggest that patients with more complex conditions can be considered for minimally invasive surgery if the correct technical setup is available and the patient is stable.[31,32] Therefore, patients who are hemodynamically stable yet frail in particular may benefit from an expedited recovery associated with RS in the acute setting, compared with traditional OS.

We noted a steep, 2-fold increase in the number of RS procedures in the final 3 years of the study, a trend that is supported by procedure volumes reported by device manufacturers.[33] For example, between 2018 and 2019, there was a 17.26% increase in the number of RS cases, from 753 000 to 883 000. Even amidst the COVID-19 pandemic, the number of RS cases increased to 876 000.[30] This increase reflects both a broader availability of technology and a rise in the uptake of robotic procedures among clinicians.[34,35] In its early stage, there were several barriers to the successful implementation of RS. Surgeons needed to invest a substantial number of hours training to overcome a steep learning curve.[36] Supporting staff, including scrub assistants, were largely unfamiliar with the equipment and programs.[37] There was little evidence to show that RS was comparable to LS, a technique with which surgical teams were already very familiar and well versed.[38] These factors made it difficult to translate the initial investment into economies of scale. However, these increasing numbers show that hospitals have since invested in training and infrastructure to use RS at a higher level and faster pace. Our data suggest that hospital systems will continue to use the existing pathways as a blueprint to increase robot use and have developed methods to integrate in the acute setting.[39,40]

Limitations

A major design limitation is that this was a retrospective cohort study and thus predisposed to selection bias and unmeasured confounding. Patient surgical history and disease severity, for example, are not available in the PHD. Both factors may influence surgical approach and patient outcomes. We have attempted to account for such unmeasured confounding with robust statistical analysis. Furthermore, administrative datasets are imperfect in that there may be unidentifiable coding errors and may not capture all relevant outcomes. We attempted to address the potential misclassification of urgent and emergent procedures with a sensitivity analysis including only inpatient emergent cases. The conversion to OS diagnosis codes accounts for robotic or laparoscopic cases that were converted to open; however, we were unable to identify robotic cases that were converted to laparoscopic. Due to the large sample size, the data stem from a heterogeneous group of hospitals, surgeons, and practice settings. This variety renders our findings more generalizable, especially given that the cohorts were matched. Our study period spans the COVID-19 pandemic, which may have influenced how robotic EGS was performed, but we could not adequately capture this factor in our analysis.

These limitations reveal several areas for further work. Few studies compare survival and procedure-specific outcomes after robotic EGS.[41] This is of particular importance given a recent study suggesting RS is associated with an increase in bile duct injury during cholecystectomy compared with LS.[42] More rigorous evidence from randomized clinical trials with long-term follow-up is required to definitively address this blind spot. Similar to cancer and trauma databases, registries for RS could be established to facilitate these studies. Furthermore, to our knowledge, no study has assessed the cost-effectiveness of robotic EGS procedures.[43] Our findings suggest that RS and LS may be comparable in costs based on surrogate measures of LOS, but with the substantial reduction in conversion to OS as a compensatory variable. However, existing evidence suggests that robotic procedures are typically longer and incur almost $3000 more in 90-day direct hospital costs.[44] There is the risk that patients will bear higher insurance premiums if these costs are eventually transferred to them.[44] Streamlining the delivery of robotic technology in EGS will require a coordinated effort of health systems, clinicians, payers, and policymakers. Further exploration of RS will be critical to scale this technology.[43]

Conclusions

The application of RS in EGS has steadily increased in the past decade, which is especially useful in older patients with several comorbidities. As observed in this cohort study, compared with LS, RS appears to have resulted in lower rates of conversion to OS from 2013 to 2021. Robotic surgery also leads to a shorter or comparable postoperative LOS in the hospital. Nevertheless, OS remains a key component for most EGS. As RS continues to increase in EGS, barriers to implementation need to be addressed and optimized through coordinated efforts across stakeholders.

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Concept and design: Lunardi, Abou-Zamzam, Florecki, Kent, Joseph, Byrne, Sakran.
Acquisition, analysis, or interpretation of data: Chidambaram, Shih, Kent, Joseph, Byrne, Sakran.
Drafting of the manuscript: Lunardi, Abou-Zamzam, Chidambaram, Shih, Joseph, Sakran.
Critical review of the manuscript for important intellectual content: Lunardi, Abou-Zamzam, Florecki, Chidambaram, Kent, Joseph, Byrne, Sakran.
Statistical analysis: Shih, Kent, Joseph, Byrne.
Administrative, technical, or material support: Lunardi, Abou-Zamzam, Florecki, Chidambaram, Kent, Joseph, Sakran.
Supervision: Kent, Joseph, Sakran.

Conflict of Interest Disclosures: Dr Shih reported being employed by Intuitive Surgical during the conduct of the study. Dr Kent reported receiving travel fees paid for by Intuitive Surgical for robotic training courses; was the director of an American College of Surgeons–organized robotic skills competition for Maryland surgical trainees; and received grant and equipment administrative support provided to Maryland American College of Surgeons by Intuitive Surgical contributing to support for this event. Dr Joseph reported receiving honoraria from CSl Behring for travel and lecture fees outside the submitted work. Dr Sakran reported receiving consultant and speaking fees from Intuitive Surgical outside the submitted work. No other disclosures were reported.

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