JOURNAL OF SURGICAL RESEARCH • SEPTEMBER 2025 (313) 198–209

Available online at www.sciencedirect.com

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journal homepage: www.JournalofSurgicalResearch.com

Global Utilization of Minimally Invasive Surgery: Practice and Challenges

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ARTICLE INFO

Article history:
Received 10 January 2025
Received in revised form
28 May 2025
Accepted 16 June 2025
Available online 16 July 2025

Keywords:
Clinical challenges
Cost-effective solutions
Global surgery
Health care access
Laparoscopy
Minimally invasive surgery
Surgical outcomes
Surgical training

ABSTRACT

Introduction: Uptake of minimally invasive surgery (MIS) in low- and middle-income countries (LMICs) has been slow due to various barriers. This study examined the experiences of surgeons across multiple countries, highlighting the complications and challenges that arise with MIS.

Methods: Forty-one surgeons from Japan, Singapore, Uganda, the United States, Cambodia, Vietnam, and Malaysia completed 12-question surveys detailing the challenges of their MIS cases. Data were collected from April 2021 to February 2023, and descriptive statistics were generated.

Results: A total of 198 MIS cases were reported by 36 surgeons during the study period. In LMICs, patients tended to be older ($P < 0.001$), more likely to be female ($P < 0.001$), and have fewer comorbidities ($P < 0.01$) than in high-income countries (HICs). Antireflux procedures, appendectomies, and cholecystectomies were the most common MIS performed. Surgical assistants varied, with Japanese surgeons reporting the highest usage of experienced surgeons as assistants ($n = 53$, 56%). Minimal blood loss was perceived for 80% of cases in HICs ($n = 99$), whereas greater than minimal blood loss was perceived in LMICs ($n = 41$, 55%; $P < 0.001$). While most HIC surgeons found cases easy ($n = 93$, 75%) with no technical challenges, a higher percentage of LMIC surgeons considered converting to open procedures ($n = 5$, 7%) or had to convert ($n = 6$, 8%; $P < 0.001$). Thematic grouping identified four key barriers in LMICs: access to resources, maintenance of equipment, difficult intraoperative pathology, and surgical training availability.

Conclusions: This study highlights significant differences in the MIS experience between HICs and LMICs. Technical difficulties and intraoperative challenges were more frequent in

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https://doi.org/10.1016/j.jss.2025.06.024

LMICs, and all cases converted to open procedures originated from these regions. The identified barriers—access to resources, equipment maintenance, difficult intraoperative pathology, and surgical training—are critical areas that need targeted interventions.

Introduction

Laparoscopy was developed in the United States and Europe in the 1970s and 1980s,[1] and it has subsequently been used in many parts of the world, without significant adaptation to cultural differences or resource challenges. In the early days, the adoption of laparoscopy in the United States and Europe faced several challenges, such as older surgeons who were resistant to change,[2,3] significant learning curves with surgical complications, and underresourced, rural areas lacking access to the necessary training and equipment.[4-7] Despite these obstacles, laparoscopy has now become the standard of care for many procedures in high-income countries (HICs).

In the United States, laparoscopic cholecystectomy was the procedure that created demand for laparoscopy. Numerous advantages, including superior visualization, decreased infections, and the ability to perform this case as an outpatient procedure, have contributed to laparoscopic cholecystectomy becoming the standard of care in the United States.[8,9] Now, knowing that laparoscopic surgery is the standard of care for many surgical conditions in HICs, many surgeons in low- and middle-income countries (LMICs) have indicated enthusiasm for performing laparoscopy, and patients in LMICs are asking for a minimally invasive approach.[10] Despite the recent focus on expanding laparoscopic surgery in LMICs,[11] little is known regarding laparoscopic practices and challenges around the world.

Due to constraints in equipment, training, and access to specialized care, health care settings in LMICs struggle to provide laparoscopic surgery.[12-14] Some tertiary health care facilities have invested in laparoscopic equipment, but intervention is often limited by access to consumable supplies and maintenance issues.[11,15,16] There is a shortage of biomedical technicians in many parts of the world,[17] and many surgeons may not have access to mentors or laparoscopic assistants. In addition, sterilization of equipment is also difficult, as many hospitals do not have autoclaves or gas sterilization capabilities.[18]

Due in part to the technology's origins in the United States and Europe, little literature exists on specific challenges faced elsewhere. Key stakeholders, such as nonprofit organizations or medical device manufacturers and distributors, may assume universal applicability, which may overlook contextual differences and resource challenges.[19] Technology designed for the needs and resources of the United States and Europe does not necessarily meet the needs of other countries. Therefore, this study leveraged international networks to compile a database of laparoscopic cases and challenges encountered globally. Understanding these realities is vital for effectively introducing and advancing laparoscopic surgery in diverse health care settings worldwide.

Materials and Methods

The study was approved by the Institutional Review Boards at Makerere University, Uganda National Council for Science and Technology, Duke University, Nagoya University, and Duke-National University of Singapore. This study follows the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.[20]

Survey tool

This study was conducted in collaboration with surgeons from Duke University, Mulago Hospital, Nagoya University, and Duke-NUS Medical School. These surgeons identified eligible participants who were recruited by email invitation. A total of 63 surgeons received an email invitation, and 36 surgeons participated in the study, resulting in a response rate of 57%. Implied consent was obtained upon completion of an intake survey in Research Electronic Data Capture.[21] The intake survey linked the participants' subsequent responses to a unique identifier so that all responses regarding operative cases were linked to the operating surgeon but remained anonymous. Participants were asked to complete a perioperative survey at the time of operation for at least 20 laparoscopic cases and then to complete a 30-d postoperative survey for each operative case. Due to differences in the utilization of laparoscopy across countries, we did not specify a time window of when the cases should be submitted. As required by the Ugandan Institutional Review Board, surgeons in Uganda received monetary compensation for participating in the study. Other surgeon participants were not compensated.

The perioperative survey (Appendix A) included patient demographics, diagnosis, comorbidities, laparoscopic case performed, type of surgical assistant, estimated blood loss, length of case, laparoscopic system used, technical challenges encountered, conversion from laparoscopic to open approach, and intraoperative complications. There was also an open response for participants to discuss aspects of the case that they preferred had gone differently. A postoperative survey was sent to assess 30-d morbidity and mortality. The postoperative survey confirmed the type of surgery performed, hospital length of stay, 30-d surgical complications, and 30-d mortality.

Countries were grouped into LMICs and HICs based on income status, as defined by World Bank classification.[22] Cambodia, Malaysia, Uganda, and Vietnam were identified as LMICs, whereas Japan, Singapore, and the United States were identified as HICs. Descriptive analysis included frequencies and percentages for all categorical variables. Chi-square tests were used to compare patient demographics and the laparoscopic systems used between LMICs and HICs. All analyses were conducted using SAS version 9.4 statistical software (SAS Institute, Cary, NC). Two-sided P-values <0.05 were considered significant.

Two authors analyzed open-ended responses using the constant comparative method.[21,23] This method requires the categorization of quotes from participants in an iterative fashion to identify recurring themes.

Results

Thirty-six surgeons from seven countries participated in the study between April 2021 and February 2023 (Fig. 1). Surgeons were located in Cambodia (n = 1, 3%), Japan (n = 14, 39%), Malaysia (n = 1, 3%), Singapore (n = 7, 19%), Uganda (n = 7, 19%), the United States (n = 4, 11%), and Vietnam (n = 2, 6%). Most surgeons were pediatric surgeons (n = 22, 61%), followed by general surgeons (n = 7, 19%) and obstetrician-gynecologists (n = 3, 8%).

Demographics of patients who received laparoscopic surgery are presented in Table I. Patients were diverse in age, but when analyzed by LMICs *versus* HICs, most patients in LMICs were aged 30-50 y (n = 28, 38%) and 18-30 y (n = 19, 26%), whereas in HICs, a larger proportion of patients were aged <2 y (n = 45, 36%) and 6-12 y (n = 24, 19%; $P < 0.001$). Patients in

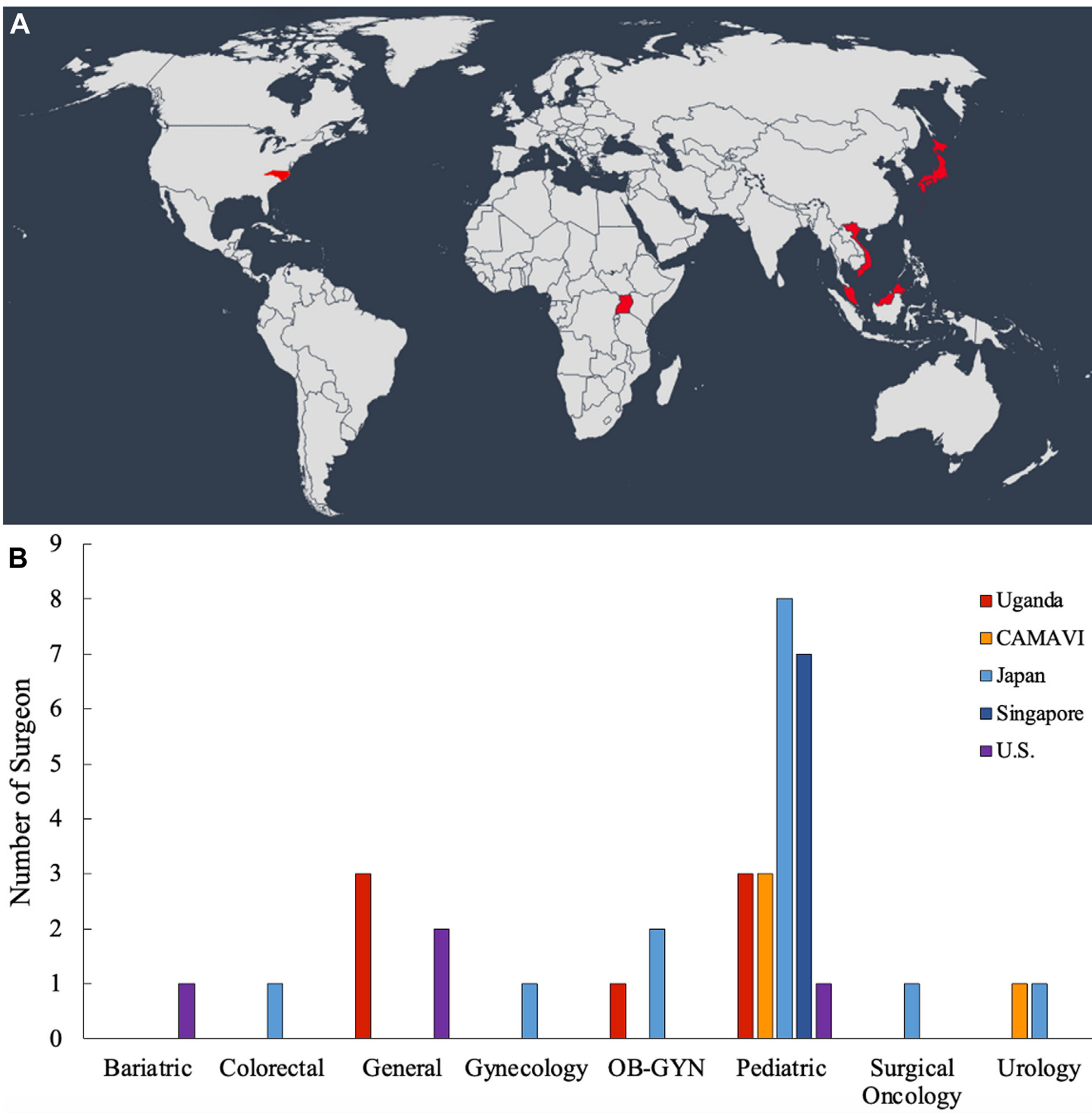

Fig. 1 – Surgeon geographic location and specialty. (A) World map showing countries represented by participating surgeons (n = 36). Countries shown represent the current practice locations of surgeons. (B) Surgical specialty distribution by country.

Table 1 – Patient demographics.

Characteristics	Total ($n = 198$)	LMIC ($n = 74$)	HIC ($n = 124$)	P value
Age (y)				
<2	45 (23%)	-	45 (36%)	
2-5	17 (9%)	4 (5%)	13 (11%)	
6-12	32 (16%)	8 (11%)	24 (19%)	
13-18	17 (9%)	6 (8%)	11 (9%)	<0.001
18-30	21 (11%)	19 (26%)	2 (2%)	
30-50	44 (22%)	28 (38%)	16 (13%)	
50-60	7 (4%)	5 (7%)	2 (2%)	
61+	15 (8%)	4 (5%)	11 (9%)	
Gender				<0.001
Male	94 (48%)	19 (26%)	75 (61%)	
Female	103 (52%)	55 (74%)	48 (39%)	
Comorbidities				<0.01
No comorbidities	138 (70%)	43 (58%)	95 (77%)	
Hypertension	21 (11%)	12 (16%)	9 (7%)	
Obesity	14 (7%)	8 (11%)	6 (5%)	
Cardiac event history	8 (4%)	1 (1%)	7 (6%)	
Asthma	5 (3%)	2 (3%)	3 (2%)	
Diabetes	5 (3%)	-	5 (4%)	
Kidney disease	3 (2%)	-	3 (2%)	
Emphysema	2 (1%)	-	2 (2%)	
Smoking history	2 (1%)	1 (1%)	1 (1%)	
Chronic liver disease	1 (1%)	1 (1%)	-	
Excess alcohol use	1 (1%)	1 (1%)	-	
Stroke history	1 (1%)	-	1 (1%)	
Other*	14 (7%)	4 (5%)	4 (5%)	

* The other category included genetic syndromes, bipolar disorder, tumors, cancer, congenital heart disease, epilepsy, prematurity, hematologic disease, hypothyroidism, anemia due to polymenorrhagia, and previous aspiration pneumonia.

LMICs were primarily female ($n = 55$, 74%), whereas patients in HICs were predominately male ($n = 75$, 61%; $P < 0.001$.). Most patients had no comorbidities in both LMICs and HICs ($n = 43$, 58%; $n = 95$, 77%, respectively). For LMICs, hypertension was the most common comorbidity ($n = 12$, 16%), followed by obesity ($n = 8$, 11%), whereas for HICs, hypertension and cardiac event history were the most common in HICs ($n = 9$, 7%; $n = 7$, 6%, respectively; $P < 0.01$).

The laparoscopic system used varied by geographic location (Table 2). LMICs were split between Karl Storz ($n = 26$, 36%), Stryker ($n = 23$, 32%), and Medtronic ($n = 24$, 33%), whereas HIC cases predominantly used Karl Storz ($n = 97$, 80%; $P < 0.01$).

Laparoscopic cases performed in each country are shown in Figure 2. The most common laparoscopic cases performed were antireflux procedures (Nissen, Dor, or Toupet fundoplication; $n = 21$, 10%), appendectomy ($n = 30$, 14%), cholecystectomy ($n = 19$, 9%), choledochal cyst excision or biliary atresia ($n = 13$, 6%), exploratory laparoscopy ($n = 12$, 6%), inguinal hernia repair ($n = 28$, 13%), thoracic cases ($n = 13$, 6%), and uterine surgery (i.e., fibroids or hysterectomy; $n = 21$, 10%). Thoracic cases included aortopexy, diaphragm plication, thymic cystectomy, talc pleurodesis, and esophagectomy. Compared with other countries, surgeons in Uganda performed more antireflux procedures ($n = 12$, 57%), appendectomies ($n = 17$, 57%), cholecystectomies ($n = 10$, 53%), exploratory laparoscopies ($n = 7$, 58%), and uterine procedures ($n = 15$, 71%). Surgeons from Japan reported more inguinal hernia repairs ($n = 16$, 57%), choledochal cyst excision or biliary atresia ($n = 13$, 100%) thoracic cases ($n = 10$, 71%), and other ($n = 11$, 52%). The other category consisted of biopsy, cyst excision, anorectal malformation repair, pyloric stenosis, loop colostomy, splenectomy, congenital diaphragmatic hernia repair, excision of urachal remnant, and spleen-preserving distal pancreatectomy. Providers from Japan were the only ones to report choledochal cysts, which comprised 16% ($n = 13$) of the laparoscopic cases in Japan. In addition, none of the following cases were performed: liver biopsy, stomach biopsy, gastric bypass, small bowel resection, and tubal ligation.

Medical personnel who were available to assist with laparoscopic cases varied greatly by country (Fig. 3). In Cambodia, one case was assisted by a more experienced surgeon, and one case in Malaysia was assisted by a surgical resident. Surgeons from Uganda reported that the surgeon was most often assisted by a nursing assistant ($n = 32$, 41%) or another more

Table 2 – Geographic location and laparoscopic system used per laparoscopic case*.

Geographic location	Total (N = 198*)	Laparoscopic system used				P value
		Karl Storz	Stryker	Olympus	Medtronic	
LMICs	73 (37%)	26 (13%)	23 (12%)	-	24 (12%)	**<0.001**
Uganda	69 (35%)	22 (11%)	23 (12%)	-	24 (12%)	
Cambodia	1 (1%)	1 (1%)	-	-	-	
Malaysia	1 (1%)	1 (1%)	-	-	-	
Vietnam	2 (1%)	2 (1%)	-	-	-	
HICs	122 (63%)	97 (49.%)	12 (6%)	11 (6%)	2 (1%)	
Japan	78 (40%)	66 (34%)	-	11 (6%)	1 (1%)	
Singapore	27 (14%)	27 (14%)	-	-	-	
United States	17 (9%)	4 (2%)	12 (6%)	-	1 (1%)	

Bold font indicates statistical significance.
*Unless otherwise indicated, data are expressed as n/total N (%) of cases with data available. Owing to missing data in categories, denominators do not always total numbers in column headings. Percentages have been rounded and may not total 100.

experienced surgeon (n = 24, 30%). In Vietnam, the assistant was another more experienced surgeon (n = 2, 40%) or a nursing assistant (n = 2, 40%). Surgeons in Japan reported the highest usage of other more experienced surgeons as assistants (n = 53, 56%). Surgeons from Singapore and the United States reported that most cases were assisted by a surgical resident (n = 17, 57%; n = 12, 67%, respectively).

There were differences in the surgical details of laparoscopic cases between LMICs and HICs (Fig. 4). HICs more often perceived minimal blood loss (n = 99, 80%), whereas LMICs perceived <50 mL blood loss (n = 28, 38%) and 51-200 mL blood loss (n = 11, 15%). Only two cases (3%), both of which were performed in LMICs, had an estimated blood loss of 200-500 mL ($P < 0.001$). In terms of case length, most cases in LMICs took 1-2 h (n = 40, 54%), whereas most cases in HICs took <1 h (n = 47, 38%; $P < 0.001$). More surgeons in HICs reported no technical challenges during laparoscopic cases (n = 109, 88%) compared to surgeons in LMICs (n = 43, 58%). The most

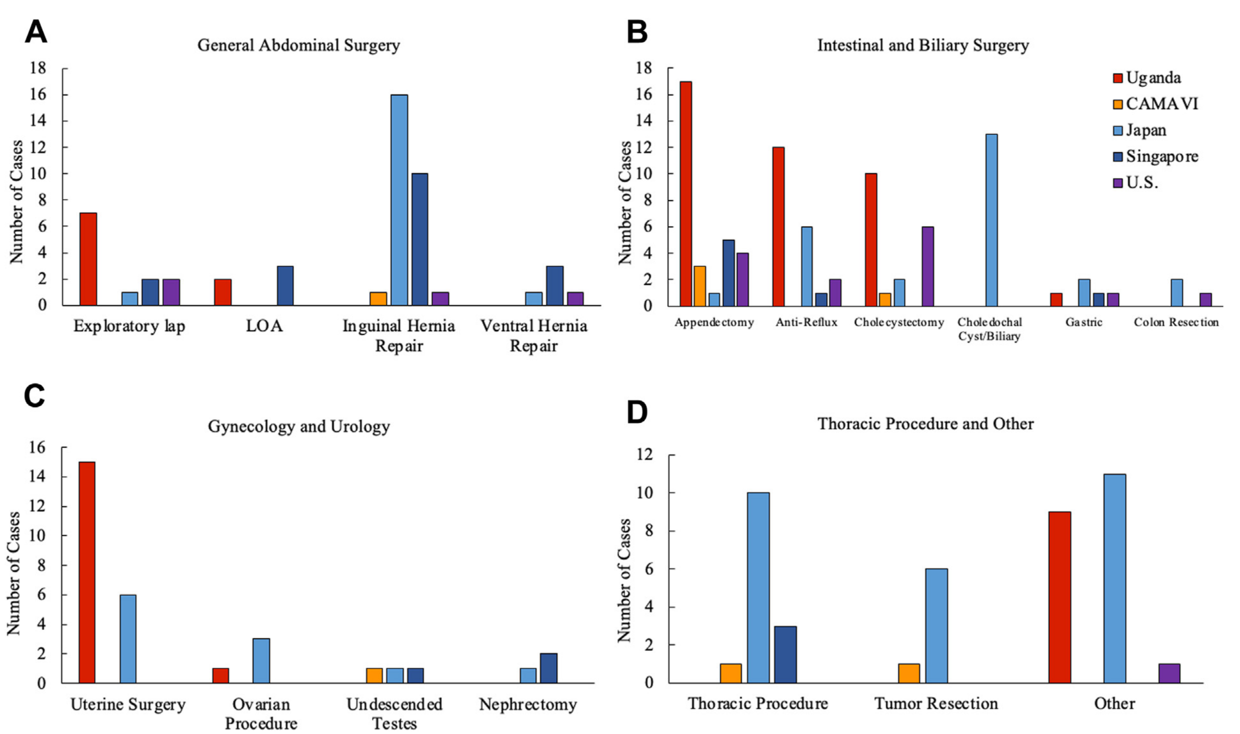

Fig. 2 – Laparoscopic cases performed according to country. CAMAVI represents the combined cases from Cambodia, Malaysia, and Vietnam. (A) General abdominal surgery. (B) Intestinal and biliary procedures. (C) Gynecology and urology cases. (D) Thoracic procedures, tumor resections, and others. The other category included biopsy, cyst resection, anorectal malformation repair, pyloromyotomy, splenectomy, CDH repair, urachal rumenotomy, distal pancreatectomy, and esophagectomy.

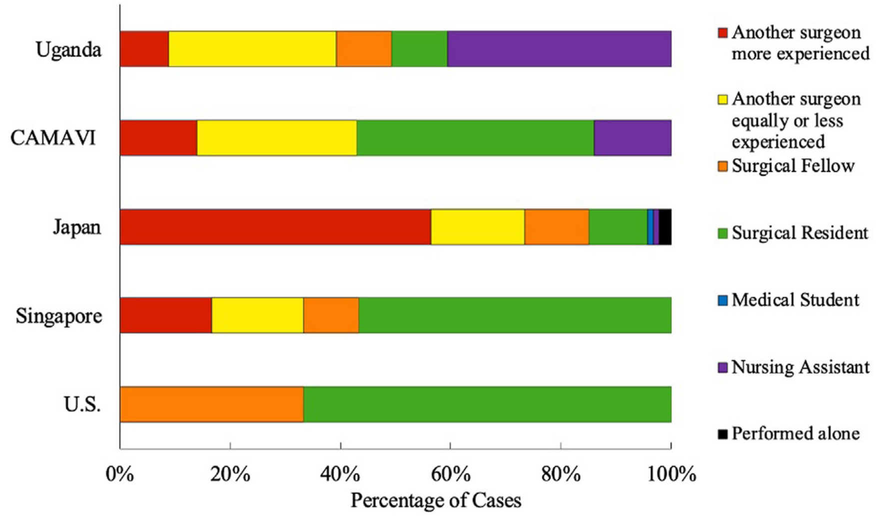

Fig. 3 – Surgical assistant present during laparoscopic cases. CAMAVI represents the combined cases from Cambodia, Malaysia, and Vietnam. Very few surgeons operated alone.

common technical challenge in LMICs was persistent fogging ($n = 10$, 14%), followed by insufflation problems ($n = 7$, 9%). A few HIC surgeons reported the image was not clear ($n = 6$, 5%). Only one HIC surgeon reported no technical challenges (6%).

Laparoscopic outcomes were explored between LMICs vs HICs (Fig. 5). HIC surgeons felt that most cases were easy ($n = 93$, 75%), whereas some were challenging, but they did not consider converting to an open procedure ($n = 29$, 23%). While most LMIC surgeons reported that cases were easy ($n = 45$, 61%), 7% ($n = 5$) reported that they considered converting to open, and 8% ($n = 6$) reported converting to open ($P < 0.001$). Both LMICs and HICs reported that most cases had no

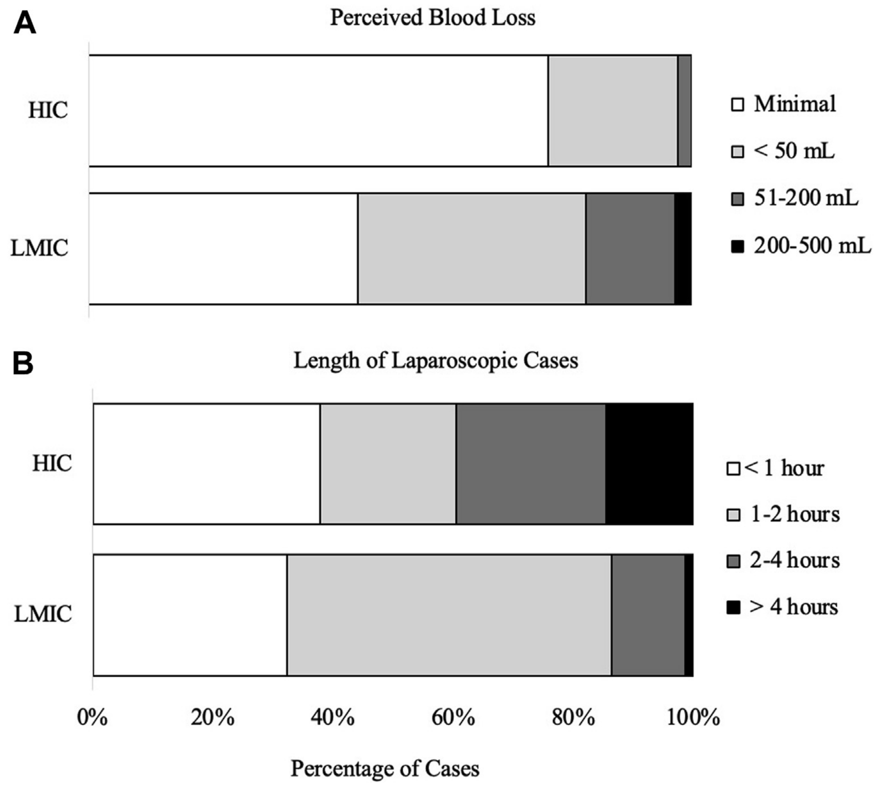

Fig. 4 – Details of laparoscopic cases. (A) Perceived blood loss. There was a significant difference in perceived blood loss between LMICs and HICs ($P < 0.0001$). (B) Length of case. Case length was significantly longer in LMICs ($P < 0.001$). (C) Technical challenges reported during laparoscopic cases. Other includes difficult entry, advanced pathology, problems with energy source, and slow response from staff.

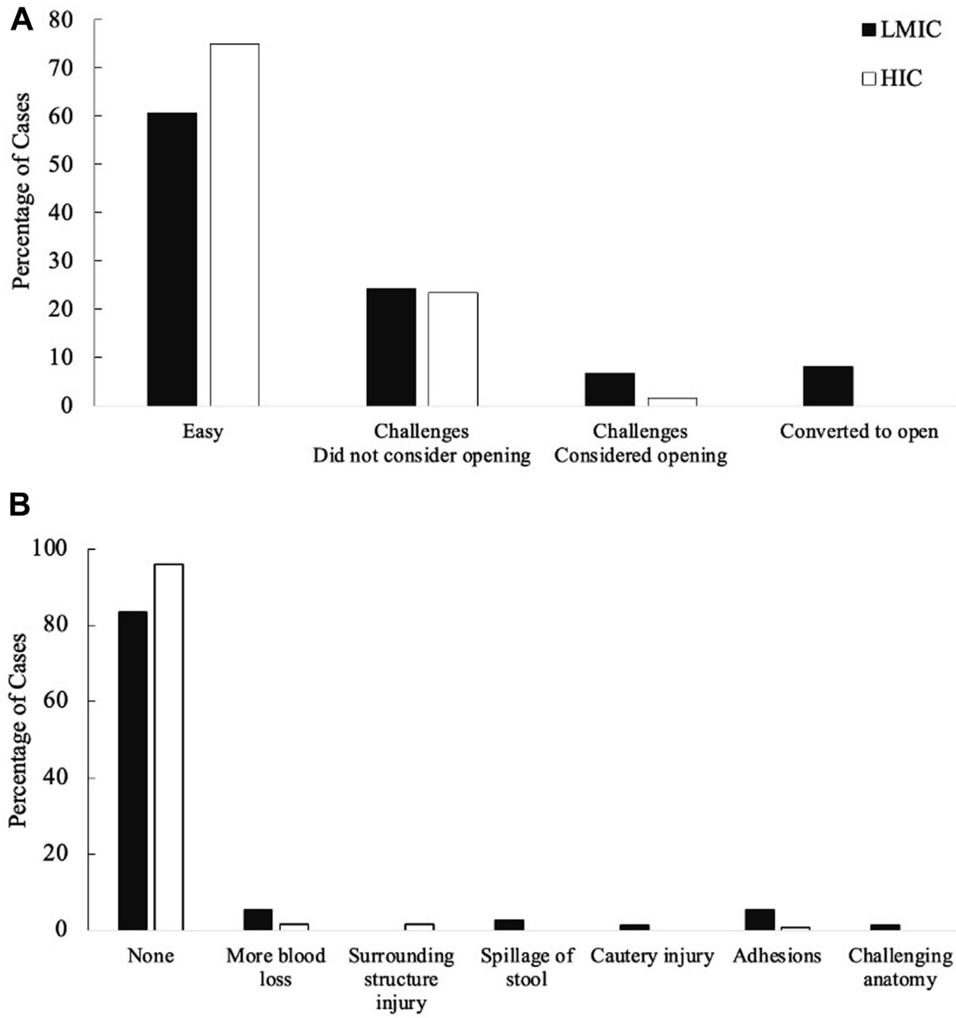

Fig. 5 – Laparoscopic outcomes. (A) Surgeons' perceived level of challenge and incidence of conversion to an open procedure. More surgeons in LMICs contemplated or opted for conversion to an open procedure ($P < 0.001$). (B) Intraoperative complications. Surgeons from LMICs reported a higher incidence of unexpected blood loss, stool spillage, and adhesions while only surgeons from HICs reported injuries to surrounding structures ($P < 0.001$).

intraoperative complications ($n = 61$, 84%; $n = 118$, 96%, respectively). More LMIC surgeons reported more than expected blood loss ($n = 4$, 5%), spillage of stool ($n = 2$, 3%), and adhesions ($n = 4$, 5%). Only HIC surgeons reported cases of injury to surrounding structures ($n = 2$, 2%; $P < 0.001$).

The survey included a free response section where surgeons shared additional insights about their experiences with laparoscopic equipment and specific cases (Table 3). Thirty-five surgeons responded with the following themes: (1) access to technology, resources, and qualified personnel, (2) maintenance and use of equipment, (3) adhesions and difficult intraoperative pathology, and (4) difficult surgical decision-making and need for training.

Access to technology, resources, and qualified personnel

Many surgeons, both from HICs and LMICs, commented on the limitations of the laparoscopic equipment available to them. The need for more advanced tools was a recurring theme. For example, one HIC surgeon noted, "It would be nice to have a ligasure with a more curved tip," while an LMIC surgeon emphasized the need for better energy sources like harmonic scalpels and advanced electrocautery devices. The lack of specific instruments, such as endoloops, forced some surgeons to use less efficient techniques. One LMIC surgeon stated, "No endo loops. Had to learn the extracorporeal Mishra and Roeder knots to snare the appendix down." The proficiency of surgical assistants varied and impacted the surgical process. An LMIC surgeon remarked, "Assistant wasn't good at holding camera," whereas another LMIC surgeon noted, "It's difficult to predict transfer of intracorporeal suturing into the under-5 pediatric population. Steep learning curve."

Maintenance and use of equipment

Equipment failures and maintenance issues were common. One LMIC surgeon reported, "The harmonic hand piece stopped working in the middle of the operation," whereas another LMIC surgeon noted, "Problems with insulation; we had to call biomedical to solve the issue."

Table 3 – Themes identified in free responses concerning operative problems encountered.

Themes	Total ($N = 35$)*			
	LMICs		HICs	
Access to technology, resources, and qualified personnel	Total	6 (17%)	Total	3 (9%)
	Cambodia	1 (3%)	Japan	-
	Malaysia	5 (14%)	Singapore	1 (3%)
	Uganda	-	The United States	2 (6%)
	Vietnam	-		
Maintenance and use of equipment	Total	6 (17%)	Total	4 (11%)
	Cambodia	-	Japan	-
	Malaysia	-	Singapore	2 (6%)
	Uganda	6 (17%)	The United States	2 (6%)
	Vietnam	-		
Adhesions and intraoperative pathology	Total	10 (29%)	Total	2 (6%)
	Cambodia	-	Japan	1 (3%)
	Malaysia	-	Singapore	1 (3%)
	Uganda	10 (29%)	The United States	-
	Vietnam	-		
Surgical decision-making or training	Total	6 (17%)	Total	-
	Cambodia	1 (3%)	Japan	-
	Malaysia	-	Singapore	-
	Uganda	5 (14%)	The United States	-
	Vietnam	-		

* Thirty-five surgeons filled in a free response about problems during the case; the total number in cells is greater than N due to surgeons stating more than one theme.

Adhesions and difficult intraoperative pathology

Surgeons frequently encountered complex cases with significant adhesions, complicating procedures. One LMIC surgeon noted, "Patient had adhesions; patient has too much pus and adhesions had to convert." Pediatric and preterm patients presented additional difficulties, as one HIC surgeon shared, "This is a preterm infant with chronic lung disease. She could not tolerate insufflation at pressure of 8 mmHg, so we had to decrease to 5 mmHg and complete surgery ASAP."

Difficult surgical decision-making and need for training

Lack of resources and training opportunities was a significant barrier in LMICs. Many surgeons emphasized the need for more training to improve outcomes. One surgeon commented, "We need more experience, equipment, and more training courses to improve our outcome." Another surgeon highlighted the steep learning curve, particularly with complex cases: "[problems were] not with equipment but was not so experienced in laparoscopy for endometriosis."

Discussion

This study leveraged international networks to compile a database of laparoscopic cases and the challenges encountered globally. Studies show that challenges specific to LMICs include the frequent need for device workarounds due to equipment scarcity and the need for more skilled personnel to maintain and repair surgical devices, often resulting in higher complication rates and operational inefficiencies.[24,25] While HICs generally benefit from better infrastructure and training, access to laparoscopic surgery can still be limited by geographic and socioeconomic factors, leading to disparities in health care access, especially in rural areas.[26,27]

Patient population and comorbidities

In this study, the patients in LMICs were often older in comparison to younger patients in HICs. HICs often have better access to pediatric health care and early diagnostic capabilities, leading to early intervention of surgical conditions in children. In LMICs, limited pediatric care may delay the diagnosis of conditions that would benefit from laparoscopic surgery.[28-30] Laparoscopic cases are often more challenging in children, as the abdominal working volume is smaller, and most LMICs do not have access to 3-mm laparoscopic instruments. Some differences seen in our study are likely due to surgeon recruitment. Although many pediatric surgeons participated in the study, they were not evenly distributed between HICs and LMICs. In addition, the pediatric surgeons from LMICs did not perform many laparoscopic cases.

Patients in this study were more likely to be female in LMICs but more likely to be male in HICs. This discrepancy could largely be influenced by the type of laparoscopic case. In LMICs, there is a growing body of literature indicating an increasing trend in laparoscopic surgeries for gynecological procedures.[31,32] This reflects a broader adoption of minimally invasive techniques for addressing common gynecological issues, as well as an emphasis on support for maternal-child health in LMICs.[33-35] In HICs, conditions such as inguinal hernias,[36] which are common indications for laparoscopic surgery, were often more prevalent in males. LMICs reported a higher percentage of hypertension in this study, which is likely attributed to the older patient demographic.

Types of case

Overall, the common laparoscopic cases were antireflux procedures, appendectomies, cholecystectomies, choledochal cysts, exploratory laparoscopies, inguinal hernia repairs, thoracic resections, and uterine surgeries. This is consistent with other studies.[37-39] There were some differences when cases were analyzed based on the surgeon's country.

Surgeons in Japan were the only providers to perform choledochal cysts and biliary atresia cases laparoscopically. While choledochal cysts are rare, Asia has a higher prevalence compared to Western populations, with more than two-thirds of the cases in Asia being reported from Japan.[40,41] This was especially evident in this study because participating surgeons from Japan belong to the leading hospital of the country in the hepato-pancreato-biliary field, which performs the largest number of laparoscopic surgeries for pediatric hepatobiliary diseases. In addition, surgeons in Uganda performed a large number of appendectomies, which is not surprising as appendicitis is one of the most common emergencies, and its incidence is increasing in Africa.[42]

Assistance for laparoscopic cases

Laparoscopic surgery usually requires an assistant, both to drive the laparoscopic camera and to provide retraction. In US teaching hospitals, this assistance is often provided by trainees, but nurses, surgical assistants, and other surgeons may also provide assistance, particularly in private practice settings. In this study, Japanese surgeons reported that most of their cases were assisted by more experienced surgeons. This is common in Japanese teaching hospitals not only among residents and fellows but also after fellowship to scrub in with their seniors to improve their skills and surgical safety further in advanced surgeries, especially for rare choledochal cysts and biliary atresia cases.[43] Conversely, in the United States, most cases were assisted by surgical residents and fellows. This aligns with the American surgical training system that expects surgeons to perform cases independently after fellowship training.[44] In LMICs, the assistance was provided by a variety of health care professionals, including other surgeons more experienced, other surgeons equally or less experienced, surgical fellows and residents, and nursing assistants, reflecting the diverse nature of surgical training and health care systems in these regions.

Intraoperative technical challenges

LMIC surgeons perceived more blood loss compared to HIC surgeons. In many LMICs, patients have delayed presentation and, subsequently, more severe pathology; LMIC surgeons are commonly presented with more difficult cases. Surgeons in Uganda reported adhesions and intraoperative pathology as making the cases more difficult. The higher incidence of untreated or poorly managed infectious diseases and higher rates of previous open surgery may also contribute to a greater prevalence of adhesions.[45] The discrepancy in blood loss could also be attributed to limited surgical tools and consumable supplies, making the case more challenging.[46-48] Similarly, LMICs reported longer case times than HICs, which may be attributed to more challenging pathology, higher incidence of adhesions, or equipment challenges.

As such, these results showed that a greater number of surgeons in LMICs experienced technical challenges and intraoperative complications during the case compared to HICs. LMICs reported a higher incidence of insufflation problems, nonavailability of a needed consumable supply, and problems with or breakage of laparoscopic instruments. As noted earlier, the lack of available replacement parts for any damaged component can lead to an entire laparoscopic system becoming nonfunctional.[49] In addition, challenges such as inconsistent electricity supply and the scarcity of essential consumables, including carbon dioxide and disposable instruments, present significant obstacles to conducting laparoscopic surgery in LMICs.[10]

LMIC surgeons trended toward thinking the case was difficult, and all the laparoscopic cases that were converted to an open procedure were from LMICs. This further emphasizes the need for training in laparoscopy, contextual-appropriate resources, and availability of working equipment so that surgeons in LMICs can be better equipped to care for challenging cases.[50,51]

Given the limited resources, insufficient training opportunities, and a high disease burden,[10] the surgical workforce shortage is particularly pronounced in LMICs.[52-54] Cambodia had four surgeons per 100,000 people in 2021.[52] In 2024, there were 250 registered surgeons in Uganda for 40 million people, with most working in Kampala.[53] In 2022, Japan reported approximately 10,300 surgeons for a population of 124 million,[55] but only 22% of hospitals had a sufficient number of surgeons, whereas 55% reported a shortage.[56] The United States had 989,320 active physicians (297 per 100,000 population) in 2022, a 5.4% increase from 2018.[57] It is currently unknown how many of these surgeons routinely practice MIS.

Limitations

This study was limited to surgeons within our social networks, and this small number of surgeons cannot adequately represent the thousands of surgeons around the world. Focusing on surgeons within a single institution in one country cannot fully represent the diversity of surgical practices and challenges across different regions and health care settings. Specifically, premier tertiary hospitals were studied, which will not accurately depict the realities faced in rural centers. Therefore, the findings may not be generalizable to all surgical contexts.

The data collection was not synchronized across all surgeons, meaning that variations in practice and technology over time were not accounted for. While the study sought to compare surgical experiences across regions, we did not control for the level of expertise or years of experience among surgeons, which may significantly impact case complexity, duration, and outcomes. For example, in the United States cohort, attending surgeons were supported by residents or fellows, but we did not capture who performed the procedure—only who assisted. In addition, estimated blood loss is a subjective measure and should be interpreted with caution, as it may vary significantly based on surgical approach and setting, further complicating direct comparisons.

Although not quantified, we observed that it was more difficult for our colleagues in LMICs to populate the database because they were seldom performing laparoscopic cases. This was due to various factors, such as emergency cases that often took priority over elective laparoscopic cases, political instability, lack of consumable supplies, and other disruptions. Furthermore, the landscape of laparoscopic surgery is evolving rapidly, which makes it challenging to accurately determine the current number of practicing laparoscopic surgeons, particularly in LMICs. This ongoing change in the field may have influenced the availability and distribution of data, potentially impacting the findings of our study.

In conclusion, this study highlights the differences in challenges with laparoscopic surgery between LMICs and HICs, underscoring the importance of addressing gaps to enhance global surgical care. We found that the types of laparoscopic cases varied by country, with Japan showing a higher frequency of biliary cases. LMIC surgeons often dealt with advanced pathology and adhesions that may lead to increased blood loss, longer procedures, and higher conversion rates to open surgery. The lack of resources, insufficient training, and limited consumable supplies in LMICs further exacerbated these challenges. In addition, the roles of surgical assistants differed significantly, with LMIC surgeons struggling to find adequate support compared to their HIC counterparts. Notably, LMIC surgeons reported issues such as instrument breakage and blood loss, whereas HIC surgeons focused on procedural efficiency. Addressing these disparities through targeted interventions to improve resources, training, and access to advanced surgical tools in LMICs will equip surgeons to perform more complicated cases, reduce health care disparities, and build long-term health care capacity.

Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jss.2025.06.024.

Disclosures

O.C.M., A.W., H.A., A.L., A.B., P.H., and R.T.S. have no conflicts of interest to disclose. J.L.M. reported grants from the National Institutes of Health during the conduct of the study and personal fees from Calla Health Foundation outside the submitted work. T.N.F. reported grants from the National Institutes of Health, Duke/Duke-NUS Pilot Project Grant, and Bass Connections at Duke University during the conduct of the study. T.N.F. and J.L.M. have PCT patent applications for the KeyScope and KeyLoop.

Funding

This project has been funded by the National Institutes of Health (grant R21 CA249696-01A1) and funding from the Duke/Duke-NUS Pilot Project Grant.

The funders had no role in the preparation, review, or approval of the manuscript and decision to submit the article for publication.

CRediT authorship contribution statement

Olivia C. McGinnis: Writing – original draft, Formal analysis. **Anne S. Wesonga:** Writing – review & editing, Data curation. **Hizuru Amano:** Writing – review & editing, Data curation. **Amos Loh:** Writing – review & editing, Data curation. **Arushi Biswas:** Writing – review & editing, Data curation. **Pierce Hollier:** Writing – review & editing, Data curation. **Robert T. Ssekitoleko:** Writing – review & editing. **Jenna L. Mueller:** Writing – review & editing. **Tamara N. Fitzgerald:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

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