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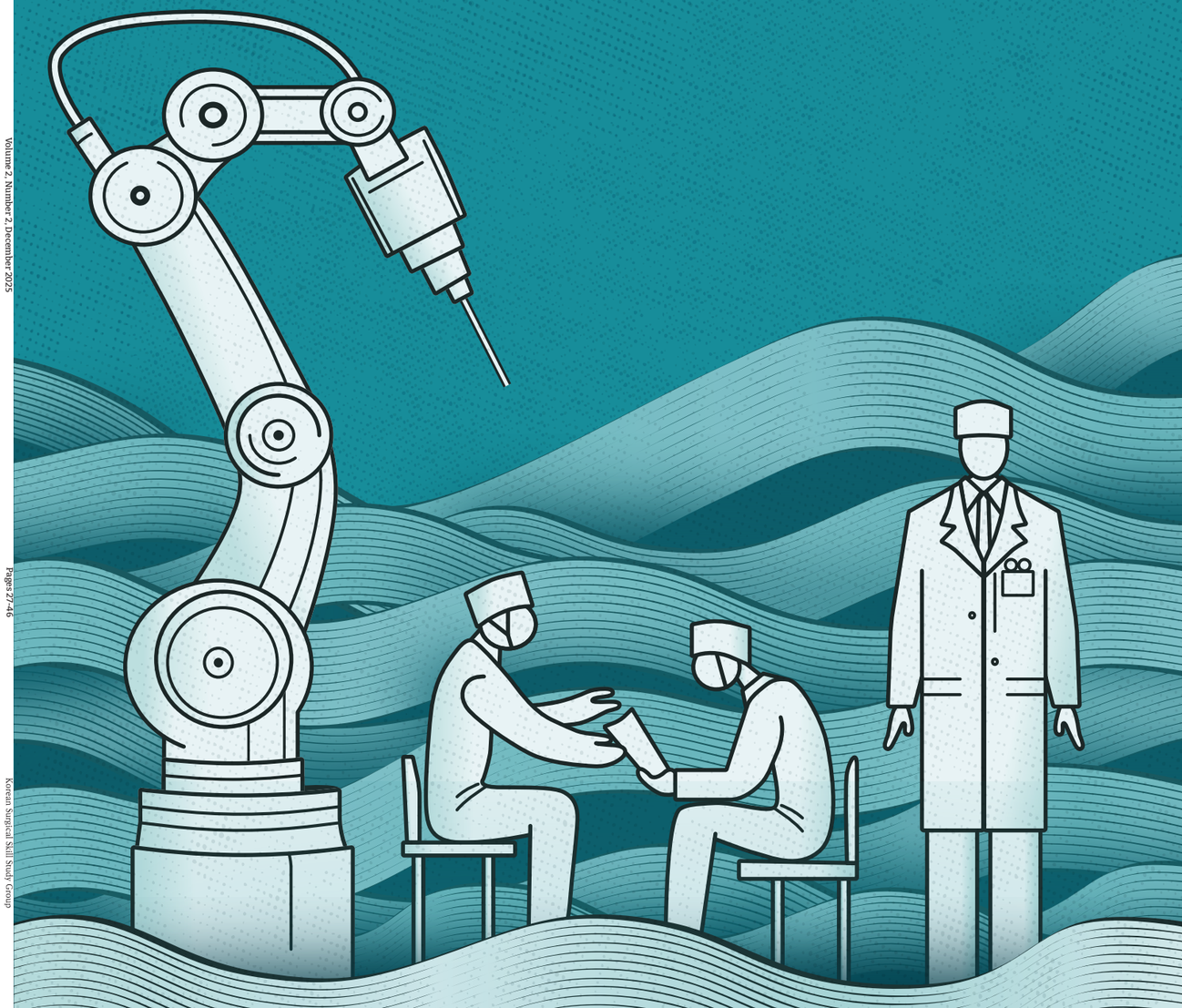

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Journal of Surgical Innovation and Education (JSIE) is an official and peer-reviewed journal of the Korean Surgical Skill Study Group. As an open-access scientific journal, JSIE is committed to promoting the transfer of cutting-edge and novel surgical 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.

JSIE aims to:
• Provide the development of innovative surgical procedure and technology
• Ensure a more effective transfer of surgery-related detail 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.

Our scope encompasses:
• Newly emerging surgical technologies and techniques
• Tutorials on essential surgical skills, catering to a range of expertise from novice to expert
• Practice and research in minimally invasive or open surgery
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High Lymph Node Dissection with Low Ligation: A Modified Technique for Left Colic Artery Preservation in Colorectal Cancer

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The optimal level of inferior mesenteric artery (IMA) ligation in colorectal cancer remains controversial. High ligation allows complete D3 lymphadenectomy but sacrifices the left colic artery (LCA), raising concerns about anastomotic ischemia. This report presents a modified low ligation technique that achieves radical D3 dissection while preserving the LCA. The technique involves complete skeletonization of the IMA root with en bloc removal of surrounding lymphatic tissue while maintaining LCA continuity. Key procedural steps include: (1) medial-to-lateral mobilization, (2) exposure of the IMA origin, (3) para-IMA lymph node dissection along the vascular sheath, (4) preservation of the LCA and autonomic plexus, and (5) distal IMA division below the LCA bifurcation. Intraoperative images illustrate the dissected nodal field and preserved vasculature. This technique enables D3-level lymph node dissection comparable to high ligation, with clear visualization of the IMA root and preserved arterial supply. Thirty-five lymph nodes, including one metastatic node, were retrieved without compromising perfusion. This modified approach balances oncologic completeness with physiologic preservation and may serve as a practical model for achieving D3 lymphadenectomy with vascular preservation.

Keywords: Colorectal neoplasms; Lymph node excision; Mesenteric arteries; Surgical procedures, Operative; Minimally invasive surgical procedures

Introduction

The level of inferior mesenteric artery (IMA) ligation in colorectal cancer surgery remains debated. High ligation (HL) at the aortic origin allows extensive D3 dissection and removal of para-IMA nodes [1], but sacrifices the left colic artery (LCA) and may increase anastomotic ischemia [2]. Low ligation (LL) preserves the LCA and physiological blood flow but may result in limited lymph node retrieval at the IMA root [1].

With open surgery and early laparoscopy, exposing the IMA origin while preserving surrounding structures was difficult [3]. Modern high-definition laparoscopy and robotic systems permit precise visualization and safer skeletonization, yet many surgeons still perform HL. This gap underscores the need for approaches that reflect current technological capabilities.

To address this, we developed a modified LL technique that enables complete D3 lymph node dissection while preserving the LCA and autonomic plexus [4].

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Case Presentation

Medial-to-lateral mobilization

The peritoneum is incised between the right common iliac artery and the IMA or sigmoid artery to enter the pelvic mesenteric plane. Cranial dissection continues beneath the IMA. The peritoneum along the right border of the inferior mesenteric vein connects upper and lower planes (Fig. 1).

Inferior mesenteric artery exposure and nerve preservation

Traction on the mesocolon exposes the IMA origin. The hypogastric plexus and autonomic nerves are preserved by maintaining the dissection anterior to the neural sheath and identifying the ureter and gonadal vessels as the lateral boundary of the safe plane, while the proximal IMA is skeletonized along the vascular sheath.

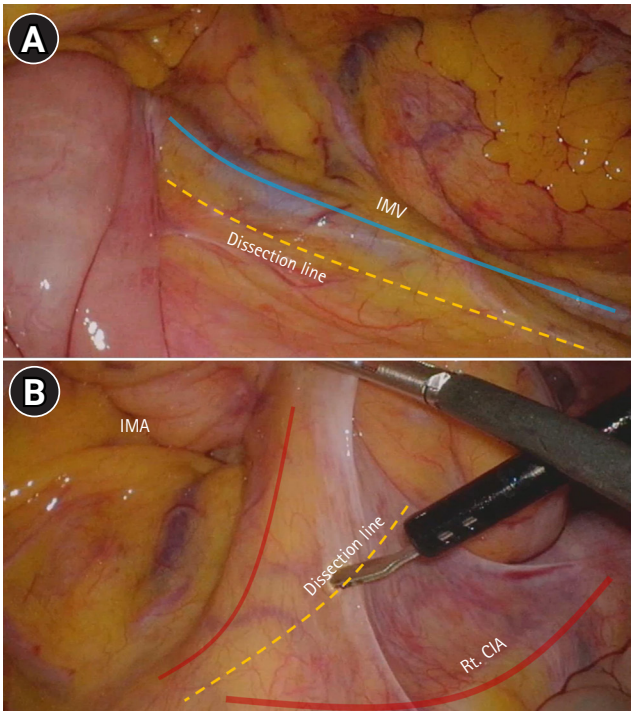

Fig. 1. Medial-to-lateral mobilization. (A) The peritoneum along the right (Rt.) border of the inferior mesenteric vein (IMV) is incised to connect the upper and lower planes, creating a continuous medial-to-lateral field. (B) The peritoneum is incised between the Rt. common iliac artery (CIA) and the inferior mesenteric artery (IMA) or sigmoid artery to enter the pelvic mesenteric plane.

Lymph node dissection

Para-IMA lymphatic tissue is removed en bloc, extending distally for full IMA skeletonization while maintaining a close posterior plane to avoid nerve injury (Fig. 2).

Left colic artery–sigmoid bifurcation and selective ligation

Complete skeletonization exposes the bifurcation. The LCA is preserved; only the sigmoid artery is ligated. Distal lymphatics along the LCA remain with the specimen (Fig. 3).

Mobilization and resection

Lateral mobilization proceeds toward the splenic flex-

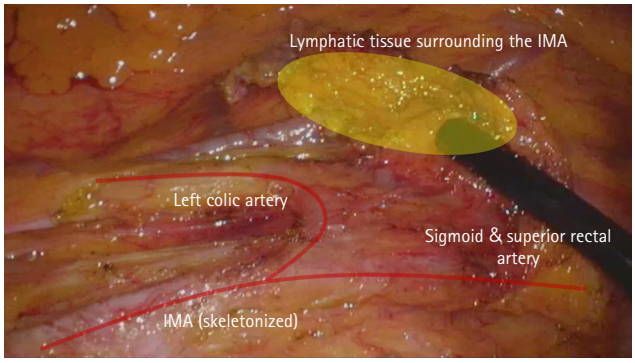

Fig. 2. Skeletonization of the inferior mesenteric artery (IMA) root. After identifying the IMA origin, lymphatic tissue is dissected en bloc along the vascular sheath while preserving the posterior hypogastric plexus.

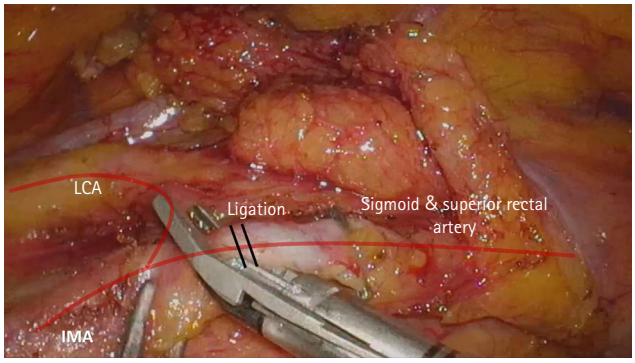

Fig. 3. Left colic artery (LCA) identification and selective ligation. Skeletonization exposes the LCA–sigmoid artery bifurcation. The LCA is preserved, and only the sigmoid artery is ligated and divided.
IMA, inferior mesenteric artery.

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ure. The specimen includes sigmoid/upper rectal mesentery and lymphatic tissue from the IMA root to the sigmoid bifurcation (Fig. 4).

Summary

This technique achieves D3 lymphadenectomy while preserving the LCA through sequential skeletonization of the IMA. Thirty-five lymph nodes were retrieved, including one metastatic, comparable to HL. The high lymph node dissection with low ligation (HD-LL) therefore provides radical oncologic clearance while maintaining physiological perfusion.

Ethical approval

This report includes non-identifiable intraoperative images; therefore, institutional review board approval was not required.

Discussion

HL enables thorough lymphadenectomy but sacrifices the LCA, increasing ischemic risk [2], whereas LL preserves blood flow but may limit lymph node clearance [1]. The HD-LL technique addresses this by enabling complete skeletonization of the IMA root and D3 lymphadenectomy while preserving the LCA and autonomic plexus [4,5].

However, preserving the LCA can reduce the mobility of the descending colon and increase anastomotic tension, which represents a practical limitation of LL.

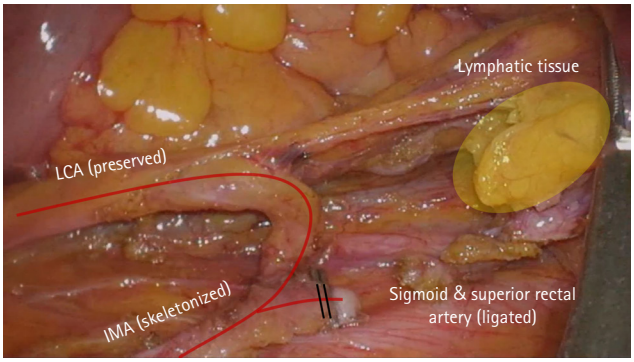

Fig. 4. Completion of the procedure. The left colic artery (LCA) is preserved, with the sigmoid and superior rectal arteries ligated. Continuous para-inferior mesenteric artery (IMA) lymphatic tissue remains attached to the specimen.

In contrast, HL can relieve mesenteric tension and facilitate a tension-free anastomosis, particularly in low rectal cancer where greater colonic reach is required. Therefore, the ligation level should be tailored to the balance between perfusion preservation and mesenteric mobility.

LL may be preferable in patients in whom preserving arterial perfusion is critical, such as those with high anastomotic leak risk. Patients with high anastomotic leak risk—such as those with corticosteroid use, smoking, diabetes, obesity, malnutrition, vascular disease, or prior neoadjuvant chemoradiation—may derive greater advantage from preserving the LCA. Conversely, when mesenteric reach is limited or tension reduction is a priority, HL may be more suitable.

The 35-node yield in our case was comparable to conventional HL [1,4], demonstrating that perfusion can be preserved without compromising oncologic completeness.

Modern laparoscopic and robotic platforms facilitate precise dissection and selective vascular preservation, shifting focus from the "height of ligation" to the "depth of dissection and anatomic precision." While promising, the technique requires adequate anatomical understanding and technical proficiency. Broader validation through multi-institutional experience will further establish its utility.

Disclosure

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

Author contributions

Conceptualization: JP, BKP; Data curation: JP, BGK, YGP; Formal analysis: JP; Investigation: JP; Methodology: JP, BGK, YGP; Project administration: BKP; Software: JP; Supervision: BKP; Validation: BGK, YGP; Visualization: JP; Writing–original draft: JP; Writing–review & editing: BGK, YGP, BKP.

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Indocyanine Green Fluorescence-Guided Enucleation via the Serosal Approach for Benign Subepithelial Tumors of the Gastroesophageal Junction

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Subepithelial tumors (SETs) located at the gastroesophageal (GE) junction remain technically challenging in minimally invasive surgery because the convergence of the esophageal sphincter, diaphragmatic hiatus, and gastric fundus creates a confined operative field. When a tumor is fully embedded within the muscular layer, its capsular margin is often indistinguishable from the serosal surface, making precise enucleation technically demanding. To address this limitation, we adopted a fluorescence-guided technique that enables accurate intraoperative localization of the tumor through indocyanine green (ICG) injection. After induction of anesthesia, approximately 0.1–0.2 mL (0.05–0.1 mg) of ICG diluted in normal saline is injected endoscopically into the submucosal plane at the tumor site for benign SETs. During surgery, near-infrared visualization provides a distinct fluorescent margin that guides safe serosal incision and enucleation while preserving the mucosa and the anatomy of the GE junction. This technique is particularly useful for benign, well-encapsulated lesions such as leiomyoma or ectopic pancreas, where clear dissection planes can be preserved. However, it should not be used for lesions with any suspicion of gastrointestinal stromal tumor or other malignant potential, because capsular or intratumoral injection may pose a theoretical risk of tumor cell dissemination. Careful peritumoral submucosal injection that avoids capsular disruption may be cautiously considered. In selected benign tumors, ICG-guided serosal enucleation provides clear localization, facilitates complete resection, and minimizes both functional and structural complications at the GE junction.

Keywords: Gastrointestinal stromal tumors; Esophagogastric junction; Indocyanine green; Optical imaging; Laparoscopy; Minimally invasive surgical procedures

Introduction

Subepithelial tumors (SETs) located at the gastroesophageal (GE) junction represent one of the most technically challenging entities in minimally invasive gastric surgery. Standard procedures such as wedge resection carry a high risk of GE stricture, while enucleation increases the risk of leakage and mucosal injury, particularly for tumors originating from the muscularis propria with limited serosal exposure [1].

Fluorescence-guided surgery using indocyanine green (ICG) has recently emerged as a valuable adjunct for intraoperative visualization. Although ICG is widely used for perfusion assessment and lymphatic mapping,

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its selective injection near benign, encapsulated lesions such as insulinomas has also been shown to enhance tumor localization [2].

Gastric SETs encompass various entities, including gastrointestinal stromal tumors (GISTs), leiomyomas, schwannomas, and ectopic pancreas. While not suitable for all cases due to oncological concerns, ICG-guided enucleation may represent a useful option for benign, well-encapsulated tumors [3].

Herein, we describe our experience with ICG-guided serosal enucleation for benign SETs at the GE junction, which enables precise tumor localization and safe resection while preserving mucosal integrity and sphincter function.

Case Presentation

A 37-year-old female presented with intermittent abdominal discomfort. Esophagogastroduodenoscopy (EGD) performed 2 years earlier had revealed a small SET at the GE junction, which showed interval growth on follow-up EGD and abdomen computed tomography (3.6×1.8 cm). The lesion demonstrated homogeneous enhancement without ulceration, consistent with a leiomyoma. The patient underwent laparoscopic ICG-guided serosal approach enucleation (Video). After induction of anesthesia and before surgical draping, an intraoperative endoscopy was performed to confirm the lesion location and assess its endoluminal characteristics. In cases where the lesion is strongly suggestive of benign pathology—such as leiomyoma or ectopic pancreas, as in the present case—a small amount of ICG (approximately 0.1–0.2 mL, corresponding to 0.05–0.1 mg diluted in normal saline) is injected directly into the tumor. Although, in theory, the ideal approach would be to position the needle within the potential space between the capsule and the tumor, this is technically unrealistic because the true capsule is extremely thin and cannot be reliably visualized endoscopically. Therefore, in practical application, gently puncturing the tumor surface and injecting ICG intratumorally allows the dye to spread into the potential space between the capsule and the tumor. On laparoscopic near-infrared imaging, the capsule then becomes clearly delineated from the surrounding tissue, enabling successful enucleation of the tumor. In this case, a small mucosal defect was identified after enucleation and repaired with interrupted primary sutures, followed by continuous barbed suture closure of the seromuscular layer. Intraoperative endoscopy was used to check the GE junction for narrowing or bleeding, while an air leak test was performed laparoscopically. No air leakage was detected. The final pathology confirmed leiomyoma. The patient resumed oral intake on postoperative day 1 and was discharged on day 3 without complications. This study was approved by the Institutional Review Board (IRB) of Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea (approval number: KC25ZISI0817). The requirement for written informed consent was waived by the IRB because this single-patient case report used only anonymized data.

Discussion

Management of GE-junction SETs demands a balance of oncologic safety, functional preservation, and technical feasibility within a very restricted operative field. To address these challenges, various approaches—including laparoscopic transgastric enucleation [4], laparoscopic transgastric resection [5], and laparoscopic-endoscopic cooperative surgery [6]—have been described, although no standardized method has been established [7].

Serosal enucleation has emerged as a compelling alternative in appropriately selected patients. By preserving the gastric contour and maintaining mucosal and junctional integrity, this technique offers the promise of functionally superior outcomes [8]. However, a significant limitation remains: many SETs—particularly those originating from the muscularis propria—are deeply embedded and lack the external bulging necessary for visual identification. In such cases, blind dissection may increase the risk of mucosal perforation, incomplete resection, or altered junctional mechanics. Recent studies underscore this challenge in GE junction SETs, noting the heightened technical demands in achieving safe and effective enucleation at this location.

Fluorescence-guided surgery using ICG offers real-time demarcation of the capsular plane without disrupting the lesion. Selection submucosal injection at peritumoral or tumor site has been shown to improve

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intraoperative localization in benign, well-encapsulated tumors such as insulinoma, without oncologic signal for harm; by diffusing along loose connective tissue, ICG highlights dissection planes and may reduce unnecessary muscular injury [2,9,10].

However, this technique must be applied with caution: in lesions where malignancy cannot be excluded, injection into the capsule or tumor parenchyma remains contraindicated due to the theoretical risk of tumor cell dissemination. Therefore, this technique was applied to SETs that were histologically confirmed as benign through preoperative EGD- or endoscopic ultrasound (EUS)-guided biopsy, or strongly suspected to be benign based on EUS and/or computed tomography findings, such as leiomyoma or ectopic pancreas [3]. In cases of GISTs or lesions with malignant potential, a peritumoral submucosal injection—similar to the technique used for ICG lymphography during gastric cancer surgery—could be considered. Even a small-volume injection at the submucosal plane provides sufficient fluorescence to localize the tumor intraoperatively without compromising oncologic safety. Although not applicable to the present case, we have previously encountered situations where very small or flat lesions were not readily identifiable from the serosal surface; in those instances, peritumoral submucosal injection allowed accurate localization and facilitated safe enucleation.

Nevertheless, from a technical perspective, ICG-guided serosal enucleation delivers several advantages. It enhances visualization of deeply embedded lesions without serosal bulging, facilitates capsular-plane dissection for complete enucleation with minimal tissue injury, and helps preserve mucosal and junctional integrity, reducing leakage or stricture. In narrow GE junction, the technique enables safe closure with tension-free barbed suture techniques that further supports functional preservation.

In conclusion, ICG-guided serosal enucleation offers a practical, safe, and function-preserving surgical option for benign GE-junction SETs. Combining endoscopic ICG injection with near-infrared imaging enables accurate localization and complete resection while preserving junctional anatomy. Going forward, prospective studies will be essential to refine technique parameters and evaluate short and long-term outcomes.

Disclosure

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

Author contributions

Conceptualization: JHP, HSS, HHL; Data curation: JHP, SK; Resources: SK, HSS, KYS, HHL; Formal analysis: JHP; Investigation: JHP; Methodology: JHP, HSS, HHL; Supervision: KYS, HHL; Visualization: JHP; Writing–original draft: JHP; Writing–review & editing: JHP, SK, HSS, KYS, HHL.

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Laparoscopic Inguinal Hernia Repair in Female Pediatric Patients

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Laparoscopic inguinal hernia repair (LIHR) has become a widely adopted surgical approach for pediatric inguinal hernia because it offers superior visualization and enables simultaneous assessment of the contralateral side. An 8-month-old female infant presented with a spontaneously reducing bulge in the right inguinal region, most noticeable during diaper changes. Physical examination revealed an easily reducible inguinal mass that was palpably firm and spherical, raising strong suspicion for ovarian inclusion. A positive silk glove sign was also identified on the contralateral side. Under general anesthesia, a three-port laparoscopic technique was used, consisting of a 5-mm umbilical port and two 3-mm working ports. The peritoneum and gubernaculum were carefully dissected from surrounding structures using electrocautery before sac closure, a step performed to minimize the risk of recurrence. Both the symptomatic right hernia sac and the asymptomatic contralateral patent processus vaginalis, which was visually confirmed intraoperatively, were closed using an intracorporeal purse-string high ligation with absorbable sutures. Three-port LIHR with meticulous dissection of the peritoneum and gubernaculum represents an effective and definitive technique for pediatric inguinal hernia repair. This approach allows simultaneous bilateral repair and is associated with excellent postoperative recovery, supporting its continued use as a primary surgical method.

Keywords: Inguinal hernia; Laparoscopy; Inguinal canal

Introduction

The cumulative incidence of inguinal hernia from birth to 15 years of age has been reported as 6.62% in boys and 0.74% in girls in a nationwide cohort study with incarceration rate around 1%–2% [1]. While traditional open herniorrhaphy remains an established approach, laparoscopic techniques have increasingly gained acceptance since the pioneering work by Esposito and Montupet [2] in the mid-1990s.

Laparoscopic inguinal hernia repair (LIHR) is now widely applied and has become a major surgical approach due to several reported advantages over open surgery, including superior visualization of the inguinal anatomy, minimal invasiveness and excellent cosmesis, and the ability to assess and simultaneously repair a contralateral patent processus vaginalis (PPV) [3].

This report details the three-port technique, which currently remains one of the most commonly practiced methods for this procedure.

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Case Presentation

Patient

An 8-month-old female infant presented to our outpatient clinic. One week prior to the visit, the patient's parents had noticed a bulging, protruding mass in the right inguinal region. They reported that the mass protruded when the infant cried but subsequently reduced spontaneously. The patient was initially taken to a local pediatric clinic where an inguinal hernia was suspected, leading to a referral to our pediatric surgery department.

On physical examination, a bulging, protruding mass was clearly visible in the right inguinal region. When the patient was laid supine on the examination bed, the mass was easily reducible. Palpation of the contralateral side revealed no evidence of herniation; however, a positive silk glove sign was noted. The patient was scheduled for an elective LIHR and was subsequently discharged home.

Surgical procedure

The procedure was initiated under general anesthesia. An open technique was used to insert a 5-mm infra-umbilical port for the introduction of a 5-mm flexible scope. Subsequently, two working ports were placed: two 3-mm trocars were inserted at the right and left midclavicular lines lateral to the umbilicus (Fig. 1). In infants and small babies, the working ports were positioned more caudally than the umbilical level to facilitate optimal instrument maneuverability.

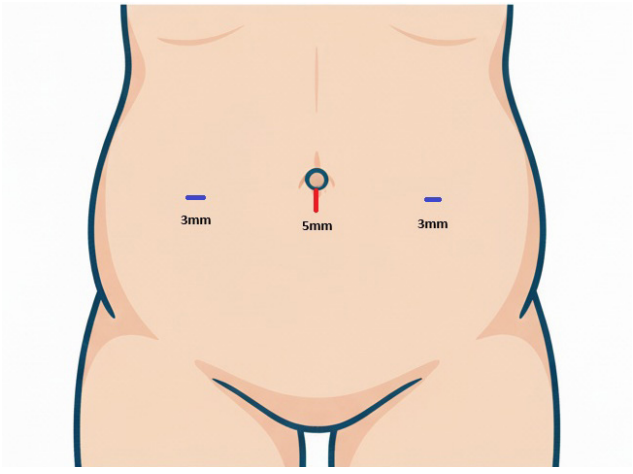

Fig. 1. The size and position of laparoscopic ports applied in pediatric laparoscopic inguinal hernia repair.

Upon insertion of the laparoscopic camera, the asymptomatic contralateral internal inguinal ring (IIR) was routinely inspected, which revealed a PPV. If ovary was herniated, immediate reduction should be performed before mobilization of the sac. Prior to defect closure, the peritoneum surrounding the IIR was circumferentially incised and meticulously dissected from underlying structures using electrocautery to ensure complete mobilization of the hernia sac neck, including the gubernaculum, without bleeding to minimize the risk of recurrence. This was initiated by gently elevating the peritoneum and making a small entry point. The opening was then gradually enlarged carefully mobilizing under direct visualization. In open pediatric inguinal hernia repair, it has long been standard practice to ligate and divide the hernia sac together with the round ligament at the level of the internal ring. When this principle is applied to laparoscopic hernia repair, the same step can be safely reproduced intraperitoneally by performing a meticulous transection of the gubernaculum. The definitive repair consisted of a laparoscopic high ligation achieved by placing a purse-string suture at the deepest margin of the peritoneal defect. Absorbable 5/0 sutures (Vicryl®) were used, and the knot was secured via intracorporeal ligation. The contralateral PPV was also ligated in the same manner (Video). To prevent a future metachronous contralateral hernia, it is considered reasonable to close a detected contralateral PPV during the same anesthesia.

Following successful closure of the internal rings, the pneumoperitoneum was released by deflating the abdomen, and all abdominal incisions were closed in layers.

Postoperative management

In line with the standard protocol, the patient was discharged on the same day of the operation. Follow-up examinations were scheduled in the outpatient clinic at 2 weeks and 3 months postoperatively.

Ethical approval

This study was reviewed and approved by the Institutional Review Board (IRB) of Seoul National University Hospital (IRB No. 2212-082-1386). The requirement for informed consent was waived because of the retrospec-

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tive nature of the study, the use of anonymized data, and the absence of any additional risk to the participants.

Discussion

Many surgical techniques for LIHR in pediatric patients have been described in the literature. These techniques can generally be summarized as intracorporeal, extracorporeal, and percutaneous approaches [4].

For instance, a single-port percutaneous method has been reported in various countries, including Japan and European nations. This technique involves placing only one port below the umbilicus solely for the camera. A small skin incision is then made in the inguinal area, allowing a suture needle to be passed from outside the abdomen to perform a simple suture closure of the IIR. This method is widely employed due to its significant advantages, such as excellent cosmetic outcomes and shorter operative time [5].

Currently, LIHR is being applied far more frequently than the traditional open method and is widely considered the main surgical approach for pediatric inguinal hernia. In the early stages of its adoption, several issues were raised against LIHR compared to open surgery, including longer operative time and a higher recurrence rate [6]. These concerns, however, have been gradually resolved. While initial reports showed a significant difference in operative time (e.g., 25 min versus 47 min), the literature indicated a gradual decrease with advancements in laparoscopic training [7]. Furthermore, in LIHR, the ovary and uterus were frequently observed to be shifted toward the hernia orifice, which highlights a potential benefit of the laparoscopic approach in reducing the risk of injury to the ovary, fallopian tube, and potentially the uterus [8].

Several modifications of the technique have been described and published, including the Z suture, and the use of interrupted or continuous sutures. However, these techniques were not without a high recurrence rate due to the “skip area” left over the vas deferens and testicular vessels [6]. Consequently, many techniques were introduced in which the peritoneum was transected or disconnected at the internal ring, aiming to create some trauma and scarring to improve healing [9]. The recurrence rate was successfully decreased to 0%–4% in many series using these techniques [10].

Disclosure

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

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Dynamic Educational Manuscript

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Carotid Endarterectomy with Plication

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Carotid endarterectomy (CEA) remains the standard surgical treatment for patients with significant carotid artery stenosis, with the primary goal of preventing ischemic stroke by removing atherosclerotic plaque and restoring normal blood flow. Achieving optimal outcomes requires careful dissection, precise endarterectomy, and meticulous arterial closure, all of which are essential for minimizing perioperative complications. Carotid plication is a surgical technique performed during CEA to correct arterial redundancy and kinking that may persist after plaque removal. By folding and suturing the redundant arterial segment without resection, the technique preserves luminal integrity and physiologic arterial length while reducing flow turbulence and the associated risk of thrombosis. This approach provides anatomical straightening and reliable restoration of blood flow, offering a simple and durable alternative to resection with end-to-end anastomosis, particularly in patients with tortuous or elongated internal carotid arteries. In this video article, we demonstrate the fundamental steps and key principles of CEA and present a representative case in which carotid plication was performed to correct redundancy of the internal carotid artery.

Chapter Summary

Disclosure

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

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Short Communication

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Robot-Assisted Surgery Training for Medical Students in Low-Resource Areas: A Study Protocol

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Robotic-assisted surgery (RAS), commonly associated with the da Vinci Surgical System (Intuitive Surgical, Inc.), has revolutionized minimally invasive surgery. As RAS systems are being increasingly adopted in teaching hospitals and used more frequently in procedures, there is a growing need for surgeons to be trained in this technology as early as the medical school years. In this article, we propose a potential low-resource, easily adoptable RAS pilot program that will be implemented at a medical school in Puerto Rico. A brief description of the program highlights faculty-led education, journal discussions, and simulation practice through hands-on modalities to establish early RAS proficiency in a feasible 2-week timeframe. By offering students early familiarity with robotic skills, this program may support specialty exploration and improve clinical preparedness. The goal of this pilot program proposal is not only to establish this protocol at a medical school in Puerto Rico but also to encourage other programs throughout the United States to consider adopting a similar training program in the hopes of making RAS training more ubiquitous in early medical training.

Keywords: Robotic surgical procedures; Minimally invasive surgical procedures; Pilot projects and schools, Medical

Introduction

Robotic-assisted surgery (RAS) has pioneered the field of minimally invasive surgery since the United States Food and Drug Administration approval of the da Vinci Surgical System (Intuitive Surgical, Inc.). Through three-dimensional (3D) image visualization and articulated instrumental control, this platform overcame many of the limitations of laparoscopic surgery [1]. As RAS implementation increases, there is a necessity to instruct future physicians to foster familiarity and foundational skills. As outlined in Fig. 1, we propose a potential 2-week pilot program to introduce medical students to RAS through didactics, lab practice, and simulator training.

San Juan Bautista School of Medicine Robotic Medical Student Training Program

The proposed protocol is intended to take place before the 6-week surgery clinical rotation at San Juan Bautista School of Medicine, though 4th-year medical students who have completed the rotation may also participate. Student performance will be evaluated through a proficiency assessment as well as pre-/post-training questionnaires, as seen in Fig. 2.

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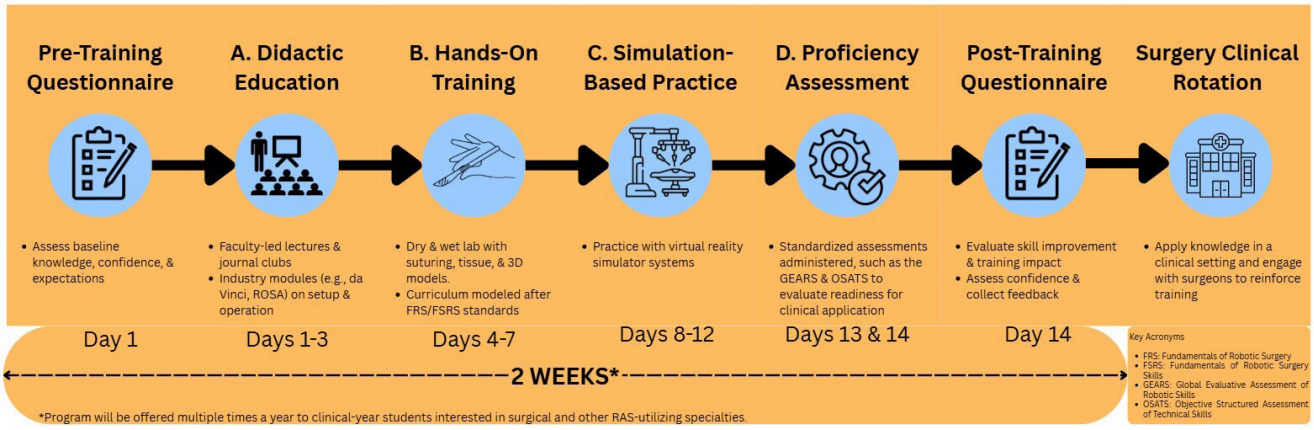

Fig. 1. Program overview and timeline.
3D, three-dimensional; RAS, robotic-assisted surgery.

Medical Student Assessment Questions

Pre-Training Questionnaire

Open-Ended Questions

- What are the three skills a medical student should acquire before assisting in a robotic procedure?
- In what ways could robotic surgery training improve your overall surgical abilities and clinical judgment?

Scaled Questions

- How would you rate your current understanding of robotic surgery and its applications? (Scale 1–5)
- How confident are you in explaining the benefits and limitations of robotic surgery? (Scale 1–5)

Post-Training Questionnaire

Open-Ended Questions

- What specific skills did you improve the most during the hands-on session (e.g., depth perception, fine motor control, etc.)?
- What challenges did you face using the robot simulator, and how did you address them?
- Which part of the training did you find most valuable: the didactics, hands-on training, simulator practice, or mentorship? Why?
- What improvements would you suggest for future robotic surgery training sessions?

Scaled Questions

- How would you rate your understanding of robotic surgery now compared to before training? (Scale 1–5)
- How confident do you now feel in explaining the benefits and limitations of robotic surgery? (Scale 1–5)

Fig. 2. Medical student assessment questions.

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Didactic education (days 1–3)

The didactic education phase focuses on introducing the background and fundamentals of robotics surgery through passive and active learning modalities brought to the students via faculty and industry manufacturers.

Faculty-sponsored

Faculty proficient in robotic surgery will provide lectures covering the history, current status, and prospects of robotic surgery. There will also be discussion of key published literature, educational videos, and evidence-based data on RAS across a broad spectrum of surgical disciplines in a 'journal club' format.

Industry-sponsored

Medical students start with online modules provided by robotic surgery system manufacturers, such as the da Vinci Surgical System. These modules cover the technical aspects of the robotic system, including setup, troubleshooting, and basic operational skills [1,2].

Hands-on training (days 4–7)

Following didactic education, students engage in hands-on training. This includes practice with suturing pads, animal tissue, and 3D printed organs. Programs such as the Fundamentals of Robotic Surgery (FRS) and the Fundamentals of Robotic Surgery Skills (FSRS) and the 'fundamentals of robotic surgery skills' further support this training with the incorporation of dry and wet lab components [1,3].

Simulation-based practice (days 8–12)

Virtual reality (VR) simulators play a crucial role in robotic surgery training, allowing students to practice and refine their skills in a controlled environment [1,3,4].

Proficiency assessment (days 13 & 14)

Proficiency is assessed using standardized tools, such as the Global Evaluative Assessment of Robotic Skills (GEARS) and the Objective Structured Assessment of Technical Skills (OSATS). These assessments will not be used as pass/fail evaluations but as tools to guide feedback and track progress. Cheng and Chao [5] emphasize the use of assessments such as GEARS as 'standardized and validated' for trainees to 'reflect real surgical situations'. Ultimately, we aim to measure students' skill acquisition using a formal framework, providing additional proctored practice for students needing more support [2].

Discussion

Since the da Vinci platform's introduction in the late 1990s, RAS has expanded beyond traditional surgical fields into procedural specialties such as pulmonology and gastroenterology. Trials by Paez et al. [6] and Iacovazzo et al. [7] demonstrated that RAS, when used in bronchoscopy and gastrointestinal procedures, led to minimal side effects and quicker recovery compared to their respective gold standards without compromising procedure outcomes.

Unlike rigid prior programs, ours emphasizes flexibility and accessibility. Similar training programs like Mullens et al. [8] showed medical students gained procedural confidence after just 2 weeks. Our 2-week program will be offered to clinical-year medical students; in the case of San Juan Bautista, throughout the 3rd and 4th years. As many students are still undecided as to their specialty of choice when clinical years begin, this early exposure can clarify career goals, fill knowledge gaps, and enhance clinical and professional skills. Multiple offerings throughout the academic year will allow students to engage when it best supports their development.

Limitations include resource constraints, as RAS and simulators require substantial financial support for software updates, instrumentation, and education. The current state of healthcare in Puerto Rico is characterized by persistent structural challenges, which are exacerbated by recurrent natural disasters and economic instability [9]. Cultural/logistics barriers, faculty buy-in, and curriculum integration, may also impact implementation.

A 2023 study by Kalinov et al. [10] raised concerns about the limited availability of VR simulators and certified instructors. While access has improved, even in resource-limited regions like Puerto Rico, Kalinov et al. [10] state that VR training alone may fall short in developing fine motor tasks, such as camera targeting and threading, due to the dexterity required by the RAS. This

reinforces the importance of hands-on skill development as a critical component of this program.

The cost is the most evident drawback of such a pilot program as hardware, software, maintenance, and consumables expenses can vary. However, many widely adopted platforms, such as da Vinci Xi and SP, arrive with integrated training packages that include online modules, VR simulators, dry labs, and certification programs. Specifically in its implementation in Puerto Rico, the equipment is government-funded in the county hospital of San Juan for clinical use and is also being used in academic hospital settings to train medical students, residents, and fellows. This infrastructure, combined with the medical school wet labs, facilitates a cost-effective implementation and sustainability at the medical school level.

As this manuscript presents a study protocol that has not yet been implemented, we have not included outcome measures or a sample-size calculation. Once approved by San Juan Bautista School of Medicine's Institutional Review Board and a pilot cohort of students is enrolled, we plan to measure percentage improvement in GEARS and learner confidence scores from pre- to post-assessment to support our determination of the sample-size for future implementations of the pilot program.

Conclusion

This proposed pilot protocol for a medical school in Puerto Rico provides a structured approach in robotic surgery, balancing knowledge with practical skills and clinical experience over a 2-week period. The curriculum is designed to be adaptable based on institutional resources and demonstrates that even with limited means, students can have early exposure to RAS, supporting early skill development and aligning with the dynamic demands of surgical education.

Disclosure

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

Author contributions

Conceptualization: PFE; Methodology: IK, JJ, JM, PFE; Project administration: IK; Visualization: IK; Writing–original draft: IK, JJ, JM, PFE; Writing–review & editing: IK, JJ, JM, PFE.

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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.

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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).

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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:

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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.
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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.
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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.

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  To qualify for authorship, all contributors must meet at least one of the seven core contributions by CRediT (conceptualization, methodology, software, validation, formal analysis, investigation, data curation), 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.

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- 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.
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- 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 15 minutes and must meet the requirements of video materials in the "Dynamic Educational Manuscripts" category, except for audio narration.

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.

- 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.
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- 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.

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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.

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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.

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