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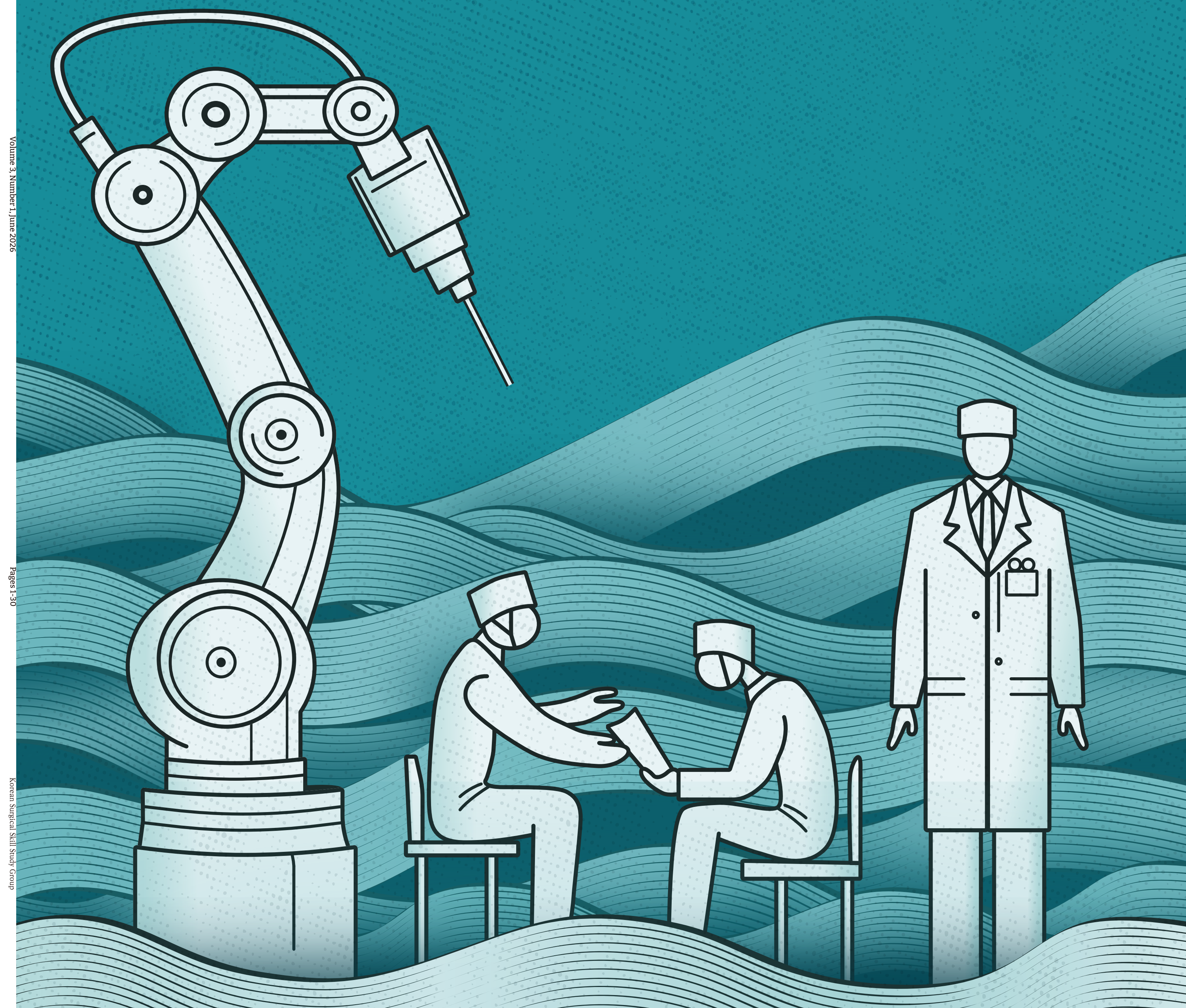

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Journal of Surgical Innovation and Education (JSIE) is an official and peer-reviewed journal of the Korean Surgical Skill Study Group. As an open-access scientific journal, JSIE is committed to promoting the transfer of cutting-edge and novel surgical techniques, as well as advancing surgical education. The journal is designed to serve as an indispensable resource for surgeons, trainees, and healthcare professionals seeking to refine their surgical practice and embrace innovation in all areas of surgery.

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- Ensure a more effective transfer of surgery-related detail and knowledge
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- Bridge the gap between traditional surgical education and the evolving demands of modern surgical practices.

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- Tutorials on essential surgical skills, catering to a range of expertise from novice to expert
- Practice and research in minimally invasive or open surgery
- Surgical endoscopy
- Other techniques in the fields of general/thoracic/traumatic/pediatric/neuro/orthopedic surgery, obstetrics, gynecology, and urology.

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Contents

Volume 3, Number 1, June 2026

How I Do It

1 Single-Incision Robotic Splenectomy Using the da Vinci SP System with an Additional Trocar
Yeongsoo Jo, Seog Ki Min

Original Articles

6 Feasibility and Competency Outcomes of a Standardized Colonoscopy Curriculum in General Surgery Residency
Dae Kyung Sohn, Sang-Ho Jeong, Seung Jae Roh, Sa-Hong Min, In-Seob Lee

14 Artificial Intelligence-Assisted Monitoring for Detecting Perioperative Safety Deviations in General Surgical Practice
Opeyemi Qozeem Asafa, Aishat Omowunmi Asafa, Ayodeji Olaolu Oyeniran, Olajide Emmanuel Babalola, Olumuyiwa Tope Ajayeoba, Roseline Olufunmilola Folami, Ganiyu Adebukola Oyeniyi, Kehinde Adesola Alatishe, Adegboyega Segun Afolabi, Ismail Idowu Uthman

Dynamic Educational Manuscript

29 Reduced-Port Robotic Distal Gastrectomy for Gastric Cancer: The Marionette Technique and Soft Coagulation Lymphadenectomy
Dongwon Lim, Si-Hak Lee, Sun-Hwi Hwang, Jae Hun Chung

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How I Do It

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Single-Incision Robotic Splenectomy Using the da Vinci SP System with an Additional Trocar

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The da Vinci SP system has been increasingly used in several surgical fields, partly because it can reduce the number of abdominal incisions by enabling surgery through a single access port. However, single-incision laparoscopic splenectomy is technically demanding because of the spleen's anatomical position and vascularity, and significant bleeding may occur without meticulous hilar and perisplenic dissection. This report describes a robotic splenectomy performed with the da Vinci SP system using a single-port-plus-one approach. A single umbilical access port was placed through an approximately 3-cm incision, and an additional trocar was inserted in the left abdomen for use by the assistant, including introduction of energy devices, a laparoscopic stapler, and a drain. We present a representative case treated using this approach. The patient was a 42-year-old woman with hemolytic anemia, hyperbilirubinemia, a body mass index of 24.2 kg/m^2, and splenomegaly measuring 15.1 cm in maximal craniocaudal diameter. The console time was 100 minutes, and the estimated blood loss was 10 mL. The splenic hilum was divided using a laparoscopic stapler. No surgical complications occurred, and the patient was discharged on postoperative day 3. Robotic splenectomy using the da Vinci SP system with an additional assistant trocar was technically feasible in this carefully selected patient. Further studies are needed to determine its safety, indications, and comparative advantages over conventional laparoscopic or multiport robotic approaches.

Keywords: Splenectomy; Robotic surgical procedures; Laparoscopy; Minimally invasive surgical procedures

Introduction

Laparoscopic splenectomy is the standard approach for elective splenectomy offering less postoperative pain, shorter hospital stay, and improved cosmetic outcomes compared with open surgery [1,2]. Conventional multiport laparoscopic splenectomy is most commonly performed, while reduced-port and single-incision laparoscopic surgery (SILS) have been introduced to further minimize access trauma [3]. Although single-port splenectomy may improve cosmesis and reduce wound-related morbidity, it remains limited by restricted instrument articulation, instrument crowding, and suboptimal ergonomics [4].

Robotic splenectomy using multiport platforms has been adopted in select centers to improve dexterity, tremor filtration, and three-dimensional visualization. However, multiport robotic approaches still require multiple incisions, potentially reducing cosmetic advantages and increasing port-site morbidity. Recently,

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single-incision and single+1 (which refers to "single-incision with an additional trocar") robotic strategies have gained attention for reducing invasiveness while maintaining robotic precision [5-8]. The da Vinci SP (Single Port) system was designed for single-site surgery and incorporates a flexible 25-mm cannula accommodating a wristed camera and three articulating instruments through a single access point. This architecture enables improved triangulation, ergonomics, and visualization in confined spaces for splenic surgery. With an auxiliary 12-mm port ("Single+1"), the assistant can introduce energy devices, suction, staplers, or retractors without negating the minimally invasive intent.

Reports of SP-based splenectomy remain scarce [9]. To our knowledge, descriptions of technical modifications and outcomes of single+1 port robotic splenectomy using the SP platform are limited. We describe our single+1 port robotic splenectomy technique using the da Vinci SP system and provide early insight into its feasibility, safety, and potential limitations for benign splenic disease.

The study was approved by the Institutional Review Board (IRB) of our institution (IRB approval no. 2025-07-078), and the requirement for informed consent was waived due to the retrospective nature of the study.

Case Presentation

Patient information

A 42-year-old woman with progressive left upper-quadrant discomfort and jaundice. She had been diagnosed with hemolytic anemia 10 years earlier without definitive therapy. Her body mass index was 24.2 kg/m^2, with no significant comorbidities. Laboratory tests showed hyperbilirubinemia (total bilirubin, 3.53 mg/dL) and mild anemia (hemoglobin, 11.9 g/dL). Contrast-enhanced computed tomography demonstrated splenomegaly, with a maximal craniocaudal diameter of 15.1 cm. A single+1 port robotic splenectomy using the da Vinci SP system (Intuitive Surgical) was planned (January 14, 2025).

Surgical technique

Under general anesthesia, the patient was placed supine. A 2.5-cm transumbilical incision was made, and a Glove port (Nelis Corp.) was inserted. The SP trocar was introduced through the port for docking. A 12-mm assistant port was placed at the level of the umbilicus along the left midclavicular line for assistant-driven instruments (energy device, suction, stapler, etc.) (Fig. 1).

The procedure followed these steps: (1) docking and positioning; (2) division of the left gastrocolic ligament with ligation/transection of accessory splenic vessels and left gastroepiploic vessels; (3) division of short gastric vessels and the gastrosplenic ligament; (4) dissection along the inferior border of the pancreas with division of the splenocolic ligament and control of splenic vessel branches; (5) isolation and stapled division of the splenic hilum; (6) division of the splenorenal and splenophrenic ligaments; and (7) hemostasis and specimen retrieval.

For steps 1 and 2, instruments were configured with a monopolar hook (3 o'clock), fenestrated bipolar forceps (9 o'clock), and Cadiere forceps (12 o'clock). The stomach was elevated sequentially (anterior then posterior

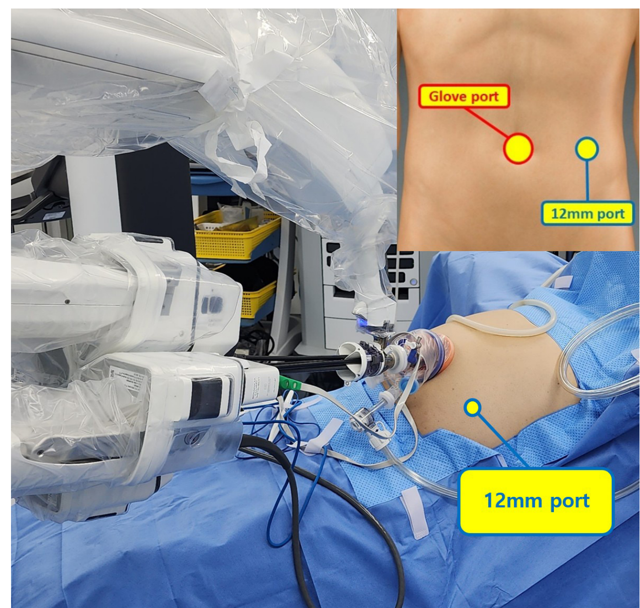

Fig. 1. Operative setup and port placement for robotic splenectomy using the da Vinci SP system with an additional assistant trocar. The da Vinci SP trocar was inserted through a 2.5-cm transumbilical incision using a Glove port, and a 12-mm assistant trocar was placed on the left midclavicular line at the level of the umbilicus. The inset schematic shows the relative positions of the umbilical SP access port and the auxiliary assistant trocar.

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wall) to expose the gastrocolic ligament and enable safe progression (Fig. 2A).

Beginning with step 3, the Cadiere forceps were repositioned to the 6 o'clock arm to improve retraction and ergonomics. Instrument selection for the 3 and 9 o'clock arms (monopolar hook, bipolar forceps, Maryland bipolar, polymer clip applier) was adjusted according to operative needs. At this stage, the stomach was retracted using the 9 o'clock arm, the gastrosplenic ligament and short gastric vessels were divided (Fig. 2B). For step 4, the pancreas or spleen was retracted using the 6 and 9 o'clock arms to secure the operative field. During step 5, isolation of the splenic hilum was facilitated, when necessary, by looping a rubber vessel loop around the hilum and retracting it. Division of the hilum was performed by the assistant through the 12-mm port using a laparoscopic linear stapler (Fig. 2C). For steps 5 and 6, adequate visualization was achieved by retracting the stomach or liver using the 9 o'clock arm (Fig. 2D). In cases where dense visceral fat or anatomical variations limited visibility, the assistant surgeon utilized the 12-mm additional port to insert a laparoscopic instrument to assist with exposure.

Total operative time was 150 minutes and console time was 100 minutes. Estimated blood loss was 10 mL, and the resected spleen weighed 232 g. There was no intraoperative conversion. The patient was discharged on postoperative day 3. No postoperative complications occurred, including no events of Clavien–Dindo grade II or higher and no postoperative pancreatic fistula requiring intervention. No transfusion was required. Postoperative vaccination was provided per institutional protocol.

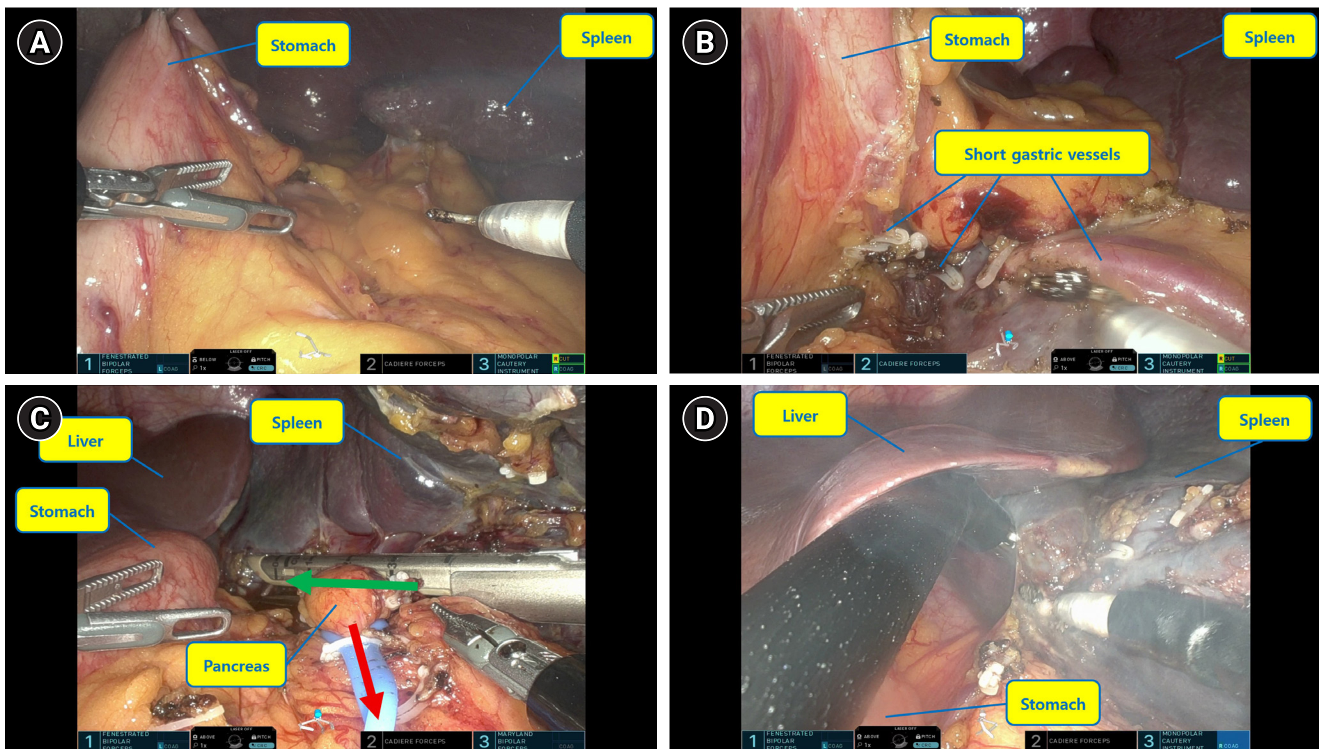

Fig. 2. (A) Exposure of the gastrocolic ligament. The stomach was sequentially elevated by grasping the anterior and posterior walls with Cadiere forceps to expose the gastrocolic ligament. (B) Division of the gastrosplenic ligament and short gastric vessels. The stomach was retracted using the 9-o'clock arm, and the short gastric vessels and gastrosplenic ligament were divided. (C) Isolation and stapled division of the splenic hilum. The splenic hilum was encircled with a rubber vessel loop to facilitate traction and define the stapling line. A laparoscopic linear stapler was introduced through the 12-mm assistant port toward the splenic hilum, as indicated by the arrow, and the hilum was divided under direct robotic visualization. (D) Exposure during the later phase of splenic mobilization. Adequate visualization was achieved by retracting the stomach or liver using the 9-o'clock arm.

Discussion

Robotic splenectomy is a valuable alternative to conventional laparoscopic approaches, offering enhanced visualization and instrument articulation. However, single-incision laparoscopic splenectomy is often constrained by instrument collision, limited triangulation, and unfavorable ergonomics, particularly around the splenic hilum. Multiport robotic platforms mitigate some of these issues but still require multiple incisions. The da Vinci SP system provides a single-site robotic platform capable of deploying a wristed camera and multiple articulating instruments through one access point, potentially improving dexterity and visualization while minimizing access trauma.

In this case, the SP system enabled stable visualization and precise dissection in a confined workspace, including safe vessel handling around the hilum. The single+1 modification was key. The auxiliary 12-mm port allowed the assistant to use suction, energy devices, staplers, and retractors, improving exposure and efficiency without compromising the minimally invasive intent. This approach may address limitations of single-site surgery, particularly in patients with visceral adiposity or complex vascular anatomy.

Compared with conventional laparoscopic splenectomy, this approach may offer improved ergonomics, stable three-dimensional visualization, and wristed articulation during dissection around the short gastric vessels and splenic hilum. Instrument collision, a limitation of conventional SILS, was not a major issue in this case because the da Vinci SP system allows articulating instruments to be deployed through a dedicated single-port cannula, while the auxiliary trocar permits independent assistant-driven suction, retraction, energy-device use, and stapler insertion. However, conventional laparoscopic splenectomy remains the standard approach in most centers because of its established safety, lower cost, wide availability, and shorter setup requirements. Compared with multiport robotic splenectomy using the da Vinci Xi system, the SP approach with an additional trocar may reduce the number of abdominal incisions, but it has several technical disadvantages, including less freedom for instrument spacing and retraction, potentially more limited exposure in challenging cases, and the lack of a dedicated robotic energy device within the SP platform. Therefore, laparoscopic energy devices or other assistant-driven instruments may be required through the auxiliary trocar. These limitations may become more relevant in patients with marked splenomegaly, visceral obesity, severe adhesions, or complex hilar anatomy. Thus, this technique should be regarded as a reduced-port strategy that balances minimal access trauma with the safety and practicality of assistant-driven maneuvers, and careful patient selection remains essential.

In conclusion, robotic splenectomy using the da Vinci SP system with an additional trocar was technically feasible in this carefully selected patient with benign splenic disease. Because this report describes a single case, the safety and effectiveness of this technique should be interpreted cautiously. Further prospective studies with larger cohorts are needed to clarify appropriate indications, technical limitations, learning curves, and comparative outcomes, including long-term results, incisional hernia rates, and patient-reported satisfaction.

Disclosure

No potential conflict of interest relevant to this article was reported.

Author contributions

Conceptualization: YJ, SKM; Data curation: YJ; Formal analysis: YJ; Investigation: YJ; Methodology: YJ, SKM; Project administration: SKM; Resources: YS; Supervision: SKM; Visualization: YS; Writing–original draft: YJ; Writing–review & editing: YJ, SKM.

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Original Article

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Feasibility and Competency Outcomes of a Standardized Colonoscopy Curriculum in General Surgery Residency

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Background: Integrating structured colonoscopy training into general surgery residency programs remains both a logistical and educational challenge. This study evaluated the feasibility and educational outcomes of a standardized colonoscopy training curriculum for surgical residents using objective competency assessments and trainee perceptions.
Methods: A retrospective mixed-methods analysis was conducted among general surgery residents who participated in a standardized colonoscopy training program between 2022 and 2025. Faculty assessed objective procedural competency using the Direct Observation of Procedural Skills framework across three domains: basic manipulation, anatomical understanding, and insertion & advancement. Trainee perceptions regarding the training environment, procedural difficulty, and perceived educational value were evaluated using a post-training survey.
Results: Objective competency data from 369 residents were analyzed. Residents demonstrated high performance in the basic manipulation and anatomical understanding domains following completion of the training program. In contrast, scores in the insertion & advancement domain were comparatively lower, suggesting greater technical difficulty. Post-graduate year (PGY)-3 residents achieved significantly higher scores than PGY-2 residents in this domain ($p=0.015$), whereas performance in the other domains was comparable between the groups. Post-training survey responses indicated that most residents considered the training duration and group size appropriate, and more than 94% reported that the program would be beneficial for their future clinical practice.
Conclusions: A standardized colonoscopy training curriculum implemented during surgical residency was feasible and was associated with high levels of competency in fundamental endoscopic skills. However, insertion and advancement techniques remained more challenging for junior trainees, suggesting that additional practice opportunities targeting complex insertion skills may improve future training programs.

Keywords: Colonoscopy; General surgery; Clinical competence; Educational measurement; Curriculum

Introduction

Proficiency in colonoscopy is an essential skill for general surgeons, as it plays a central role in colorectal cancer screening, diagnostic evaluation, and perioperative management of colorectal diseases. High-quality

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colonoscopy has been associated with improved adenoma detection and reduced colorectal cancer incidence and mortality, highlighting the importance of adequate training and procedural competence [1-3].

Traditionally, endoscopic training in surgical residency has followed an apprenticeship-based model in which trainees acquire procedural skills through supervised clinical exposure. Although experiential learning remains fundamental to procedural education, reliance on opportunistic case exposure can result in substantial variability in training experiences depending on institutional case volume, instructor availability, and local educational practices [4,5]. In recent years, medical education has increasingly adopted competency-based training frameworks that emphasize clearly defined learning objectives, structured educational interventions, and objective assessment of procedural competence [6-8].

In the field of gastrointestinal endoscopy, several professional societies have emphasized the importance of structured training programs and competency-based assessment to ensure consistent procedural quality and patient safety [9,10]. Within such frameworks, objective evaluation tools—such as structured workplace-based assessments—have been introduced to evaluate technical performance in a standardized manner and support competency-based progression in procedural training [11,12].

Despite these developments, the optimal timing for introducing colonoscopy training during surgical residency remains a subject of discussion. While early exposure to procedural training may facilitate progressive skill acquisition, limited data are available regarding the specific technical challenges encountered by residents at different stages of training. Previous studies examining colonoscopy learning curves have shown that different procedural components develop at different rates, with tasks such as scope manipulation and anatomical recognition often acquired earlier, whereas loop management and advancement through complex colonic segments may require more extensive clinical experience [13-15].

Understanding these domain-specific learning patterns is important for designing effective training curricula. In addition to objective competency assessment, trainee perceptions of the educational environment and perceived procedural difficulty can provide valuable insights into educational needs and program feasibility [16,17].

Therefore, the aim of this study was to evaluate the educational outcomes of a standardized colonoscopy training program for general surgery residents using both objective competency assessment and trainee perceptions. Specifically, this study sought to (1) analyze domain-specific procedural competency using a structured Direct Observation of Procedural Skills (DOPS)-based assessment, (2) compare competency outcomes between residents undergoing training at different stages of residency, and (3) evaluate trainee perceptions regarding the educational environment and perceived value of the training program.

Materials and Methods

Study design and participants

This retrospective mixed-methods study evaluated the educational outcomes of a standardized colonoscopy training program for general surgery residents. The study included residents who participated in the program between 2022 and 2025. Participants were categorized into two cohorts according to the timing of the training: a traditional cohort (training conducted in 2022, targeting post-graduate year [PGY]-3 residents; n=145) and an early-intervention cohort (training conducted between 2023 and 2025, targeting PGY-2 residents; n=225). Because the dataset was fully anonymized, two residents who completed the training during their PGY-3 year in the early-intervention period could not be individually identified and were therefore retained in the 2023–2025 cohort for analysis.

The study protocol was approved by the Institutional Review Board (IRB) of Asan Medical Center, Seoul, Korea (IRB No. 2026-0291).

Standardized educational intervention

The standardized colonoscopy training program was designed using a flipped-learning model to maximize the efficiency of the hands-on training session (Fig. 1). Prior to attending the practical session, all residents were required to complete a video-based pre-learning

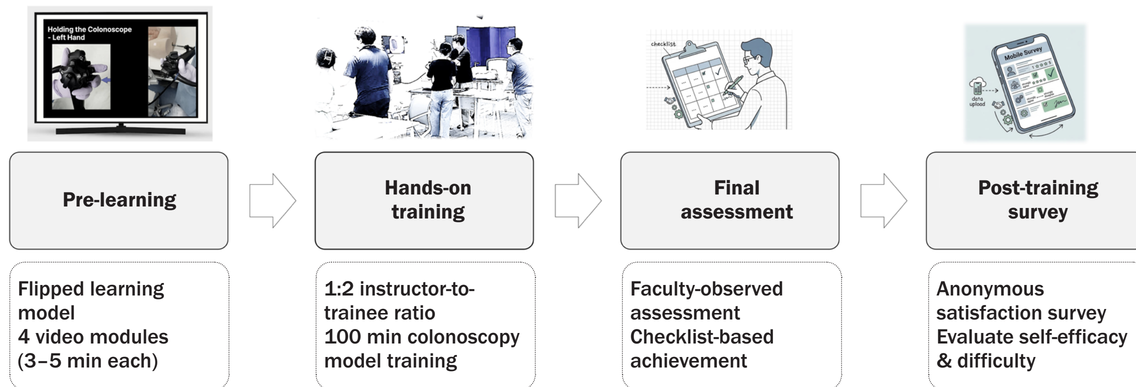

Fig. 1. Structure of the standardized endoscopy training program. Schematic illustration of the training curriculum, which consisted of four sequential components: pre-learning, hands-on training, final competency assessment, and a post-training survey.

module consisting of short instructional videos (approximately 5 minutes each). The modules covered four core topics: endoscopic system setup, basic insertion techniques, recognition of endoscopic anatomy, and documentation of key findings.

After completing the pre-learning module, residents participated in a structured half-day hands-on training session. Because the theoretical components were addressed during the pre-learning phase, the practical session focused entirely on procedural skill training under direct faculty supervision. The hands-on curriculum consisted of two dedicated training modules: 100 minutes of upper gastrointestinal endoscopy training and 100 minutes of colonoscopy training, allowing residents to practice fundamental scope manipulation, insertion techniques, and loop-reduction strategies in a supervised environment.

To ensure standardized instruction, training was conducted in small groups of six to seven residents supervised by three or four experienced instructors, maintaining an instructor-to-trainee ratio of approximately 1:2. This program was implemented as part of a standardized national training initiative for general surgery residents in Korea, supported by the Korean Surgical Society and the Korean Surgical Skill Study Group. Tutors were recommended by residency-training hospitals as faculty tutors with substantial colonoscopy experience and were selected from those who had participated in at least one tutor workshop held three times annually. The hands-on training was performed primarily using the Olympus EVIS EXERA III 290 system (Olympus), and colonoscopy simulation training was conducted using a Kyoto Kagaku colon simulator (Kyoto Kagaku Co., Ltd.). This structure allowed individualized feedback and sufficient procedural practice for each trainee.

Objective assessment (Direct Observation of Procedural Skills)

At the end of the training session, residents underwent a faculty-observed performance assessment. Procedural competency was evaluated using a structured checklist based on the DOPS framework and aligned with the program's official evaluation rubric.

The checklist was designed to reflect the sequential workflow of colonoscopy and to evaluate both technical manipulation and anatomical recognition skills. The checklist consisted of 10 task-specific items reflecting the procedural workflow of colonoscopy, including scope manipulation, anatomical recognition, and safe advancement to the cecum (Table 1). The items were grouped into three competency domains: Basic Manipulation Skills (four items), Anatomical Understanding and Documentation (two items), Insertion and Advancement Skills (four items). To improve reproducibility, the core technical components of the standardized colonoscopy training program and the corresponding DOPS-based assessment framework are summarized in Supplementary Table 1.

Each item was rated by faculty using a 3-point scale (Excellent, Satisfactory, or Needs Improvement). For

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Table 1. Assessment checklist for colonoscopy skills

Domain 1. Basic manipulation skills
Understanding the structure of the endoscopic system
Left-hand control (air, water, suction control, control wheels)
Right-hand manipulation (torque, jiggling)
Coordinated use of both hands during scope manipulation
Domain 2. Anatomical understanding & documentation
Recognition of the anatomical characteristics of each colonic segment
Image documentation of key anatomical landmarks
Domain 3. Insertion & advancement skills
Advancement through the rectosigmoid junction
Advancement through the splenic flexure
Advancement through the hepatic flexure
Successful cecal intubation

quantitative analysis, ratings were converted to numerical scores (Excellent=3 points, Satisfactory=2 points, Needs Improvement=1 point). Scores were summed within each domain to generate domain-specific performance scores. The maximum possible scores were 12 points for Basic Manipulation Skills, 6 points for Anatomical Understanding and Documentation, and 12 points for Insertion and Advancement Skills.

One resident in the 2023–2025 cohort was excluded because of missing evaluation data, resulting in a final sample of 369 residents for the objective analysis.

Subjective assessment (survey)

Following completion of the hands-on training session, participating residents completed a structured questionnaire designed to evaluate their perceptions of the training program. The survey assessed four key domains: adequacy of trainee numbers, appropriateness of training duration, perceived procedural difficulty, and perceived usefulness of the training for future clinical practice. Responses were recorded using categorical options for each item.

Statistical analysis

Continuous variables from the DOPS evaluations were expressed as mean±standard deviation (SD). Differences in mean scores between cohorts were analyzed using the independent samples t-test; Welch's t-test was applied when the assumption of equal variances was not met.

Categorical variables from the survey responses were summarized as frequencies and percentages, and differences in group distributions were assessed using the Pearson chi-square test or Fisher's exact test, as appropriate.

All tests were two-sided, and a $p<0.05$ was considered statistically significant. Statistical analyses were performed using R software (version 4.4.2; R Foundation for Statistical Computing).

Results

Baseline characteristics and study flow

As detailed in the study flow diagram (Fig. 2), a total of 370 general surgery residents were initially enrolled in the standardized colonoscopy training program. Following the exclusion of one resident due to missing objective evaluation data, the final cohort for the DOPS analysis comprised 369 residents. This included 145 residents in the 2022 traditional cohort (target PGY-3) and 224 residents in the 2023–2025 early-intervention cohort (target PGY-2). For the subjective survey analysis, after excluding three non-respondents from the 2022 cohort and retaining two unidentifiable duplicate responses in the 2023–2025 cohort due to anonymous submission, a total of 369 responses (n=142 for the 2022 cohort; n=227 for the 2023–2025 cohort) were analyzed.

Objective clinical competency (Direct Observation of Procedural Skills outcomes)

The results of the faculty-rated DOPS assessment are summarized in Table 2. Overall competency scores were high in both cohorts. There were no significant differences between PGY-3 and PGY-2 residents in Basic Manipulation Skills (10.74±1.37 vs. 10.60±1.55, p=0.380) or Anatomical Understanding and Documentation (5.63±0.70 vs. 5.54±0.81, p=0.214).

In contrast, PGY-3 residents achieved significantly higher scores in Insertion and Advancement Skills compared with PGY-2 residents (11.32±1.20 vs. 10.98±1.44, p=0.015). The total DOPS score was slightly higher in PGY-3 residents but did not reach statistical significance (27.69±2.79 vs. 27.12±3.24, p=0.071).

Across all domains, mean scores exceeded 85% of the maximum possible score in both cohorts. To provide a

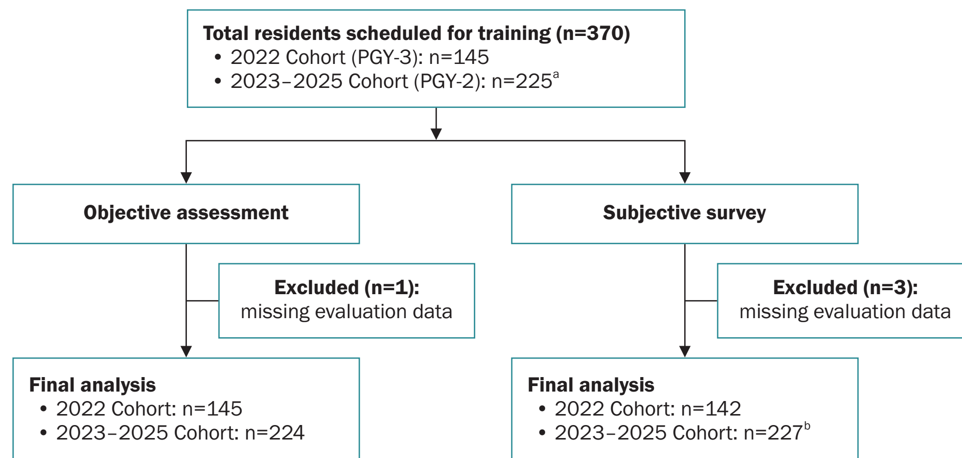

Fig. 2. Flowchart of resident participation and analysis cohorts.
PGY, post-graduate year.
[a]Includes 2 residents who completed training in PGY-3; [b]Includes 2 unidentifiable duplicate responses.

Table 2. Comparison of domain-specific colonoscopy competency scores between PGY-3 and PGY-2 residents

Competency domain	Maximum score	Mean±SD		p-value[a]
		PGY-3 (n=145)	PGY-2 (n=224)	
Basic manipulation skills	12	10.74±1.37	10.60±1.55	0.380
Anatomical understanding & documentation	6	5.63±0.70	5.54±0.81	0.214
Insertion & advancement skills	12	11.32±1.20	10.98±1.44	0.015
Total score	30	27.69±2.79	27.12±3.24	0.071

PGY, post-graduate year; SD, standard deviation.
[a]p-values were calculated using the independent t-test (Welch's t-test for unequal variances).

more granular interpretation of procedural competency, item-level results corresponding to the assessment checklist are presented in Supplementary Table 2.

Trainee perceptions of the training program

Survey responses are summarized in Table 3. Most residents in both cohorts considered the number of trainees and the duration of the training session to be appropriate. Specifically, 96.5% of PGY-3 residents and 97.4% of PGY-2 residents reported that the trainee number was appropriate (p=0.551), while 85.9% and 85.5%, respectively, reported that the training time was appropriate (p=0.731).

Regarding perceived procedural difficulty, the majority of participants rated the difficulty level as appropriate (76.8% in PGY-3 vs. 76.7% in PGY-2). However, PGY-2 residents more frequently reported the procedure as difficult compared with PGY-3 residents (22.9% vs. 19.0%), whereas PGY-3 residents more often rated the difficulty as easy (4.2% vs. 0.4%), resulting in a statistically significant difference between the groups (p=0.027).

Most residents reported that the training would be helpful for their future clinical practice (95.1% in PGY-3 vs. 94.3% in PGY-2, p=0.721).

Discussion

This study evaluated the outcomes of a standardized colonoscopy training program for general surgery residents using both objective competency assessment and trainee perceptions. Residents who participated in the training during their PGY-2 year achieved overall competency scores comparable to those of PGY-3 residents trained under the traditional model. However, domain-specific analysis revealed lower scores among PGY-2 residents in insertion and advancement skills. In

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Table 3. Trainee perceptions of the hands-on colonoscopy training program according to residency year

Survey question	Response	PGY-3 (n=142)	PGY-2 (n=227)	p-value[a]
Q1. Was the number of trainees appropriate?	Too many	5 (3.5)	5 (2.2)	0.551
	Appropriate	137 (96.5)	221 (97.4)	
	Too few	0	1 (0.4)	
Q2. Was the training time appropriate?	Insufficient	20 (14.1)	32 (14.1)	0.731
	Appropriate	122 (85.9)	194 (85.5)	
	Excessive	0	1 (0.4)	
Q3. Perceived difficulty of colonoscopy	Easy	6 (4.2)	1 (0.4)	0.027
	Appropriate	109 (76.8)	174 (76.7)	
	Difficult	27 (19.0)	52 (22.9)	
Q4. Will this training be helpful in future clinical practice?	Helpful	135 (95.1)	214 (94.3)	0.721
	Neutral	7 (4.9)	12 (5.3)	
	Not helpful	0	1 (0.4)	

Values are presented as number (%).
PGY, post-graduate year.
[a]p-values were calculated using the Pearson chi-square test.

addition, trainees from both cohorts reported high levels of acceptance of the training structure and perceived educational value. These findings provide insight into the early learning profile of surgical residents undergoing structured colonoscopy training.

The need for structured training in procedural education has been increasingly emphasized within competency-based medical education. Traditional apprenticeship-based training models rely heavily on variable clinical exposure and instructor-dependent teaching approaches, which may lead to inconsistencies in training experiences among residents [4,5]. In response, modern educational frameworks advocate clearly defined learning objectives, structured curricula, and objective workplace-based assessments to ensure consistent baseline competency [6-8]. Within endoscopy education, professional societies have similarly emphasized the importance of standardized training pathways and competency-based assessment systems to maintain procedural quality and patient safety [9,10].

The present training program was designed to address several of these educational considerations by integrating pre-learning modules, structured hands-on practice, and checklist-based competency assessment. The flipped-learning approach allowed residents to acquire foundational theoretical knowledge before attending the hands-on session, thereby enabling the practical training time to focus primarily on technical skill development. In addition, maintaining a low instructor-to-trainee ratio allowed individualized instruction and immediate feedback during procedural practice. Such educational strategies have been increasingly incorporated into procedural training programs in order to optimize learning efficiency within limited training time [18].

The domain-specific performance pattern observed in this study provides further insight into early colonoscopy skill acquisition. Residents in both cohorts demonstrated high scores in basic manipulation skills and anatomical recognition, suggesting that these competencies can be effectively introduced through structured training sessions. In contrast, lower scores were observed in insertion and advancement skills among PGY-2 residents. These procedural steps require integration of scope control, loop management, and spatial interpretation during navigation of complex colonic segments. Previous studies examining colonoscopy learning curves have consistently identified insertion and loop reduction as among the most technically demanding components of the procedure and among the last skills to be mastered by trainees [11-15,19]. The difference observed between PGY-2 and PGY-3 residents therefore likely reflects differences in cumulative procedural exposure rather than limitations of the standardized training program itself.

The high level of trainee acceptance observed in

this study also supports the feasibility of implementing structured colonoscopy training early in surgical residency. Most residents reported that the number of trainees, the duration of the training session, and the overall educational format were appropriate, and the majority perceived the program to be beneficial for their future clinical practice. Evaluations of learner perceptions are commonly incorporated into educational research because they provide insight into the perceived effectiveness and practicality of training interventions within real educational environments [16,17].

Several limitations should be considered when interpreting the findings of this study. First, the study was conducted within a single structured training program, which may limit generalizability to other educational settings. Second, the evaluation focused on procedural performance immediately following the training session, and long-term skill retention or translation into clinical practice was not assessed. Third, although a structured checklist was used for objective competency assessment, formal inter-rater reliability among faculty evaluators was not evaluated. Finally, trainee perceptions were measured using self-reported survey responses, which may be influenced by response bias.

In conclusion, a standardized colonoscopy training program implemented early in surgical residency was associated with high levels of competency across most procedural domains. While overall competency was similar between PGY-2 and PGY-3 residents, insertion and advancement skills remained more challenging for earlier trainees. These findings suggest that early structured exposure may help establish foundational endoscopic skills, while continued clinical experience and targeted practice may be required for more advanced procedural tasks.

Supplementary Materials

Supplementary Table 1. Core technical components and DOPS-based assessment framework of the standardized colonoscopy training program.
Supplementary Table 2. Item-level results of the assessment checklist for colonoscopy skills according to residency year.

Disclosure

In-Seob Lee is and editor-in-chief and Sa-Hong Min is an associate editor of the journal, but they were not involved in the evaluation or decision-making process for this article and adhered to the decision made by independent reviewers. No other potential conflicts of interest relevant to this article was reported.

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Author contributions

Conceptualization: DKS, SHJ, SJR, SHM, ISL; Supervision: DKS, SHJ, SHM, ISL; Writing–original draft: DKS, SJR; Writing–review & editing: DKS, SHJ, SJR, SHM, ISL.

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Artificial Intelligence-Assisted Monitoring for Detecting Perioperative Safety Deviations in General Surgical Practice

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Background: Perioperative safety deviations remain an important challenge in surgical care despite implementation of safety measures such as the surgical safety checklist. Emerging digital technologies, particularly artificial intelligence (AI), may provide additional support for identifying potential safety threats during surgical care. This study evaluated the usefulness of AI-assisted monitoring for identifying and helping prevent common perioperative safety deviations in routine general surgical practice.

Methods: This prospective observational study included 136 patients who underwent general surgical procedures at a tertiary hospital. Procedures included inguinal hernia repair, exploratory laparotomy, appendectomy, ventral or incisional hernia repair, excisional biopsy, and other minor surgical operations. AI-supported monitoring tools were integrated into perioperative workflows to identify potential safety deviations during operative care. Demographic characteristics, procedure types, and intraoperative safety events were recorded. The primary outcome was the frequency of safety deviations and their detection using AI support. Secondary outcomes included the proportion of identified deviations corrected before completion of surgery.

Results: Among the 136 procedures, 26 perioperative safety deviations (19.1%) were identified. The most common deviations involved incomplete checklist steps, delayed administration of prophylactic antibiotics, and discrepancies in instrument or sponge counts. AI-assisted monitoring detected 20 of the 26 deviations (76.9%), and 17 of the 20 detected deviations (85.0%) were corrected before completion of the procedure. The overall detection rate increased from 53.8% with routine observation alone to 76.9% with AI-assisted monitoring ($p=0.02$). No cases of retained surgical items or wrong-site surgery occurred during the study period.

Conclusions: AI-assisted monitoring demonstrated the potential to improve early recognition and correction of perioperative safety deviations during general surgical procedures. Integration of such systems into perioperative workflows may strengthen existing safety practices and improve detection of workflow-related safety irregularities.

Keywords: Artificial intelligence; Patient safety; General surgery; Surgical safety checklist; Perioperative safety; Digital health

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Introduction

Patient safety remains a central priority in surgical practice, yet preventable errors continue to occur in operating rooms worldwide. These events often arise from complex interactions between human factors and system limitations, including communication failures, incomplete adherence to protocols, and lapses in attention during critical steps of care. Such breakdowns may result in complications such as retained surgical items, wrong-site procedures, or delayed administration of prophylactic antibiotics, all of which can adversely affect patient outcomes [1].

Over the past two decades, structured interventions have been introduced to improve perioperative safety. Among these, the World Health Organization (WHO) Surgical Safety Checklist has become a widely adopted tool, with evidence demonstrating reductions in postoperative morbidity and mortality following its implementation [2]. Despite its effectiveness, maintaining consistent compliance in routine clinical settings remains challenging. Factors such as workload, time constraints, and variability in team communication can limit its optimal use [3].

Advances in digital technology have created new opportunities to strengthen patient safety efforts. Artificial intelligence (AI), defined as computational systems capable of learning from data and identifying patterns, is increasingly being applied in healthcare. In surgical practice, AI has been explored for applications including image interpretation, risk prediction, and workflow analysis [4]. These developments suggest that AI may provide additional support in identifying potential safety risks during operative care.

One emerging application involves the use of AI to detect deviations from expected perioperative processes. By analyzing workflow data and clinical inputs, machine learning systems can identify irregularities such as incomplete checklist execution, discrepancies in surgical counts, or delays in essential interventions [5]. Early recognition of such deviations may allow timely correction and reduce the likelihood of harm.

Although prior studies have demonstrated the feasibility of AI-based tools in controlled or specialized settings [6,7], there remains limited evidence regarding their performance in routine general surgical practice. This study was therefore undertaken to evaluate the ability of AI-assisted monitoring to identify and support correction of perioperative safety deviations during everyday surgical procedures.

Materials and Methods

Study design and setting

This prospective observational study evaluated an AI-assisted monitoring system integrated into routine perioperative workflows. It was conducted at a tertiary care teaching hospital providing elective and emergency general surgical services over a 6-month period, involving consecutive eligible patients undergoing commonly performed general surgical procedures.

Study population

The study included 136 adult patients undergoing common general surgical procedures, such as hernia repair, appendectomy, and laparotomy. Patients below 18 years, those undergoing highly specialized surgeries, or with incomplete perioperative records were excluded. Participants were enrolled consecutively during routine preoperative assessment to minimize selection bias.

Monitoring

Artificial intelligence-assisted monitoring and model development

Data sources

A locally adapted mobile perioperative monitoring platform was used during the investigation to support surveillance of perioperative safety processes within the operating room. The system was developed as an institutional pilot workflow-support framework and was not based on a commercially distributed monitoring application or a previously published independent surgical AI platform.

The framework analyzed structured perioperative clinical documentation and workflow-related information rather than continuous video monitoring or audio-visual recording. Data sources included anesthesia records, nursing documentation, surgical safety checklist

entries, medication-administration records, operative timing logs, surgical-count forms, operative notes, and standardized perioperative workflow documentation routinely completed during surgical care.

No continuous video capture, audio surveillance, facial-recognition systems, speech-analysis software, or wearable tracking technologies involving patients or healthcare personnel were employed during the study. All analyzed information originated from structured written or electronic perioperative records already incorporated into routine institutional practice.

Variables evaluated by the framework included completion of surgical safety checklist phases, timing of prophylactic antibiotic administration, verification of patient identity and operative site, completeness of perioperative documentation, reconciliation of surgical instrument and sponge counts, urgency of surgery, anesthesia category, and workflow-related timing intervals recorded during perioperative care.

Artificial intelligence architecture

The monitoring framework incorporated two integrated analytical components: a protocol-based safety-rule module and a supervised machine-learning workflow classifier. The rule-based component identified departures from predefined perioperative safety procedures, including incomplete checklist performance, delayed antimicrobial prophylaxis, and unresolved count discrepancies.

The machine-learning component utilized a random forest classification approach. This method was selected because the developmental dataset contained structured perioperative variables consisting of both categorical and numerical features. In addition, the algorithm demonstrated acceptable interpretability, computational efficiency, and relative resistance to over fitting when applied to moderate-sized clinical datasets.

The framework was designed to function as a supportive perioperative surveillance tool rather than an autonomous clinical decision-making system.

Model development

Development of the machine-learning component utilized retrospectively reviewed anonymized perioperative workflow information obtained from 412 previously completed general surgical procedures performed before initiation of the prospective phase of the study.

The developmental dataset included both routine perioperative workflows and documented perioperative safety deviations identified through institutional quality-review activities. These deviations included incomplete checklist execution, delayed or omitted prophylactic antibiotic administration, surgical-count inconsistencies, documentation deficiencies, and procedural-verification irregularities.

Prior to model training, all datasets underwent anonymization and preprocessing procedures. Incomplete workflow fields were reviewed, numerical variables were standardized where appropriate, and categorical variables were transformed into encoded computational formats suitable for analysis.

The dataset was randomly divided into training and validation subsets using an 80%–20% allocation strategy. Five-fold cross-validation was subsequently performed during developmental testing to improve model stability and reduce the likelihood of over fitting.

Performance evaluation during developmental validation included sensitivity, specificity, positive predictive value, negative predictive value, false-positive rate, false-negative rate, and area under the receiver-operating characteristic curve (AUROC) for detection of predefined perioperative safety deviations.

A classification probability threshold of 0.50 was selected during optimization procedures to balance sensitivity with acceptable alert frequency within the operating-room environment.

Workflow integration

The finalized workflow-classification model was incorporated into a mobile perioperative monitoring interface used during the observational phase of the study. The framework operated passively in the background while continuously analyzing structured perioperative workflow inputs in real time.

When predefined perioperative safety deviations or workflow abnormalities were recognized, concise automated notifications were displayed through the monitoring interface available to operating-room personnel. In selected situations requiring urgent review, supplementary audio alerts were also generated.

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Alert oversight was performed primarily by the circulating nurse, who communicated relevant notifications to appropriate members of the surgical or anesthesia teams. Following review of alerts, corrective measures were implemented where necessary, including completion of omitted checklist steps, confirmation of antibiotic administration, reconciliation of surgical counts, or correction of documentation deficiencies.

Representative examples of the mobile monitoring interface and alert notifications are presented in Fig. 1.

Ethical safeguards

The monitoring framework functioned exclusively as a supportive perioperative surveillance tool and did not independently initiate clinical interventions or replace clinical judgment. Interpretation of alerts and implementation of corrective actions remained entirely under the supervision of the surgical and anesthesia teams throughout the study period.

Conventional observation process and distinction from artificial intelligence-assisted monitoring

Routine perioperative observation within the operating room was carried out through standard team-based safety practices already established in surgical care. Monitoring responsibilities were shared among surgeons, anesthetists, scrub nurses, and circulating nurses, who supervised operative activities through direct visual assessment, verbal communication, and manual verification of safety procedures throughout surgery.

During conventional practice, Surgical Safety Checklist activities were performed verbally at the recognized perioperative phases of sign-in, time-out, and sign-out. Administration of prophylactic antibiotics was monitored manually using anesthesia documentation, operative timing records, and communication between operating room personnel. Instrument and sponge counts were conducted through routine manual counting procedures involving both scrub and circulating

Fig. 1. Representative mobile interface of the AI-assisted perioperative monitoring system.
AI, artificial intelligence.

nurses before wound closure and at the completion of surgery. Verification of patient identity, operative site, and planned procedure was also undertaken through standard pre-incision confirmation processes.

Under this conventional approach, recognition of perioperative safety deviations depended primarily on human observation, team attentiveness, communication efficiency, and clinical experience. Identification of irregularities occurred when theatre personnel noticed omissions, inconsistencies, or workflow disruptions during the procedure. Consequently, detection could vary depending on workload, fatigue, environmental distractions, or interruptions occurring within the operating room.

The AI-assisted monitoring framework differed from this approach by providing continuous automated surveillance of structured perioperative workflow information. Rather than relying solely on manual recognition of irregularities, the digital platform analyzed perioperative data inputs in real time and generated automated notifications when predefined deviations or workflow inconsistencies were identified.

An additional difference involved the timing of detection. Conventional observation frequently relied on delayed recognition during routine workflow review, whereas the AI-supported system generated immediate on-screen prompts through the mobile monitoring interface once a potential deviation was detected. This allowed earlier review and possible correction before the end of the procedure.

Importantly, the digital monitoring platform was designed to complement existing perioperative safety practices rather than replace human supervision. Clinical interpretation of alerts and all corrective decisions remained under the responsibility of the operating team throughout the study period.

Data collection and variables

Surgical team composition and clinical experience

Operations included in the study were conducted by standard multidisciplinary operating team team's routinely involved in general surgical care within the institution. These teams consisted of consultant general surgeons, surgical residents, anesthetic personnel, scrub nurses, circulating nurses, and operating-room support staff participating in both elective and emergency procedures.

Most surgical interventions were carried out under the supervision of consultant surgeons experienced in general surgery, while resident doctors assisted according to the institution's postgraduate surgical training structure. Perioperative nursing personnel participating in the study were familiar with routine theatre safety practices, including checklist implementation, operative documentation, and surgical count protocols. Anesthesia services were similarly provided by experienced anesthesia staff and supervised trainees working within established institutional perioperative guidelines.

The study did not formally categorize surgical teams according to years of professional experience or level of seniority. Nevertheless, all participating personnel routinely practiced within a tertiary teaching hospital environment where perioperative safety measures, including use of the WHO Surgical Safety Checklist, already formed part of daily surgical workflow before introduction of the monitoring system.

The influence of clinical experience on perioperative safety performance is acknowledged. Teams with greater operative experience and familiarity with operating room protocols may demonstrate stronger communication, improved workflow coordination, and better adherence to established safety measures, which could contribute to lower rates of perioperative deviations. Since operator experience was not independently analyzed in the present investigation, its possible effect on deviation frequency and detection rates remains a potential confounding factor.

Additional multicenter studies involving larger patient populations may help clarify the relationship between surgical team experience, workflow performance, and the effectiveness of AI-supported perioperative monitoring systems.

Data collection

Data were gathered using a structured proforma during the perioperative period. Recorded variables included patient demographics (age and sex), type of surgical procedure, American Society of Anesthesiologists (ASA) classification, urgency of surgery (elective or emer-

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gency), comorbid conditions, and anesthesia type. Information on perioperative safety practices was also documented, including checklist completion, timing of antibiotic prophylaxis, surgical counts, and operative documentation. Any deviation from standard safety processes was noted and categorized accordingly. The method of detection—whether identified by the AI system or routine team observation—was recorded for each event to enable comparison of detection approaches.

Definition and categorization of perioperative safety irregularities

In the present investigation, a perioperative safety irregularity was defined as any identifiable interruption, omission, or inconsistency within established perioperative safety procedures occurring during surgical care that could potentially expose the patient to avoidable risk if not recognized and corrected promptly. The term referred primarily to breakdowns in workflow processes and perioperative safety practices rather than confirmed postoperative complications or direct patient injury.

The operational definitions used in the study were adapted from established perioperative safety standards rather than independently created by the investigators. These definitions were based on principles incorporated within the Surgical Safety Checklist, institutional operating room safety protocols, and internationally accepted perioperative quality-assurance recommendations relating to checklist performance, antimicrobial prophylaxis timing, procedural verification, surgical count reconciliation, and documentation accuracy.

Perioperative safety irregularities were classified into predefined operational categories adapted from established perioperative safety standards and institutional workflow protocols. The classification framework used during the study is summarized in Table 1.

Identification of deviations was performed through structured assessment of perioperative workflow documentation and intraoperative process records. Before initiation of prospective data collection, predefined classification categories were developed using commonly recognized perioperative safety domains to improve consistency of event reporting.

Checklist-performance irregularities

This category included incomplete, omitted, or inadequately documented checklist activities occurring during the sign-in, time-out, or sign-out phases of perioperative care as recommended within established surgical safety frameworks [2].

Antimicrobial prophylaxis timing irregularities

These events involved delayed administration, omission, or administration of prophylactic antibiotics outside the recommended pre-incision interval described in recognized infection-prevention guidelines [8].

Table 1. Classification framework for perioperative safety deviations

Category	Operational definition	Reference standard
Checklist-performance deviations	Incomplete, omitted, or improperly documented checklist activities during sign-in, time-out, or sign-out phases	WHO Surgical Safety Checklist [2]
Antimicrobial prophylaxis timing deviations	Delayed, omitted, or improperly timed prophylactic antibiotic administration before incision	WHO surgical infection-prevention guidelines [8]
Surgical count inconsistencies	Unresolved discrepancies involving instrument, needle, or sponge counts during operative procedures	Standard perioperative counting protocols [9]
Documentation-related deviations	Missing, incomplete, or inconsistent perioperative documentation or workflow records	Institutional perioperative documentation standards
Procedural-verification deviations	Failure or inconsistency in confirming patient identity, operative site, or intended procedure before incision	WHO perioperative verification recommendations [2]
Additional workflow-related deviations	Other perioperative workflow disruptions considered potentially relevant to patient safety	Institutional workflow review criteria

WHO, World Health Organization.

Surgical count inconsistencies

This group included unresolved mismatches, uncertainties, or discrepancies involving surgical instruments, needles, or sponges identified during operative counting procedures [9].

Documentation-related irregularities

These consisted of incomplete, inconsistent, or absent perioperative documentation, including deficiencies involving operative notes, procedural records, or operating room workflow forms.

Procedural-verification irregularities

These events involved inconsistencies in confirmation of patient identity, intended procedure, or operative site before surgical incision according to accepted perioperative verification standards [2].

Additional workflow-related irregularities

This category captured other perioperative process disruptions considered relevant to patient safety but not fully represented within the predefined groups above.

Since the investigation focused on perioperative workflow surveillance, all identified events were analyzed as process-based safety irregularities irrespective of whether direct patient harm occurred. Minor documentation deficiencies and higher-risk perioperative concerns were therefore categorized separately using predefined operational criteria established before commencement of the study.

To improve methodological consistency, the classification framework was reviewed internally by members of the perioperative quality-improvement and surgical teams prior to implementation of the monitoring system.

Outcome measures

The primary outcome of interest was the frequency and type of surgical safety deviations identified during the procedures. Secondary outcomes included the proportion of deviations detected through AI-assisted monitoring, the rate of corrective actions taken before completion of surgery, and the overall detection rate of potential errors when AI support was available compared with routine observation alone.

Statistical analysis

Data were entered and analyzed using IBM SPSS Statistics version 26. Continuous variables, such as age and operative duration, were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages. Where appropriate, 95% confidence intervals (CIs) were calculated to describe the precision of key estimates.

To compare detection rates of perioperative safety deviations between conventional observation and AI-assisted monitoring, the chi-square test was applied. Assumptions for this test, including independence of observations and adequate expected cell counts, were considered prior to analysis. A two-sided p-value of less than 0.05 was regarded as statistically significant.

Given the exploratory nature of the study, no formal sample size calculation was performed. All eligible cases during the study period were included in the analysis.

Ethical considerations

Ethical approval for this study was obtained from the Research ethics committee of UNIOSUN Teaching Hospital (Osogbo, Osun State, Nigeria). The study protocol was reviewed and approved prior to commencement (approval No.: UTH/REC/2025/01/1472). The investigation was conducted in accordance with the principles outlined in the Declaration of Helsinki. Patient confidentiality was maintained throughout the study, and all data were anonymized prior to analysis.

Results

Patient and procedure characteristics

A total of 136 patients who underwent general surgical procedures were included in the analysis. The most common operation performed was inguinal hernia repair, accounting for 40 cases (29.4%). This was followed by exploratory laparotomy in 33 patients (24.3%) and appendectomy in 25 patients (18.4%).

Less frequently performed procedures included ventral or incisional hernia repair (18 cases, 13.2%) and excisional biopsy of superficial lesions (13 cases, 9.6%). A small subset of procedures (7 cases, 5.1%) comprised other minor operations such as abscess drainage and lymph node biopsy.

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The study population had a mean age of 43.9±14.1 years, with a slight male predominance (55.1% male's vs. 44.9% females). Most interventions were carried out electively (78.7%), while the remainder (21.3%) were performed under urgent conditions.

Assessment of baseline health status showed that the majority of patients were classified as ASA II, indicating the presence of mild systemic disease. Common comorbid conditions included hypertension and diabetes mellitus, although a considerable number of patients had no significant medical history.

General anesthesia was the most frequently employed anesthetic technique, while regional and local anesthesia were utilized in selected cases depending on procedural requirements (Table 2).

Table 2. Baseline demographic and clinical characteristics of the study population (n=136)

Variable	Value
Age (yr)	43.9±14.1
Sex	
Male	75 (55.1)
Female	61 (44.9)
ASA physical status classification	
ASA I	39 (28.7)
ASA II	68 (50.0)
ASA III	29 (21.3)
Nature of surgery	
Elective	107 (78.7)
Emergency	29 (21.3)
Type of anesthesia	
General anesthesia	82 (60.3)
Regional anesthesia	34 (25.0)
Local anesthesia	20 (14.7)
Common comorbid conditions[a]	
Hypertension	31 (22.8)
Diabetes mellitus	14 (10.3)
No major comorbidity documented	63 (46.3)
Primary surgical procedure	
Inguinal hernia repair	40 (29.4)
Exploratory laparotomy	33 (24.3)
Appendectomy	25 (18.4)
Ventral/incisional hernia repair	18 (13.2)
Excisional biopsy	13 (9.6)
Other minor procedures[b]	7 (5.1)

Values are presented as mean±standard deviation or number (%).
ASA, American Society of Anesthesiologists.
[a]Only selected common comorbid conditions are presented; other comorbidities are not shown. [b]Other procedures included abscess drainage, lymph-node biopsy, and minor soft-tissue operations.

Frequency and nature of perioperative safety deviations

Across all procedures, 26 safety deviations were documented, corresponding to an overall incidence of 19.1% (Fig. 2).

Checklist-related lapses were the most frequently encountered issue, representing 30.8% of all deviations (8 cases). Deviations involving antibiotic prophylaxis timing occurred in six cases (23.1%), while discrepancies in surgical counts were observed in five procedures (19.2%).

Other identified issues included documentation errors (4 cases, 15.4%) and procedure/site verification inconsistencies (2 cases, 7.7%). A single deviation (3.8%) was categorized under other workflow irregularities (Table 3).

Fig. 2. Distribution of perioperative safety deviations identified during general surgical procedures. The figure illustrates the relative frequency of predefined perioperative safety deviations detected during the study period, including checklist omissions, antibiotic-timing irregularities, surgical-count discrepancies, documentation deficiencies, and procedural-verification concerns.
AI, artificial intelligence.

Performance of artificial intelligence-assisted monitoring in deviation detection

The AI-based monitoring system identified 20 out of the 26 deviations, yielding a detection proportion of 76.9%.

In contrast, routine intraoperative observation by the surgical team detected 14 deviations (53.8%). The inclusion of AI support therefore resulted in a higher recognition rate of perioperative safety deviations (Fig. 3).

When examined by category, the system demonstrated strong detection capability:

Checklist omissions were identified in 87.5% of cases (7/8)

Antibiotic timing issues were detected in 83.3% (5/6)

Surgical count discrepancies were recognized in 80.0% (4/5)

The remaining six events were identified through conventional observation without AI prompts.

Table 3. Types of perioperative safety deviations detected during procedures (n=26)

Type of surgical perioperative safety deviation	Value
Incomplete surgical safety checklist steps	8 (30.8)
Incorrect or delayed antibiotic prophylaxis	6 (23.1)
Instrument or sponge count discrepancies	5 (19.2)
Documentation errors in operative records	4 (15.4)
Wrong-site/procedure verification issues	2 (7.7)
Other workflow-related safety deviations	1 (3.8)
Total	26 (100)

Values are presented as number (%).

Performance of the Monitoring System

The monitoring platform identified 20 of the 26 perioperative safety deviations recorded during the study, giving a detection rate of 76.9%. By comparison, routine perioperative observation recognized 14 deviations (53.8%), representing a significantly lower detection rate (p=0.02). Recognition was highest for checklist-related omissions, followed by antibiotic-timing deviations and surgical-count discrepancies.

Diagnostic assessment showed a sensitivity of 76.9% (95% CI, 56.4%–91.0%) and specificity of 91.8% (95% CI, 84.8%–96.2%). The positive and negative predictive values were 83.3% and 88.2%, respectively. Receiver-operating characteristic analysis produced an AUROC of 0.84 (95% CI, 0.74–0.93), indicating good ability to distin-

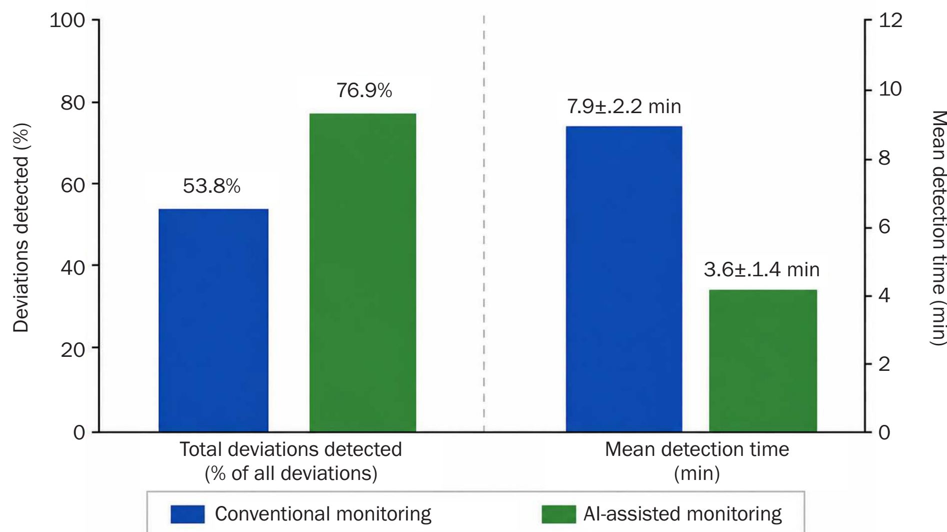

Fig. 3. Comparison between AI-assisted monitoring and conventional monitoring for detection of perioperative safety deviations. The figure compares the proportion of perioperative safety deviations identified through routine conventional monitoring and AI-assisted monitoring during the study period. AI-supported monitoring demonstrated a higher overall detection rate and shorter mean detection time compared with conventional perioperative monitoring. Total deviations detected are presented as % of 26 total deviation.

AI, artificial intelligence.

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guish between the presence and absence of predefined safety deviations.

Safety issues were generally recognized sooner when the monitoring platform was used. The mean interval from occurrence to detection was 3.6±1.4 minutes compared with 7.9±2.2 minutes during routine observation ($p<0.001$). Of the 20 deviations identified by the system, 17 were addressed before the procedure ended. Corrective actions included completion of missed checklist items, administration of overdue prophylactic antibiotics, reconciliation of count discrepancies, and correction of documentation errors. No retained surgical items or wrong-site procedures were recorded during the study period.

Clarification of detection-time measurements

In the present study, AI-assisted detection time referred to the elapsed interval between the first recorded occurrence of a perioperative workflow irregularity and the time at which the monitoring platform generated an automated alert indicating the deviation. These measurements were obtained from timestamp-based workflow logs and system-generated notification records within the mobile perioperative monitoring interface.

The term conventional detection time described the interval between the occurrence of the same perioperative irregularity and the point at which the issue was identified through routine operating-room observation by members of the surgical team. Conventional recognition depended on standard perioperative supervision carried out by surgeons, anesthetists, scrub nurses, and circulating nurses during operative care.

Timing for conventional recognition was determined using perioperative workflow records, operative documentation, nursing entries, and timestamps associated with verbal acknowledgment or corrective intervention recorded during surgery. When exact timing of verbal recognition could not be confirmed directly, the earliest documented indication of deviation recognition within the perioperative record was used for analysis.

These timing variables were included to compare the relative speed of perioperative deviation recognition between automated workflow surveillance and standard human observation. Earlier identification of workflow abnormalities was considered clinically relevant because timely recognition may permit corrective action before escalation into more significant safety-related events.

The detection-time measures applied in this investigation were developed specifically for the present workflow-monitoring analysis rather than adopted from an external validated scoring framework. Nevertheless, the conceptual basis for these measurements was informed by previous studies examining intraoperative workflow recognition, surgical process analysis, and real-time AI-supported monitoring systems.

The shorter average detection interval observed with the AI-supported framework suggests that automated perioperative workflow surveillance may facilitate earlier recognition of predefined safety-process irregularities during surgical procedures.

Intraoperative correction of Identified deviations

Among the 20 deviations detected by the AI system, 17 (85.0%) were resolved during the procedure, allowing correction before completion of surgery.

These corrective actions included:

Completion of omitted checklist steps

Timely administration of delayed antibiotics

Verification and reconciliation of surgical counts

Correction of incomplete documentation

Three deviations required postoperative documentation updates but were not associated with adverse outcomes (Table 3).

Comparison with conventional detection

The use of AI-assisted monitoring was associated with a statistically significant improvement in detection of safety deviations. Detection increased from 53.8% with routine observation to 76.9% with AI support ($p=0.02$) (Table 4).

Comparative analysis of artificial intelligence-supported surveillance and routine perioperative observation

An additional comparison was performed to examine differences between AI-supported workflow surveillance and standard perioperative monitoring carried out within the operating room. In the institutional setting of the present study, routine or conventional detection referred to the usual perioperative supervision

performed by surgeons, anesthetists, scrub nurses, and circulating nurses through direct observation, verbal communication, manual checklist confirmation, and standard workflow monitoring during operative care.

Using conventional practice alone, perioperative irregularities were recognized when operating-room personnel manually identified omissions, inconsistencies, or workflow disruptions during surgery. Consequently, detection depended heavily on human vigilance, communication efficiency, situational awareness, and operative experience.

The AI-supported framework differed by continuously evaluating structured perioperative workflow inputs and automatically generating alert notifications whenever predefined workflow abnormalities or safety-process deviations were recognized. The system therefore acted as a supplementary surveillance mechanism designed to support—rather than replace—existing perioperative safety practices.

Among the 26 documented perioperative irregularities identified during the investigation, routine observation detected 14 events (53.8%), whereas the AI-supported monitoring framework recognized 20 events (76.9%). This difference in overall recognition rate reached statistical significance ($p=0.02$) as in Table 5.

Differences between the two approaches were most apparent in relation to incomplete checklist execution and delayed antimicrobial prophylaxis, where automated alerts frequently enabled earlier review and correction before the conclusion of the procedure. From a clinical perspective, earlier recognition of workflow-related abnormalities may help reduce persistence of unresolved perioperative process failures that could potentially contribute to avoidable complications.

Although the present study did not directly evaluate postoperative morbidity or long-term patient outcomes, the findings suggest that automated perioperative workflow surveillance may improve consistency of deviation recognition during routine surgical care, particularly in busy operating-room environments where fatigue, interruptions, or communication challenges may influence human observation.

Table 4. Diagnostic performance of the AI-assisted monitoring system

Metric	Value
Sensitivity (%)	76.9 (56.4–91.0)
Specificity (%)	91.8 (84.8–96.2)
Positive predictive value (%)	83.3 (62.6–95.3)
Negative predictive value (%)	88.2 (80.7–93.6)
False-positive rate (%)	8.2 (3.8–15.2)
False-negative rate (%)	23.1 (9.0–43.6)
AUROC	0.84 (0.74–0.93)
Classification threshold	0.50
Mean AI detection time (min)	3.6±1.4
Mean conventional detection time (min)	7.9±2.2

Values are presented as estimate (95% confidence interval), threshold value, or mean±standard deviation.
AI, artificial intelligence; AUROC, area under the receiver-operating characteristic curve.

Impact on surgical workflow

The introduction of the monitoring system did not result in measurable disruption to operative processes. The average operative duration (81.6±24.3 minutes) remained consistent with standard practice within the institution.

Importantly, no major preventable intraoperative

Table 5. Comparison between AI-assisted monitoring and conventional observation for detection of perioperative safety deviations

Variable	Conventional observation	AI-assisted monitoring	p-value
Total deviations detected	14/26 (53.8)	20/26 (76.9)	0.02
Mean detection time (min)	7.9±2.2	3.6±1.4	<0.001
Checklist-related deviations detected	5/8 (62.5)	7/8 (87.5)	-
Antibiotic-timing deviations detected	3/6 (50.0)	5/6 (83.3)	-
Surgical-count discrepancies detected	3/5 (60.0)	4/5 (80.0)	-
Corrective actions completed before completion of surgery	11/14 (78.6)	17/20 (85.0)	-

Values are presented as number (%) or mean±standard deviation.
AI, artificial intelligence; -, not applicable.

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complications—including retained surgical items or wrong-site surgery—were observed during the study period.

Discussion

The present study explored the role of AI-assisted monitoring in identifying perioperative safety deviations during routine general surgical procedures. The findings indicate that deviations from established safety practices remain relatively common, even in structured operating room environments, and that AI-supported systems may enhance their recognition and timely correction. In particular, the integration of real-time monitoring into perioperative workflows was associated with a higher detection rate of safety deviations compared with conventional observation alone, as well as earlier identification of workflow irregularities.

Patient safety in surgery continues to represent a global concern, despite longstanding efforts to standardize perioperative practices. Previous research has demonstrated that a substantial proportion of surgical adverse events are preventable and often arise from system-level factors rather than isolated individual errors [1]. These factors commonly include communication breakdowns, incomplete adherence to established protocols, and coordination challenges within the surgical team. Consequently, modern approaches to improving surgical safety increasingly emphasize strengthening systems of care rather than focusing solely on individual performance.

One of the key findings of this study was the relatively frequent occurrence of incomplete surgical safety checklist execution. Since its introduction, the WHO Surgical Safety Checklist has become a cornerstone of perioperative safety initiatives. Its implementation has been associated with reductions in postoperative morbidity and mortality across diverse healthcare settings [2]. However, maintaining consistent adherence remains a challenge in routine practice. Factors such as time constraints, workflow interruptions, and team dynamics may contribute to variability in compliance. Similar observations have been reported in previous studies examining long-term checklist utilization [10,11]. In this context, AI-assisted monitoring may provide an additional safeguard by identifying missed steps and prompting their completion during ongoing procedures.

Another important category of deviation observed in this study was delayed administration of prophylactic antibiotics. Appropriate timing of antibiotic prophylaxis is a well-established strategy for reducing surgical site infections. International guidelines recommend administration within a defined interval prior to incision to ensure optimal tissue concentrations at the time of surgery [8]. Despite these recommendations, adherence to timing protocols remains inconsistent in practice. Contributing factors may include communication gaps between surgical and anesthesia teams, as well as workflow disruptions in the operating room. The ability of AI systems to track perioperative timelines and generate real-time alerts may therefore offer a practical approach to improving compliance with established guidelines.

Discrepancies in surgical counts were also identified as a notable safety concern. Retained surgical items, although uncommon, represent one of the most serious preventable complications in surgical care. Traditional counting protocols rely heavily on manual processes, which may be affected by human factors such as fatigue, distraction, or interruptions. Technological innovations, including barcode systems and radiofrequency identification, have been shown to enhance the detection of counting errors [9]. AI-assisted monitoring may further strengthen these systems by identifying irregularities in workflow patterns that suggest potential counting discrepancies. In the present study, the monitoring system successfully detected the majority of such deviations, supporting its potential role as an adjunct to existing safety measures.

An important observation from this study was the earlier detection of safety deviations when AI-assisted monitoring was used. Timely recognition of workflow disruptions is critical in preventing escalation into adverse events. Delays in detection may allow minor process deviations to evolve into clinically significant complications. AI-based systems capable of real-time analysis may enhance situational awareness within the operating room by identifying irregular patterns as they occur. Previous studies on AI in healthcare have highlighted its potential to support early risk detection and clinical decision-making [4,12]. The findings of the

present study are consistent with this perspective and suggest that AI-assisted monitoring may facilitate earlier intervention in perioperative care.

It is important to note that this study focused primarily on process-related safety indicators rather than direct clinical outcomes. While improvements in perioperative processes are often considered proxies for quality of care, their direct relationship with patient outcomes may not always be immediately measurable. Nevertheless, several of the processes evaluated—such as adherence to checklist protocols, timely antibiotic administration, and accurate surgical counts—have been linked to reductions in preventable complications in previous studies [2,8,11,13]. Therefore, improvements in these areas may reasonably contribute to better patient outcomes, although this relationship was not directly assessed in the present investigation.

The integration of AI into surgical practice also introduces important ethical and practical considerations. Issues related to data privacy, algorithm transparency, and accountability must be carefully addressed. Concerns have been raised regarding the interpretability of machine learning models, particularly those that function as “black box” systems with limited explainability [14]. Ensuring transparency and maintaining clinician oversight are therefore essential when implementing AI-based tools in healthcare. In the present study, the AI system functioned strictly as a decision-support tool, with all clinical decisions remaining under the authority of the surgical team. This approach is consistent with current recommendations that AI should augment, rather than replace, human expertise.

The monitoring platform integrated predefined protocol-monitoring rules with supervised machine-learning functions and should therefore be regarded as a hybrid exploratory workflow-surveillance system rather than an entirely autonomous AI model. Its operation depended mainly on structured perioperative data inputs and predefined safety-process indicators, without the use of advanced deep-learning methods or continuously adaptive self-learning algorithms [5,14,15].

Another important consideration is the applicability of AI technologies across different healthcare environments. Many AI systems are developed and validated in high-resource settings with advanced digital infrastructure. However, a significant proportion of surgical care globally is delivered in resource-limited environments. For AI-assisted monitoring to achieve broader impact, systems must be adaptable to varying clinical contexts. The present study, conducted in a tertiary care setting, provides preliminary evidence of feasibility, but further research is needed to evaluate implementation in diverse healthcare systems.

Several limitations should be considered when interpreting the findings of this study. First, the absence of a distinct control group limits the ability to determine the independent effect of AI-assisted monitoring. Because the system was active during all procedures, comparisons were made between AI-assisted detection and routine observation within the same cases. This design restricts causal inference and introduces the possibility of observer-related bias.

Second, the total number of documented perioperative safety deviations was relatively low. Although 136 procedures were included in the investigation, only 26 deviations were identified during the study period. This limited event frequency may affect the precision and stability of several reported performance measures, including sensitivity, specificity, predictive values, false-positive and false-negative rates, and AUROC estimates. Accordingly, these findings should be interpreted carefully, particularly because the study was exploratory in nature and developmental validation was performed using a relatively modest institutional dataset. Previous studies evaluating AI applications in surgery and clinical prediction modeling have similarly emphasized the importance of larger datasets and external validation when interpreting model-performance metrics [15-17]. Additional investigations involving larger multicenter cohorts and external validation strategies will be required to determine the reproducibility and generalizability of the reported model-performance characteristics. The relatively small number of observed perioperative safety deviations may also have limited the precision and stability of diagnostic-performance estimates.

An additional limitation concerns the validation strategy used during development of the monitoring framework. Model assessment was limited to internal validation procedures performed within the institutional dataset, including random training-validation

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partitioning and five-fold cross-validation. Independent external validation using datasets from other healthcare institutions was not conducted. In addition, neither temporal validation nor prospective adaptive retraining of the algorithm was evaluated during the study period. As a result, the extent to which the reported performance measures can be generalized to different surgical settings, institutional workflows, or patient populations remains uncertain. Prior research involving clinical machine-learning systems has consistently highlighted the importance of external validation before wider clinical application of predictive models [15-17]. Further multicenter studies using independent datasets will therefore be required to determine the reproducibility, stability, and broader applicability of the monitoring framework across diverse perioperative environments.

Third, the study was conducted in a single institution, and local workflow characteristics may influence both the occurrence of deviations and the performance of the monitoring system. Variations in surgical practices, staffing, and institutional protocols may limit generalizability. Multicenter studies would provide more robust evidence regarding the broader applicability of these findings [15,18].

Finally, the study did not evaluate patient-centered outcomes such as postoperative complications, length of hospital stay, or mortality. While improvements in process measures are encouraging, further research is required to determine whether AI-assisted monitoring leads to measurable improvements in clinical outcomes.

Despite these limitations, this study contributes to the growing body of literature on the application of AI in surgical safety. By demonstrating improved detection rates and earlier recognition of perioperative deviations, the findings support the potential role of AI as an adjunct to existing safety systems. As interest in data-driven quality improvement continues to expand, AI-assisted monitoring may become an increasingly valuable tool in enhancing surgical safety.

Future research should focus on more rigorous study designs, including controlled or randomized approaches, to better evaluate the causal impact of AI-assisted monitoring. Larger, multicenter studies will also be important in improving generalizability. In addition, evaluating the relationship between improved process measures and clinical outcomes will be essential in determining the true value of AI in surgical care.

Conclusion

AI-assisted monitoring demonstrated a promising ability to identify and help correct common safety deviations during general surgical procedures. When integrated thoughtfully into clinical workflows, AI technologies may complement existing safety strategies and support surgical teams in monitoring perioperative processes. Continued investigation and careful implementation will be essential to ensure that these tools are used effectively and responsibly in the operating room.

Disclosure

No potential conflict of interest relevant to this article was reported.

Author contributions

Conceptualization: OQA; Data Curation: OTA, GAO, KAA, ASA; Resources: OQA, AOA, ROF; Software: OQA, ROF, ASA; Writing–original draft: OQA, AOA, AOO, KAA; Writing–review & editing: OQA, AOA, AOO, OEB, OTA, ROF, GAO, KAA, ASA, IIU.

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Reduced-Port Robotic Distal Gastrectomy for Gastric Cancer: The Marionette Technique and Soft Coagulation Lymphadenectomy

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Radical gastrectomy with meticulous lymph node dissection remains the definitive treatment for gastric cancer, and ongoing technical advances continue to focus on minimizing surgical trauma while preserving oncological safety. Robotic gastrectomy provides enhanced surgical precision through three-dimensional visualization and articulated instrumentation. Because a 3–4 cm umbilical incision is required for specimen extraction, maximizing the utility of this incision to reduce the need for additional ports represents a practical surgical strategy. Reduced-port and single-port approaches have therefore been introduced to decrease postoperative pain, improve cosmetic outcomes, and reduce port-related complications. Building on this concept, reduced-port robotic distal gastrectomy (rpRDG) utilizes a “4-arms in 3-ports” configuration that maximizes the utility of the umbilical incision while reducing surgical access trauma. A major technical consideration in rpRDG is the efficient use of robotic arms. In this video article, we demonstrate the marionette technique using endoclips to avoid dedicating a robotic arm exclusively to static traction. Briefly, the target tissue is grasped using an endoclip with a pre-tied suture, after which the free end of the suture is exteriorized through the abdominal wall and secured externally with a mosquito or Kelly clamp to provide stable, hands-free gastric retraction. Alternatively, the exteriorized suture can be weighted with heavy surgical instruments, such as long Kelly clamps, rather than fixed in place with a clamp. Additional instruments may then be added incrementally as dissection proceeds, allowing gravity-assisted traction with finely adjustable tension. This approach permits all robotic arms to remain available for active dissection, thereby improving operative ergonomics. We further present a strategic operative workflow in which bipolar dissection with soft coagulation using Maryland forceps is performed for precise lymphadenectomy around major vessels, whereas a vessel sealer is used along the greater curvature to reduce operative time. Through a representative case, we illustrate the fundamental procedural steps and technical principles of rpRDG.

Chapter Summary

00:00:01 Introduction
00:00:06 Case summary
00:00:26 Port placement
00:00:34 Liver traction
00:00:57 Omentectomy
00:01:16 Lymph node station 4sb dissection
00:01:45 Lymph node station 6 dissection
00:05:51 Duodenal transection
00:06:13 Suprapancreatic lymph node dissection (stations 5, 7, 8a, 9, 11p, 12a)
00:10:36 Lesser curvature dissection (lymph node stations 1, 3)

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00:11:05 Gastric transection
00:11:31 Billroth II anastomosis
00:12:15 Petersen's space repair

Ethical approval & Patient consent

Ethical approval was obtained from the Institutional Review Board (IRB) of the Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital (IRB No. 55-2026-078), with informed consent waived due to the retrospective study design.

Disclosure

No potential conflict of interest relevant to this article was reported.

Author contributions

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6. Seo WJ, Son T, Shin H, Choi S, Roh CK, Cho M, et al. Reduced-port totally robotic distal subtotal gastrectomy for gastric cancer: 100 consecutive cases in comparison with conventional robotic and laparoscopic distal subtotal gastrectomy. Sci Rep. 2020;10:16015.
7. Wang CY, Chen YH, Huang TS. Reduced-port robotic radical gastrectomy for gastric cancer: a single-institute experience. BMC Surg. 2022;22:198.

https://doi.org/10.69474/jsie.2026.00073

JSIE Journal of Surgical Innovation and Education

Instructions for authors

Enacted June 30, 2024

GENERAL INFORMATION

Journal of Surgical Innovation and Education (J Surg Innov Educ, JSIE; pISSN 3022-9065/eISSN 3022-9073) is the official journal of the Korean Surgical Skill Study Group. Launched on June 30, 2024, with its inaugural issue as volume 1, number 1, JSIE is published biannually in English on the last day of June and December. JSIE is a peer-reviewed scientific journal dedicated to the advancement of surgical education and the dissemination of innovative surgical techniques. The journal's goal is to serve as an indispensable resource for surgeons, trainees, and healthcare professionals seeking to embrace innovation and refine their surgical practice in all surgical disciplines.

- Promote the development of innovative surgical procedures and technology.
- Ensure more effective transfer of surgery-related details and knowledge.
- Provide an immersive learning experience through high-definition surgical video demonstrations.
- Bridge the gap between traditional surgical education and the evolving demands of modern surgical practices.

JSIE publishes Original Articles, Review Articles, Short Communications, Letters to the Editor, and Editorials. This journal follows the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals (https://www.icmje.org/) in cases not described otherwise below.

MANUSCRIPT PREPARATION

1. Reporting Guidelines for Specific Study Designs

Research reports frequently omit important information. Therefore, reporting guidelines have been developed for several study designs that some journals may ask authors to follow. JSIE encourages authors to consult the reporting guidelines relevant to their specific research design. A good source of reporting guidelines is the EQUATOR Network (https://www.equator-network.org/home/) and the United States National Institutes of Health/National Library of Medicine (https://www.nlm.nih.gov/services/research_report_guide.html).

2. Article Types

The journal welcomes high-quality papers, and the following article types are considered for publication:

A. Original Articles
- Clinical Trials
- Observational Studies (cohort, case-control)
- Innovative Technology/Procedure (including video)
  - Papers in this category describe new technologies/procedures and their evaluation. Any such manuscript must report data on the benefits, efficacy, and/or safety of the technology, regardless of whether it is experimental or clinical.
- How I Do It (include video)
- Dynamic Educational Manuscripts (video tutorial)
- Reviews (including systematic reviews and meta-analyses)

B. Case Reports

C. Short Communications

D. Letters to the Editor

E. Editorials

All manuscripts submitted to JSIE must be original, not published elsewhere, except in abstract form, and should not be under consideration for publication elsewhere.

JSIE will consider manuscripts prepared according to the instructions below. Other types are also negotiable with the Editorial Board.

3. Organization of the Manuscript

A. General Requirements and Manuscript Structure

Manuscripts should be composed in clear and concise English. Authors are encouraged to strive for clarity, brevity, and precision in both information

and language.

The main body and tables should be formatted as an MS Word file (.doc, .docx). Figures must be in .jpg, .gif, .tiff, or .pdf files. Use 12-point Calibri, Arial, or Times New Roman, double-spaced, with 3.0 cm margins on all four sides. Avoid using bold, italic, or underlining within the text, except for exceptional circumstances when this is necessary for clarity. Abbreviations should be generally avoided (except for units of measurement). When used, they should be defined the first time that they appear in the manuscript. Units of measurement must conform to the International System (SI) of Units, with the following abbreviations: year(s), yr; month(s), mo; day(s), day; hours, hr; minutes, min; second(s), sec; grams, g; liters, L; meters, m; sample size, n; degrees of freedom, df; standard error of the mean, SEM; standard deviation, SD; probability, p.

All original article manuscripts except for "How I Do It", "Dynamic Educational Manuscripts", and "Reviews" should be prepared as follows:

a. Title Page

- Article type
- Full title of the manuscript. The title should be as brief as possible. A running title should also be included, not exceeding 40 characters.
- List of authors: The first and last names of each author should be given, along with their highest academic degree. Authors should fulfill the International Committee of Medical Journal Editors (ICMJE) authorship criteria (https://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html). All authors are recommended to provide an ORCID (Open Researcher and Contributor ID; to obtain an ORCID, authors can register at the ORCID web site: https://orcid.org).
- Authors' affiliations: The department and institutional affiliation for each author should be given.
- The name, address, telephone, and email of the author to whom correspondence being addressed should be provided.
- Funding information specific to this paper. For each source of funding, both the research funder and the grant number (if available) should be given.

b. Abstract

- The abstract should be structured (Background, Methods, Results, and Conclusions) and should not exceed 300 words.
- Up to six keywords from the MeSH (Medical Subject Heading) of Index Medicus should be given, separated by a semicolon.
- Abstracts for "How I Do It" and "Dynamic Educational Manuscripts" do not need to follow this structure; a free-form format is acceptable.

c. Main Text

The main text should be organized in the following order: Introduction, Materials and Methods, Results, Discussion, Disclosure, Acknowledgments, References, and Figure legends. The position of figures and tables should be indicated in the text. Tables and Figures should be prepared separately. The text should not exceed 3,500 words (excluding abstract, references, tables, figures, and legends to figures and illustrations), and there should be no more than seven tables and figures in total, if possible.

- Introduction: Briefly describe the purpose(s) of the investigation, including relevant background information.
- Materials and Methods: Describe the research plan, materials or subjects, and methods used. Explain in detail how the disease was confirmed and how subjectivity in observations was controlled. When experimental methodology is the main issue of the paper, describe the process in detail to enable a reader to recreate the experiment as precisely as possible. When quoting specific materials, equipment, or proprietary drugs, the name of the manufacturer must be given in parentheses. Generic names should be used instead of commercial names. Clearly describe the selection of observational or experimental participants (healthy individuals or patients, including controls), including eligibility and exclusion criteria and a description of the source population. Because the relevance of such variables as age,

sex, or ethnicity is not always known at the time of study design, researchers should aim for the inclusion of representative populations into all study types and at a minimum provide descriptive data for these and other relevant demographic variables.

Ensure correct use of the terms sex (when reporting biological factors) and gender (identity, psychosocial or cultural factors), and, unless inappropriate, report the sex and/or gender of study participants, the sex of animals or cells, and describe the methods used to determine sex and gender. If the study was done involving an exclusive population, for example in only one sex, authors should justify why, except in obvious cases (e.g., prostate cancer). Authors should define how they determined race or ethnicity and justify their relevance.

- Results: Results should be presented in logical sequence in the text, tables, and illustrations, and repetitive presentation of the same data in different forms should be avoided. Any data mentioned in the Methods must be presented in the Results section.
- Discussion: The results should be interpreted for readers. Emphasize new and important observations. Do not merely repeat the contents of the Results. Explain the meaning of the observations, along with relevant limitations. The answer to the purpose of the research should be connected to the results.
- Disclosures: Disclosures are required for each author, and every conflict of interest must be clearly disclosed.
- Acknowledgments: Individuals who contributed to the research but not significantly enough to be credited as authors can be acknowledged in this section.
- Author Contribution: All types of submitted articles should include the following. Enter all author contributions in the submission system during submission.

  To qualify for authorship, all contributors must meet at least one of the six core contributions by CRediT (Methodology, investigation, resources, data curation, visualization, writing), as well as at least one of the writing contributions (original draft preparation, review, and editing). Authors may also satisfy the other remaining contributions; however, these alone will not qualify them for authorship.

  Contributions will be published with the final article, and they should accurately reflect contributions to the work. The submitting author is responsible for completing this information at submission, and it is expected that all authors will have reviewed, discussed, and agreed to their individual contributions prior to manuscript submission.
- References: In the text, references should be cited with Arabic numerals in brackets, numbered in the order cited. In the References section, the references should be numbered and listed in order of appearance in the text. All references should be presented in English, including the author, title, and the name of the journal. In the References section, journals should be abbreviated according to the style used in the list of journals indexed in the NLM Journal Catalog (https://www.ncbi.nlm.nih.gov/nlmcatalog/journals). Journal titles that are not listed in the Catalog should follow the ISO abbreviation as described in Access to the LTWA (List of Title Word Abbreviations; https://www.issn.org/services/online-services/access-to-the-ltwa). If there are six or fewer authors, all the authors should be recorded, and if there are seven or more authors, "et al." should be placed after the first six authors. Please see the following recommended citation style:

  The References follow the NLM Style Guide for Authors, Editors, and Publishers (https://www.ncbi.nlm.nih.gov/books/NBK7256/) if not specified below.

  In principle, the number of references is limited to 50 for original articles. Exceptions can be made only with the agreement of the Editor.

• Journal articles

1. Jung S, Lee HS. Robotic transabdominal preperitoneal repair for bilateral obturator

hernia: a video vignette. J Minim Invasive Surg. 2024;27:40-43.
2. Yang HJ, Lee H, Kim TJ, Jung DH, Choi KD, Ahn JY, et al. A modified eCura system to stratify the risk of lymph node metastasis in undifferentiated-type early gastric cancer after endoscopic resection. J Gastric Cancer. 2024 Jan 10 [Epub]. DOI: 10.5230/jgc.2024.24.e13

• Books and book chapters
3. White ME, Choyke PL. Duplex sonography. Springer; 1988.
4. White ME, Choyke PL. Duplex sonography of the abdomen. In: Grant EG, White EM, editors. Duplex sonography. Springer; 1988. p. 129-190.

• Online sources
5. World Health Organization (WHO). World health statistics 2021: a visual summary [Internet]. WHO; 2021 [cited 2021 Feb 1]. Available from: https://www.who.int/data/stories/world-health-statistics-2021-a-visual-summary

- Tables: Present tables in consecutive order of their appearance in the main body, followed by table captions. Avoid explaining content in the tables that is already visible in figures. Ensure that the contents are presented clearly and concisely in English, allowing readers to understand the table without needing to refer to the main body. Include footnotes below the tables and define all abbreviations that are not standard in this field in footnotes. Indicate footnotes in tables in superscripts as a), b), c). Statistical values, such as standard error of the mean (SEM), should be presented. Omit vertical and horizontal lines in the tables.
- Figures: Figures include graphs or images. Authors are required to provide save each image in a separate file with either uncompressed TIFF, GIF, JPEG, or EPS format. When citing separate figures, supply captions such as “Figure 1A” and “Figure 1B.” JSIE encourages authors to use color to increase the clarity of figures. Provide brief and easy-to-read footnotes. The minimum resolution required is 300 dpi (dots per inch) or 3 million pixels, as per the Guidelines for Digital Art (http://art.cadmus.com/da/guidelines.jsp). To cite figures that have been previously published, a written consent is required, and a copy of the permission letter(s) must be attached. Figure legends should be typed double-spaced on a separate sheet at the end of the manuscript. Symbols, arrows, and letters should be used to indicate parts of illustrations. Each figure should be referred to in the text consecutively and should be numbered according in order of citation. All images must be correctly exposed, sharply focused, and prepared in files of 300 dpi or more.
- Videos: Video clips related to surgery and advanced surgical techniques can be submitted for placement on the Journal website. The video may be up to 15 minutes in duration with a maximum file size of 2 gigabytes. Video exceeding 2 gigabytes should be sent via email (support@m2-pi.com). The available video formats are Windows Media Player (.wmv), MPEG (.mpg, .mpeg), Audio Video Interleave (.avi), and QuickTime (.mov). Free video editing assistance will be provided for submitted videos. There should be no audio narration in the videos, except for Dynamic Educational Manuscripts. Only written scripts (subtitles) should be used.

B. How I Do It

Manuscripts for “How I Do It” should be organized in the following order: Title page, Abstract, Introduction, Case Presentation, Discussion, Disclosure, Acknowledgements, References, and Figure legends. The title page and abstract should meet the general requirements outlined in the section above. The position of figures and tables should be indicated in the text. Tables and Figures should be prepared separately. These should be presented as briefly as possible. Succinct articles are more likely to be accepted for publication. Manuscript should be no more than 1,000 words, with a maximum

of 10 references and 5 tables/figures in total (i.e., the total number of tables and figures and tables should not exceed 5). The title page should be the first page. The Case Presentation section should not include any detailed information that can be used to identify the patient. Only a brief clinical information should be included that is relevant to the technique or procedure described in the paper. When using specific patient information and photos the Release Form for Photographs of Identifiable Patients or consent from the patient(s) and IRB approval might be required. All information that may reveal the patient identification or the hospital, including the date, must be omitted from images. Video clips that are presented in manuscripts should not exceed 10 minutes and must meet the requirements of video materials in the "Dynamic Educational Manuscripts" category, except for audio narration. Author contribution should be stated as mentioned above in the "General Requirements" section.

C. Dynamic Educational Manuscripts (video tutorials)

Dynamic manuscripts are submitted as video articles accompanied by regular text abstracts, which will play when the hyperlink is selected. A dynamic manuscript is recommended as a way for authors to demonstrate the details of surgical skill or technology with a video and explanation.

When using specific patient information and photos, the Release Form for Photographs of Identifiable Patients or consent from the patient(s) and IRB approval might be required. All information that may reveal the patient identification or the hospital, including the date, must be omitted from images. Author contribution should be stated as mentioned above in the "General Requirements" section.

- Examples of this category could include: live demonstration or an intraoperative segment of the details of a surgical procedure/technology, a narrated educational lecture in any field of surgery, a surgical endoscopic procedure, a bed-side procedure, or a physical examination.
- References: Include no more than ten references below the chapter summary. Ensure all references follow the guideline stated in the Reference section above.
- Requirements:
- The video file resolution aspect ratio must be preferably 16:9 or alternatively 4:3.
- Video clips should not exceed 15 minutes in total.
- A high-quality audio narration in English must accompany the video. (Only for Dynamic Educational Manuscript)
- The maximum size for all files (including videos) in the submission is 2 gigabytes.
- Please submit a detailed chapter summary with time stamps and titles for key points in your video content.

Ex) 00:00:01 Introduction
00:00:10 Case summary
00:00:26 History of present illness

- Do not use any soundtrack.
- Annotation of anatomic structurestructures or a brief explanation is encouraged.

D. Review Articles

Review articles provide concise reviews of subjects important to medical researchers and can be written by an invited medical expert. Both solicited and unsolicited review articles will undergo peer review prior to acceptance.

These have the same format as original articles, but the details may be more flexible depending on the content. The length of the manuscript should not exceed 5,000 words, 100 references, and no more than seven tables and figures in total, if possible. The abstract should not exceed 300 words and must be written as one unstructured paragraph.

E. Case Reports

Manuscripts for "Case Reports" should follow the same format and submission requirements as those for "How I Do It," including organization, word limits, references, and figure/table restrictions. The required sections are: Title page, Abstract, Introduction, Case Presentation, Discussion, Disclosure,

Acknowledgements, References, and Figure Legends. However, unlike "How I Do It," video clips are not required and should not be submitted for Case Reports. All patient-identifiable information must be omitted or anonymized, and appropriate consent and IRB approval may be required for clinical images or details.

F. Short Communications

A Short Communication generally takes one of the following forms: A substantial re-analysis of a previously published article in JSIE or in another journal; a brief report on the comments and discussion of a previously published article about the surgical techniques described in the "How I Do It" or "Dynamic Educational Manuscript" types; an article that may not cover "'standard research" but that is of general interest to the broad readership of JSIE; a brief report of research findings adequate for the journal's scope and of particular interest to the community.

An abstract is required in an unstructured format. The word count of the main text should not exceed 1,000, and the total number of references is recommended to be equal to or less than 10. A submission in this category may be edited for clarity or length and may be subject to peer review at the editors' discretion.

G. Letters to the Editor

Any opinion or inquiry on a published paper can be addressed to the Editorial Board. An abstract is not required. A title page, main text, and references are required. The total number of references is recommended to be equal to or less than 5. The word count of the main text should be equal to or less than 1,500.

H. Editorials

An Editorial is usually invited by the Editorial Board. An abstract is not necessary. Title page, main text, and references are required. The total number of references is recommended to be equal to or less than 10. The word count of the main text should be equal to or less than 1,500.

MANUSCRIPT SUBMISSION AND PEER REVIEW

1. Online Submission

Submission is processed online, via the electronic manuscript management system, https://submit.jsiejournal.org. Authors are required to attach the manuscript file, copyright form, and checklists. Every document, including the manuscript and tables, must be prepared in MS Word.

Questions regarding manuscript submission may be sent to the JSIE Editorial Office.

- Tel: 070-8691-1704, 1705
- E-mail: 2008surgeryedu@gmail.com

2. Peer Review Process

Each manuscript is reviewed by at least two independent reviewers. The reviewers of the journal are recruited from various specialties related to the topic. To ensure fair reviews, the process is double-blinded. Authors are required to complete revisions requested by the editors within 4 weeks. If the revised version is not submitted within 4 weeks, the submission will be considered as withdrawn by the author.

3. Cover Letter

The cover letter should inform the editor that neither the submitted material nor portions have been published previously or are under consideration for publication elsewhere. The authors should also explain why the submitted manuscript should be reviewed and considered for publication for JSIE.

4. Feedback after Publication

If authors or readers find any errors, or contents that should be revised, a request can be made to the Editorial Board. The Editorial Board may consider an erratum, corrigendum, or retraction. If a reader submits an opinion on a published article in the form of a letter to the editor, it will be forwarded to the authors. The authors are then able to respond to the reader's letter. Both the letters to the editor and the authors' replies may also be published.

5. Article Processing Charge

There are no author submission fees or other publication-related charges. All costs for the publication process are supported by the Publisher except for English editing service. JSIE is a platinum open-access journal that does not charge author fees.

JSIE Journal of Surgical Innovation and Education

Checklist

- ☐ Authors have written the manuscript in compliance with Instructions for Authors and Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals (http://www.icmje.org) from the International Committee of Medical Journal Editors, and the Guideline of Committee on Publication Ethics (https://publicationethics.org).
- ☐ Authors have omitted names and organizations in the manuscript submitted for review.
- ☐ The title page should include the title, author(s) full name(s), written as First Name then Last Name, and the name(s) of the affiliation(s), contact information of the corresponding author(s), ORCID, and notes.
- ☐ A running title should be no more than 40 characters including spaces.
- ☐ For original articles, the abstract should be within 300 words in the structure of Background, Methods, Results, and Conclusions. For reviews articles, short communications, how I do it, and dynamic educational manuscript include an unstructured abstract of no more than 300 words.
- ☐ The abstract should be included in the manuscript, regardless of whether it is included in the submission system.
- ☐ Up to six keywords should be included (those recommended in MeSH; http://www.ncbi.nlm.nih.gov/mesh).
- ☐ Information regarding the approval of an institutional review board and obtaining informed consent should be mentioned in article.
- ☐ The number of references is limited to 50 (for original articles), 100 (for reviews), or 10 (for short communication, How I Do It, and Editorials).
- ☐ Each figure should be uploaded as a separate file and should not be included in the main text. The file name of each figure should be the figure number.
- ☐ Figures must be prepared in no less than 300 dpi.
- ☐ The video may be up to 15 minutes in duration with a maximum file size of 2 gigabytes.
- ☐ Copyright transfer form has been signed by corresponding author with the consent of all authors.
- ☐ The authors are responsible for obtaining permission from the copyright holder to reprint any previously published material in JSIE.
- ☐ A checklist for the appropriate reporting guidelines, as available on the EQUATOR website (http://www.equator-network.org/), should be uploaded along with the manuscript.

JSIE Journal of Surgical Innovation and Education

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Manuscript title: ______________________________

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The authors hereby transfer all copyrights in and to the manuscript named above in all forms and media, now or hereafter known, to the Korean Surgical Skill Study Group effective if and when the paper is accepted for publication in the *Journal of Surgical Innovation and Education*. The authors reserve all proprietary right other than copyright, such as patent rights.

Everyone who is listed as an author in this article should have made a substantial, direct, intellectual contribution to the work and should take public responsibility for it.

This paper contains works that have not previously published or not under consideration for publication in other journals.

II. Conflict of Interest Disclosure Form

All authors are responsible for recognizing any conflict of interest that could bias their work in the acknowledgments, disclosing all financial support and any other personal connections.

Please check the appropriate box below:
☐ No author of this paper has a conflict of interest, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included in this manuscript.
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These interests may include one or more of the following: employment; consultancy within the past two years; ownership interests – including stock options – in a start-up company, the stock of which is not publicly traded; ownership interest - including stock options but excluding indirect investments through mutual funds and the like - in a publicly traded company; research funding; honoraria directly received from an entity; paid expert testimony within the past two years; any other financial relationship (e.g., receiving royalties); membership on another entity's Board of Directors or its advisory committees (whether for profit or not for profit).

☐ All authors certify that the work followed the research ethics and have approved the submission of the manuscript for publication.

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