Pediatric Minimally Invasive Surgery: Implications for Very Small Patients in the Long-term and the Future of Pediatric Surgical Training

GO MIYANO*, ATSUYUKI YAMATAKA*

*Department of Pediatric General & Urogenital Surgery, Juntendo University Faculty of Medicine, Tokyo, Japan

This digest of reports was prepared as part of an academic encouragement award from the Juntendo Alumni Association. Ten published reports covering five different topics focusing on technical innovations and approaches to management for enhancing long-term outcomes of pediatric minimally invasive surgery (MIS) through the application of currently available technology will contribute to exposing surgical residents to sustainable training and learning opportunities that they can use to enhance their expertise and skills.

While MIS has many advantages compared with conventional open surgery, many are somewhat subjective and difficult to assess objectively. Thus, new MIS procedures require motivation, creativity, and skill to develop but are only of practical value if they can be performed safely and effectively with acceptable cost performance ratios.

Pediatric surgical patients have a much longer postoperative period than adult patients and coupled with decreased mortality and increased longevity, postoperative quality of life (QOL) is a long-term factor that pediatric surgeons are in a position to control. Because pediatric MIS requires more specific skills because of size limitations that are associated with longer learning curves, the chosen reports reflect how balancing surgical/anatomic challenges, maximizing postoperative QOL, and maintaining teaching and skill acquisition at a high standard of excellence are crucial for managing pediatric patients successfully.

Key words: postoperative quality of life (QOL), surgical education, minimally invasive surgery, learning curve, pediatric surgical training

Being the first dedicated department of pediatric surgery in Japan, Juntendo's Department of Pediatric Surgery has pioneered technical and procedural innovation since it was inaugurated in 1968. Minimally invasive surgery (MIS) is now so well accepted as an option for surgical intervention in all age groups that for some procedures it has even replaced conventional open surgery. Because MIS is performed indirectly through very small incisions using specialized devices and instruments, there is less requirement for postoperative analgesia, postoperative recuperation is faster, and hospitalization is shorter. In addition, there is less manipulation of

tissues, with lower risk for complications. The advantages of MIS were obvious to both health care providers and caregivers and the Department was quick to adopt MIS because of the special needs of pediatric patients and introduced thoracoscopy and laparoscopy to support open surgical intervention in the first instance. However, specific training is required to learn basic skills and once mastered, further training is necessary to maintain skills and use new devices confidently. Thus, surgical training must keep pace with demand for MIS to ensure quality care.

Today, caregivers have enough resources to be

Corresponding author: Go Miyano

Department of Pediatric General & Urogenital Surgery, Juntendo University Faculty of Medicine
2-1-1 Hongo, Bunkyo-ku, Tokyo 113-8421, Japan

TEL: +81-3-3813-3111 FAX: +81-3-5802-2033 E-mail: go@juntendo.ac.jp

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able to choose a hospital for a particular procedure. Surgeons and hospitals must be prepared for patients and caregivers to be well-informed and to some extent preoccupied with value-added aspects of health care such as service and postoperative quality of life (QOL), two aspects of health care that have not traditionally been considered necessary for surgeons to consider.

The following topics will be covered in this digest.

1. Pediatric MIS and long-term postoperative QOL
2. New MIS procedures in children
3. The effect of pneumoperitoneum during MIS in children
4. Expanding the indications for MIS to smaller children
5. Pediatric MIS: Education and training

1. Pediatric MIS and long-term postoperative QOL

Esophageal atresia (EA), especially type-A, and total colonic aganglionosis (TCA), the most severe form of Hirschsprung's disease remain problematic because good long-term outcomes and stable quality of life (QOL) have yet to be achieved¹⁾⁻¹⁰⁾. Outcomes of MIS for (a) EA and (b) TCA are presented as examples of an attempt to address long-term QOL goals and sequelae.

Current treatment strategies are not providing patients with EA and TCA with ideal postoperative QOL, although MIS is a definite improvement over open surgery. With this in mind, extensive multi-center research on factors related to surgical maneuvers and perioperative management required to further improve long-term postoperative QOL in patients with type-A long-gap EA and TCA involving leading major children's hospitals in Japan is in progress.

(a) Changes in quality of life from infancy to school age after esophagoesophagostomy for tracheoesophageal fistula: Thoracotomy versus thoracoscopy [2017]¹⁾

Background: QOL of postoperative EA with tracheoesophageal fistula (TEF) cases was assessed, comparing open with thoracoscopic repair.

Methods: A retrospective review of consecutive EA/TEF repairs (2001–2014) was performed,

excluding cases with birth weight less than 2000g and severe cardiac/chromosomal anomalies. Of 37 cases, 13 had thoracoscopic repair (TR) and 24 had open repair (OR) according to the operating surgeon's preference. QOL was determined regularly by scoring responses to a standard questionnaire about oral intake, vomiting, bougienage, coughing, growth retardation, learning ability, and thoracic deformity. Lower scores reflected poorer outcomes. QOL after TR and OR were compared one year postoperatively (POQ) and after starting school (ScQ).

Results: Subject demographic characteristics were similar. Apart from two anastomotic leaks that resolved spontaneously after TR, there were no intraoperative complications or recurrence of TEF. Laparoscopic fundoplication was required for gastroesophageal reflux in four cases (OR 1; TR 3) ($p=ns$). QOL scores increased from 6.5 to 11.5 in OR and 4.6 to 11.3 in TR. Final ScQ scores were similar, but POQ was significantly higher after OR ($p<0.05$) (Figure-1).

Conclusion: Initial QOL scores were significantly lower after TR, but by school age, QOL scores were similar.

(b) Laparoscopy-assisted Duhamel-Z anastomosis for total colonic aganglionosis: Outcome assessed by fecal continence evaluation [2017]²⁾

Background: A Z-shaped colorectal side-to-side anastomosis was introduced to improve the Duhamel procedure by eliminating the rectal blind pouch. All TCA patients treated by laparoscopy-assisted Duhamel-Z (LapDZ) between 2009 and 2014 were reviewed retrospectively, focusing on annual fecal continence evaluation scores (CES) as an indicator of outcome.

Methods: LapDZ was performed conventionally. Postoperatively, defecation was regulated with medications and enemas according to our standard protocol. Stool frequency, stool consistency, fecal soiling/incontinence, growth, and severity of enterocolitis were each scored (0–2) to give a total CES (maximum: 10).

Results: Eleven subjects (6 males, 5 females) were reviewed. Mean age and mean weight at LapDZ were 10.2 months and 8.4 kg, respectively. Mean length of aganglionic ileum resected

Figure-1 Changes in quality of life from infancy to school age
 QOL scores range from 6.5 to 11.5 in OR and 4.6 to 11.3 in TR, respectively. Final scores are similar, but POQ is significantly higher after OR.
 POQ: 1 year postoperative
 ScQ: after starting school

was 19.5 cm. Mean operative time was 6.2 hours. Postoperative oral intake took an average of 5.7 days to be restarted. There were no intraoperative complications, no anastomotic leaks or strictures, and no intestinal obstruction. Postoperative blood transfusion was required in 1 case for chronic bleeding unrelated to surgery. No subject was constipated postoperatively. Follow-up was for 5 years. The number of subjects who had CES assessments each year was: after 1 year ($n=11$), after 2 years ($n=10$), after 3 years ($n=10$), after 4 years ($n=8$), and after 5 years ($n=5$). Average annual CES scores during follow-up were 4.5, 6.1, 7.7, 8.1, and 8.4, respectively (Figure-2). Conclusion: LapDZ and strict management of postoperative bowel function may have contributed to improving CES over time.

2. New MIS procedures in children

Surgery takes on added potential with every invention and improvement in technology. Robot-assisted surgery now allows small complex anasto-

moses that would have tested the limits of human performance just 20 years ago to be performed. Reports covering (a) inventing a new surgical procedure, and (b) modifying an existing procedure by taking advantage of new technology illustrate the dreams, ambitions, and fascination that has intrigues surgeons throughout history. Pediatric surgery has more potential for creativity because of the wider spectrum of patient sizes, age related physiologies, and instruments/devices required^{11) 12)}.

Surgical trainees must feel encouraged to innovate. Senior staff surgeons should provide an environment conducive to creativity and encourage efforts to improve and modify by encouraging discussion and discuss advantages/disadvantages compared with existing techniques. The extent to which existing staff are supportive and nurture trainees to consider and suggest new ideas, including maneuvers/procedures, instruments, or approaches is one way to resolve the issue of decreasing numbers of medical students and residents choosing to become surgeons.

Figure-2 Continence evaluation score (CES) changes
Average annual CES scores during follow-up improve gradually.

To attract young medical residents to the field of surgery, an opportunity for practical creativity must be nurtured given the hands-on nature of surgery. Routine procedures will always be the base of every surgeon's livelihood, but the chance to modify/innovate must be maintained to keep trainees interested to further their skills. We believe surgery has more potential for younger trainees, including residents, to apply their creativity to develop something new or better, especially in pediatric surgery, because there are many conditions that have no established treatments of choice because of rarity or complexity.

(a) Laparoscopic Heller myotomy for non-dilated esophageal achalasia in children with intraoperative stepped dilation under image guidance: Attempting complete myotomy [2016]¹³⁾

This study presents a modified surgical approach to laparoscopic myotomy for achalasia using stepped dilation with a Rigiflex balloon and contrast medium under imaging guidance. A 10-year-old boy with persistent dysphagia and vomiting was limited to ingesting liquids for 3 months prior to presentation resulting in weight loss of 10 kg. Barium swallow and esophageal manometry diagnosed esophageal achalasia with mild esophageal dilatation. After failed pneumatic dilatation, laparoscopic Heller myotomy with Dor

fundoplication was performed. Prior to surgery, a Rigiflex balloon dilator was placed within the esophagus near the diaphragmatic hiatus. A four-port technique was used, and mobilization of the esophagus was limited to the anterior aspect. A 5-cm Heller myotomy was performed, extending another 2 cm onto the anterior gastric wall. During myotomy, the dilation of the Rigiflex balloon was adjusted repeatedly from 30 to 50 ml with contrast medium under fluoroscopic imaging guidance to maintain appropriate tension on the esophagus during myotomy incisions and to confirm there was adequate release of lower esophageal sphincter after resecting circular muscle fibers. Residual circular muscle fibers could be visualized simultaneously under both fluoroscopic imaging and direct observation through the laparoscope and were cut precisely until the residual notch disappeared fully (Figure-3). Dor fundoplication was completed. Operative time was 180 minutes, and oral intake was started after esophagography on postoperative day 1. At 12-month follow-up, the patient showed no symptoms, and his postoperative course appeared satisfactory.

(b) Laparoscopy-assisted stoma closure [2007]¹⁴⁾

Purpose: The aim of this study was to describe our improved technique for stoma closure,

Figure-3 Laparoscopic Heller myotomy with stepped dilatation under imaging guidance
Residual circular muscle fibers can be visualized under both fluoroscopic imaging and direct observation through the laparoscope.

Figure-4 Laparoscopy-assisted stoma closure
Laparoscopy is used to observe the intestines, stoma, line of separation, and adhesions.
sb: stomal bowel, aw: abdominal wall.

laparoscopy-assisted stoma closure (LASC). Patients and methods: Eleven (11) children underwent LASC at our institute during 2005. Ages at LASC ranged from 4 to 23 months, and body weight ranged from 3.4 to 10.0 kg. Under general anesthesia, a 5-mm trocar was inserted through an infraumbilical, left-lower, or upper quadrant incision, and laparoscopy was used to observe the intestines, stoma, line of separation, and any adhesions. Externally, a circumferential incision was made around the stoma, and a pair of mosquito forceps was inserted into the abdomen along the attachment between the stoma and the abdominal wall where no intra-abdominal adhesions were present, and the tips of the mosquito

forceps were used to free the stoma along the proposed line of separation (Figure-4). Electrocautery was used for hemostasis and for completing the separation. After the stoma was taken down, the intestine was anastomosed, and the abdomen closed in layers. Results: All stomas were taken down easily without any complications in all cases. The average time for each stomal separation, from incising around the stoma until the stoma was taken down, was 23.1 minutes (range: 17–42 minutes). Injury to the abdominal wall musculature was minimal. There was 1 case of postoperative small bowel obstruction and no cases of wound infection or incisional herniation. Conclusions: Although our experience

is limited to only 11 patients, our LASC procedure appears to be an effective option for stoma closure.

3. The effect of pneumoperitoneum during MIS in children

MIS has many advantages compared with conventional open surgery, but adverse effects should be evaluated not only symptomatically, but also scientifically. Insufflation using carbon dioxide is necessary during MIS and because of the variety of pediatric patients, there is a spectrum of physical effects during laparoscopy and thoracoscopy^{15)–17)}. Two reports documenting the hemodynamic effects of insufflation are presented as examples of fundamental issues that require better management for smoother surgery. In the second report (b), conducted 15 years ago, the mechanism by which insufflation could be detrimental was not well understood.

(a) Pneumoperitoneum and hemodynamic stability during pediatric laparoscopic appendectomy [2016]¹⁸⁾

Background: Conventional pneumoperitoneum (CP) and automatically maintained pneumoperitoneum using the AirSeal Intelligent Flow System (AiFS) were compared during pediatric laparoscopic appendectomy (LA) by monitoring intraperitoneal pressure (IPP) and hemodynamic parameters.

Methods: A prospective review of 39 children aged 3–14 years who underwent standard 3-trocar LA was performed. Pneumoperitoneum was either AiFS (n=18) or CP (n=21) according to the surgeon's preference. IPP during insertion of trocars in all subjects was initially 8–10 mmHg, which was decreased to 5 mmHg and then maintained until LA was completed. Data were collected every 5 min during pneumoperitoneum. **Results:** Subject demographics were similar for both groups. During pneumoperitoneum, mean IPP (AiFS: 7.9; CP: 9.0 mmHg), mean systolic blood pressure (AiFS: 100.4; CP: 106.9 mmHg), and mean end-tidal CO₂ (EtCO₂; AiFS: 35.7; CP: 38.5 mmHg) were significantly different (p<.05, respectively), whereas pulse (AiFS: 92.1; CP: 96.4 bpm), oxygen saturation (AiFS: 98.8; CP:

98.8%), body temperature (AiFS: 37.2°C; CP: 37.4°C), urine output (AiFS: 2.7; CP: 2.4 mL/kg per hour), operative time (AiFS: 72.2; CP: 76.2 min), blood loss (AiFS: 3.6; CP: 3.5 mL), restarting oral intake (AiFS: 1.3; CP: 1.4 days), and postoperative hospitalization (AiFS: 4.3; CP: 3.8 days) were not.

Conclusion: Because IPP was significantly lower during LA with AiFS, EtCO₂ and BP were significantly lower.

(b) Carbon dioxide pneumoperitoneum prevents intraperitoneal adhesions after laparotomy in rats [2006]¹⁹⁾

Purpose: The aim of this study was to assess whether carbon dioxide insufflation (CDI) pneumoperitoneum prevents intraperitoneal adhesions (IPAs).

Methods: Laparotomy was performed in 8-week-old Lewis rats (n=40) and their intestines were delivered through the wound and manipulated. The rats were divided into 4 groups; laparotomy only (Lp group, n=15); Lp with CDI (Lp-CDI group, n=15); Lp and bowel anastomosis (LpBA group, n=5); and LpBA with CDI (LpBA-CDI group, n=5). LpBA and LpBA-CDI group rats had 1 cm of ileum excised and an end-to-end anastomosis performed. To accelerate IPA formation, all rats had intestines heated to 45°C for 40 seconds and 0.5 mL of Lewis rat blood spilled over them. Rats in the control group (n=5) had Lp alone without heating or blood spillage. Pneumoperitoneum involved insufflating carbon dioxide into the peritoneal cavity through a cannula at the time of final abdominal closure to create pneumoperitoneum to a pressure of 5 mmHg. All rats had re-laparotomy 10 days after surgery, and IPA were assessed blindly using an IPA severity score (IPASS: 0=no adhesions, 1=no serosal tears during adhesiolysis, 2=serosal tears during adhesiolysis, 3=bowel perforation during adhesiolysis). Only the worst IPA in each rat was scored. Rats were sacrificed after re-laparotomy and their peritoneums and intestines excised for histopathology.

Results: Pneumoperitoneum resolved in approximately 5 days. There were no associated side effects. The Lp-CDI group had significantly lower IPASS than the Lp group (0.23 ± 0.46 vs

Figure-5 Intraperitoneal adhesion scores with or without carbon dioxide pneumoperitoneum. Lp-CDI has significantly lower IPASS than Lp group; LpBA-CDI has significantly lower IPASS than LpBA.
 Lp-CDI: laparotomy with carbon dioxide insufflation
 IPASS: intraperitoneal adhesion severity score
 LpBA: laparotomy with bowel anastomosis

1.07 ± 1.18 , $P < .05$), and the LpBA-CDI group had significantly lower IPASS than the LpBA group (1.50 ± 0.61 vs 2.40 ± 0.55 , $P < .05$) (Figure-5). Histopathology showed that pneumoperitoneum had no effect on the peritoneum or intestines.

Conclusions: The present results suggest that CDI pneumoperitoneum appears to prevent IPA, especially intestinal IPA.

4. Expanding the indications for MIS to smaller children

Compared with adult surgery, pediatric MIS has developed relatively late due to technical difficulties, such as small working spaces, lack of dedicated instruments of various sizes, and a variety of anatomic anomalies peculiar to morbidity seen in children²⁰⁾⁻²³⁾. Two reports address the application of MIS in smaller children; (a) indications for MIS in neonates and children, and (b) use of an AirSeal intelligent flow system.

Many procedures are customized to be performed in small patients requiring modification of instrumentation and rethinking of protocols; these

are issues that are not even considered in adult surgery and non-surgical specialties. Thus, acquiring a solid repertoire of skills is the basis for expanding clinical application. This is a unique feature of pediatric surgery; the adaptive application of diverse skills to a spectrum of patients and clinical settings.

(a) Laparoscopic repair of malrotation: What are the indications in neonates and children? [2015]²⁴⁾

Aim: To define the role of laparoscopy for treating malrotation in children.

Materials and methods: Ladd procedures performed in 26 children laparoscopically (lap-Ladd; $n = 9$) and open (open-Ladd; $n = 17$) were compared retrospectively according to age at surgery; up to and including 30 days of age (neonatal; Group N) and older (child; Group C). **Results:** Group N ($n = 14$) comprised 3 lap-Ladd and 11 open-Ladd patients. Group C ($n = 12$) comprised 6 lap-Ladd and 6 open-Ladd patients. No case had ischemic bowel preoperatively. Intestinal volvulus was confirmed in 3/3 lap-Ladd and 9/11 open-Ladd patients in Group N,

Figure-6 Laparoscopic Toupet fundoplication for a 1.8 kg infant

The gastrosplenic ligament is dissected free, and a posterior hiatoplasty is performed, followed by a 270-degree fundoplication.

compared with 5/6 lap-Ladd and 6/6 open-Ladd patients in Group C ($p = \text{not significant}$). Mean operative times were significantly longer for lap-Ladd patients (130.7 minutes versus 81.1 minutes in Group N and 119.2 minutes versus 74.2 minutes in Group C). Conversion to open-Ladd was necessary in 1/3 patients in Group N and 1/6 patients in Group C ($p = \text{not significant}$). Complications arose in open-Ladd patients, including bowel obstruction in Group N (1 of 11) and mesenteric chylorrhea in Group C (1 of 6). There was recurrence in 1/3 lap-Ladd patients in Group N. Mean time to restart feeding was earlier for lap-Ladd patients ($p = \text{not significant}$). Lengths of hospitalization were similar in all Group N patients, but shorter for lap-Ladd patients in Group C ($p = \text{not significant}$).

Conclusions: Although lap-Ladd appears to be a safe procedure, it cannot be recommended for the treatment of malrotation in neonates.

(b) Laparoscopic Toupet fundoplication using an AirSeal intelligent flow system and Anchor Port in a 1.8 kg infant: A Technical Report [2015]²⁵⁾

Introduction: A case of a 1.8 kg infant who had laparoscopic Toupet fundoplication (LTF) using an AirSeal Intelligent Flow System and Anchor Port (AP) is reported.

Materials and surgical technique: The patient had severe gastroesophageal reflux in association with genetic and cardiac anomalies. Despite the patient being continuously fed, persistent vomiting caused failure to thrive, and LTF was performed at 4 months of age when he weighed 1.8 kg. The AirSeal Intelligent Flow System is a novel laparoscopic CO₂ insufflation system that improves the visual field by constantly evacuating smoke and providing a more stable pneumoperitoneum. The AP is a recently developed, stretchable, elastomeric, low-profile cannula. Three 5-mm APs were inserted; one subumbilically for the scope and one in both the right and left upper abdominal regions for the surgeon. A 5-mm AirSeal trocar was inserted in the left lower abdomen for the assistant. The gastrosplenic ligament was dissected free, and the intra-abdominal esophagus was prepared. A posterior hiatoplasty was performed, followed by a 270° fundoplication during which the esophagus was fixed to the crus, and then the right and left wraps were fixed to the esophagus (Figure-6). The AirSeal System maintained a stable pneumoperitoneum throughout the LTF procedure creating an optimal operative field. Total operative time was 90 minutes. Body temperature dropped from 37.4°C to 35.7°C during pneumoperitoneum but resolved once pneumoperitoneum

was ceased. Postoperative progress was uneventful, and an upper gastrointestinal study on postoperative day 2 showed no residual gastroesophageal reflux.

Discussion: We believe that the AirSeal Intelligent Flow System and AP contributed to the successful completion of LTF in a 1.8 kg infant.

5. Pediatric MIS: Education and training

The indications for MIS in small children and infants are increasing and require highly specialized skills with long learning curves. Unfortunately, the number of patients requiring such surgery is limited, and this is a major disadvantage for training in MIS for pediatric surgeons²⁶⁾⁻²⁸⁾. In 2019, a cadaver surgical training program was introduced at Juntendo University as part of a new education/training system for residents and faculty in all surgery-related departments, as well as anesthesiology and emergency medicine. A report about experienced trainees assisting with teaching (a) is presented as a trial of simultaneous teaching and learning that could make the most efficient use of limited exposure to patients, and a report about training outside the operating room using human adult cadavers and their practical value for learning MIS techniques required for pediatric surgery (b) is presented as an example of how learning curves could be improved.

(a) Retroperitoneoscopic nephrectomy/heminephrectomy in children planned, performed, and managed by supervised senior pediatric surgical trainees [2013]²⁹⁾

Introduction: Retroperitoneoscopic nephrectomy (R-neph) is still not generally favored by pediatric surgeons for various reasons, including lack of experience with retroperitoneal anatomy, concern about long operative times, and risk for complications.

Materials and methods: Nephrectomies/heminephrectomies planned, performed, and managed by five senior pediatric surgical trainees (SPST) under the supervision of a board-certified pediatric surgeon (BCPS) using four-trocar retroperitoneoscopy (R-neph) (n=11) were compared with conventional open nephrectomy and heminephrectomy (O-neph) (n=20) per-

formed by 4 BCPSs.

Results: O-neph included 14 nephrectomies and 6 upper pole nephrectomies; R-neph included 9 total nephrectomies and 2 upper pole nephrectomies. Mean ages and weights at nephrectomy were not significantly different. Mean operative time (MOT) was 137 minutes (range: 85–290 minutes) in O-neph versus 197 minutes (range: 116–341 minutes) in R-neph. MOT for the first 5 R-neph cases was 249 minutes versus 153 minutes for the last 6 cases. Mean blood loss was 17 ml (range: 1–55 ml) in O-neph versus 10.3 ml (range: 2–40 ml) in R-neph. One R-neph case required conversion to O-neph. There were no transfusions and no intraoperative complications. Two partial heminephrectomy patients (one O-neph and one R-neph) developed transient urinomas postoperatively that resolved conservatively. The mean duration of postoperative bed rest was 1.0 day in O-neph versus 0.6 days in R-neph. Differences in the mean postoperative fentanyl requirement O-neph: 21.5 µg/kg (range: 10–40 µg/kg) versus R-neph: 4.1 µg/kg (range: 0–20 µg/kg) and duration of nonsteroidal anti-inflammatory suppository usage O-neph: 2.3 days (range: 0–5 days) versus R-neph: 0.9 days (range: 0–2 days) were significant (both $p < .05$). Full oral feeding was resumed after a mean of 1.6 days (range: 1–2 days) in O-neph and 1.2 days (range: 1–2 days) in R-neph.

Conclusions: R-neph were safely performed by SPST with similar results to O-neph performed by BCPS.

(b) Use of human cadavers for minimally invasive pediatric surgical training: A first report

Aim: The practical value of using human adult cadavers for learning minimally invasive surgical (MIS) techniques required for pediatric surgery (PS) was assessed.

Methods: Three junior PS trainees (JTs), 3 senior trainees (STs), and 3 board-certified consultant surgeons (CSs) from one institute participated in this trial. Each participant was asked to perform the following procedures on a human cadaver (usually elderly adult) and a live pig; (1) thoracoscopic esophagoesophagostomy (TEE) and (2) thoracoscopic right lower lobectomy (TRL), (3) laparoscopic fundoplication

(LFN), (4) laparoscopic hepaticoduodenostomy (LHD), and (5) laparoscopic ureteroureterostomy (LUU). An assessment questionnaire about their experiences was administered anonymously after all procedures were completed. Five criteria were evaluated on a four-point scale to grade to what extent a human cadaver or a pig resembled a pediatric patient. Participants were also asked to rank the procedures they performed according to how realistic they were.

Results: TRL was considered to be most realistic, followed by LFN, TEE, LUU, and LHD. Scores for difficulty, operative field, and anatomical relationships for each of the 5 procedures tended to score highly, meaning that procedures were moderately difficult, the operative field was good, and the anatomic relationships were familiar. The effect of experience was evident; average scores were higher for CS versus ST, and ST versus JT. However, all groups considered human cadavers to be more realistic than live pigs.

Conclusions: Adult human cadavers were found to be highly representative of pediatric patients and could be used as an option for training pediatric surgeons, even experienced pediatric surgeons.

This digest presented a selection of published reports that highlight issues related to pediatric MIS that are crucial for continued quality management. A solid understanding of basic microsurgical techniques is the foundation upon which to build more specialized skills that need to be customized flexibly as the broad spectrum of pediatric patients dictates. Maintaining skills and expertise thus becomes crucial for providing care at a level of maximal excellence, but innovation is also necessary for the further growth and development of MIS.

No matter what improvements occur in technology, surgery is still a hands-on profession that requires a balance of knowledge and skill. The quality of health care relies on solid education/training to ensure that future generations achieve strong foundations in basic skills.

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