

R E V I E W

Usefulness of intraoperative endoscopy in pediatric surgery: state of the art

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Summary. *Introduction:* Intraoperative endoscopy is a procedure that supports open and laparoscopic surgery, helping the surgeon to identify the presence of endoluminal gastrointestinal lesions which need to be treated, with a correct diagnosis and an adequate therapy. *Material and methods:* A search on PubMed was performed using "intraoperative esophagoscopy", "intraoperative duodenoscopy", and "intraoperative enteroscopy" as Mesh terms. The applied exclusion criteria were: papers written before 2000, not concerning pediatric or gastrointestinal pathology, literature-review articles, language different from English. *Results:* Sixteen studies from 2000 to 2018 were included. Overall, 1210 patients were treated. Different pathologies were considered. Complications were observed in a range of 0.3-14%. The most frequent complications were perforation, bleeding and mucosal tear. Mortality ranged between 0.7% and 1,2%. *Conclusion:* Intraoperative endoscopy is an indispensable tool for gastrointestinal surgery. In the hands of experienced endoscopists, intraoperative endoscopy can be performed safely, in time-efficient manner, facilitating diagnosis and treatment. (www.actabiomedica.it)

Key words: intraoperative endoscopy, pediatric gastroenterology, esophagogastroduodenoscopy, enteroscopy

Introduction

As well as the surgeon could be helpful to the pediatric endoscopist in case of complications during a diagnostic or operative endoscopy, the contribution of the endoscopist could be important for the surgeon, in several types of procedures. Although in the surgical practice laparoscopy is considered one of the most important innovations in the last 30 years, its big limitation still remains the impossibility to palpate the tissues directly, causing the loss of precision in some procedures, especially in those where the identification of solid endoluminal lesions is needed. Intraoperative gastrointestinal endoscopy allows increasing precision and sensitivity of both open and laparoscopic surgery, helping the surgeon to locate exactly endoluminal lesions of the digestive system which have to be treated

(1). The operative maneuverability of current endoscopes makes every portion of the gastrointestinal tract accessible to direct visualization by the operating surgeon and by the endoscopist (2).

Intraoperative endoscopic procedures include:

Intraoperative esophagoscopy. It has different applications, mostly in case of Gastro-Esophageal Reflux Disease (GERD), as it allows the direct localization of the gastroesophageal junction (GEJ) and can recognize typical GERD's complications as ulcers, stenosis, Barrett's esophagus and short esophagus (3) and, in case of achalasia, where it allows to evaluate mucosal conditions that could change certain decisions as, for example, the type of fundoplication, the width of myotomy and eventually a postponement of the operation (4).

Intraoperative duodenoscopy. The main duodenal pathological conditions of surgical interest include atresia, annular pancreas and congenital stenosis in pediatric patients (5). Practising an intraoperative duodenoscopy in those cases could be helpful to accurately identify the position of the obstruction and to clarify the etiology.

Intraoperative enteroscopy. Despite the improvement of the tools, enteroscopy still presents several difficulties, mainly due to the length and small bowel's natural anatomic tortuosity (6). Both in adult and pediatric patients the main diagnostic and therapeutic conditions are gastrointestinal idiopathic bleeding, Crohn disease, localized lesions out of reach of upper and lower endoscopy, incomplete information gathered with TC and/or RM and Peutz-Jeghers syndrome. In particular, in this last case, intraoperative enteroscopy enhances polyps' resection without the necessity of additional enterotomy and intestinal resections and can help in reducing number of laparotomies (7).

Intraoperative colonoscopy. Taking advantage from the direct help of the surgeon in reducing colonic curves, it is faster than the standard colonoscopy and fundamentally it doesn't add any risk to the procedure (2). The most common indication concerns intestinal bleeding and the localization of tumors when palpation is not enough to achieve the purpose (8, 9).

Materials and methods

In order to verify the utilities of intraoperative gastrointestinal endoscopy, a research of the literature was performed by using Pubmed, Medline, Embase databases.

Cochrane database and google Scholar were searched as well, using the following mesh terms: "intraoperative esophagoscopy", "intraoperative enteroscopy", "intraoperative duodenoscopy". Additional articles were selected reviewing the references of the papers identified using these mesh terms.

Exclusion criteria were: papers written before 2000, not concerning pediatric or gastrointestinal pathology, literature-review articles, language different

from English. Each article was tabulated as follows: authors; year of the study, number of patients, surgical technique, follow-up time and complications.

Results

We identified 518 full-text articles; 502 did not meet inclusion criteria. Sixteen studies published from 2000 to 2018 were included (Table 1). Five were case reports and 12 were retrospective studies. Overall, 1210 patients underwent surgical procedures under intraoperative endoscopic control. Different surgical procedures were analysed: 4 studies concerning Achalasia disease (10-13); 4 studies concerning GERD (14-17); 6 studies concerning Peutz-Jeghers syndrome (18-23); 1 case report of GI hemorrhage (24); 1 study concerning duodenal obstruction (25). Regarding achalasia, 303 patients underwent a laparoscopic Heller's myotomy under intraoperative endoscopic control. All patients complained of dysphagia, although heartburn, regurgitation/emesis, postprandial chest pain. The diagnosis of achalasia was confirmed by barium esophagogram, upper GI endoscopy and, in some cases, esophageal manometry studies. The average

Table 1. Studies included

Authors	Year	N° patients included	Disease requiring the procedure
Fernandez et al.	2001	81	Achalasia
Adikibi et al.	2009	5	Achalasia
Chapman et al.	2004	139	Achalasia
Bloomston et al.	2002	78	Achalasia
Oelschlager et al.	2002	142	GERD
Becerril et al.	2006	277	GERD
Chang et al.	2002	40	GERD
Del Genio et al.	2007	380	GERD
Ricco' et al.	2003	33	DO
Lin et al.	2000	1	PJ
Ross et al.	2006	3	PJ
Edwards et al.	2003	25	PJ
Lee et al.	2014	1	PJ
Pennazio et al.	2000	3	PJ
Chui et al.	2006	1	PJ
Jolley et al.	2001	1	GI Bleeding

time of surgical procedure was 50-300 minutes with a range of hospital stay of 1.9-6 days. Follow-up period ranged from 1.5 months to 91 months. Patients were asked to list their symptoms, grade their heartburn, if present, and grade their outcome compared with their preoperative status as: excellent (complete resolution of symptoms), good (greatly improved symptoms), fair (slightly improved symptoms), or poor (no improvement or worsened symptoms). In particular, Adikibi et al. (2009) (11) used the modified Visick symptom scale for evaluating the postoperative outcome, including 1) no symptoms (80% of patients), 2) better than before surgery (20% of patients), 3) no modifications, and 4) new symptoms or complications. Chapman et al. (2004) (12) used a questionnaire based on the quality of life with a score of 0-6, depending on the ability to eat, swallow, sleeping lying down etc. Around 90-96% of all patients had an improvement in their symptoms. Mortality occurred in a range of 0.7-1.2%, because of esophageal perforation in the post-operative period or because of other diseases not concerning the surgical procedure. From 2 to 3.8% cases, it was required a conversion to open-surgery; from 6 to 14% cases, esophageal perforation occurred.

Regarding GERD, 839 patients performed intraoperative endoscopy undergoing laparoscopic anti-reflux procedures. All patients had been evaluated preoperatively with esophageal manometry, 24-h pH monitoring, esophagogram and upper endoscopy. Hiatal hernia, esophagitis, and Barrett's esophagus were present in a range of 73.9-76%, 39.2%, and 3.9-12.5%, respectively. The average time of surgical procedure ranged from 38 to 139 minutes. The location of the laparoscopic GEJ was found to be the same as that of the endoscopic GEJ in a range of 65-90% and different in a range of 10-35%, appearing proximal or distal to the endoscopically identified GEJ. In particular, Becerril-Martinez et al. (2006) (15) noticed that intraoperative endoscopy permitted the correction of the fundoplication in 27.79% of cases: in 88.3% of those, because of the angulation of the fundoplication; in 1.3% of cases the gastric fundus was redundant; in 9.1% of cases it was necessary a switch of the procedure from a complete fundoplication to a partial one. There were no deaths; complications occurred in a range of 0.3%-1.4%, such as bleeding, perforation, anesthesio-

logic complications, mucosal tear. Mean postoperative hospital stay was 2.9 ± 0.9 days. Patients had a follow-up of 1-13 years.

In case of congenital duodenal obstruction (DO), we report surgical records (25) of 33 patients with intraoperative diagnosis of DO, studied retrospectively. Surgical management required 26 bypass-procedure, 4 web excisions and 3 excisions of the Ladd. There were no signs of biliopancreatic tract lesions and no operative deaths. Outcome was considered excellent or good by patients or parents in all cases.

In case of GI bleeding in pediatric age, we present a case report (24). A 15 years old adolescent with Turner's syndrome was evaluated for GI bleeding, before the experience of 2 previous episodes of hemorrhage. She had undergone esophagogastroduodenoscopy as well as colonoscopy, abdominal CT scan with no source of bleeding identified. Laparoscopy was performed to identify any possible bleeding sites: several dilated vessels were noted on the surface of the small bowel as was an intestinal malrotation. Ladd's procedure was performed noticing the presence of dilated vessels from the ligament of Treitz to the ileocecal valve. The small bowel then was intussuscepted over a neonatal size endoscope, appreciating tortuous and dilated submucosal vessels and well-circumscribed hemangiomas in the ileum and in the jejunum, with evidence of recent bleeding and several of the vascular lesions. The patient has had no further evidence of bleeding in the 20 months since the initiation of estrogen therapy.

Regarding Peutz-Jeghers syndrome, 34 patients underwent laparoscopic-assisted enteroscopy. All patients had undergone upper and lower gastrointestinal endoscopy with polypectomy before surgery. Surgical procedures were required if intestinal obstruction occurred. Symptoms reported before the procedures were: abdominal pain, fullness, hematochezia. The entire procedure lasted with a range of 60-265 minutes, 506 PJS polyps were found (10-25 polyps per patient) without evidence of dysplasia, except for one case. No serious complications occurred. In 1 patient, a limited laceration of the mucosa of the small bowel was found together with some small submucosal hematomas, both of a traumatic nature. The majority of polyps were 5-8 mm (range: 0.5-4 cm). Postoperative hospital stay was

5-18 days. After procedure, the patient did not exhibit any gastrointestinal symptoms and could tolerate an oral diet. No patient required operative polypectomy within 4 years of polyp clearance by intraoperative enteroscopy. The median follow-up was 53 months (13-133 months).

Further analysis of the studies showed many critical points. Firstly, most of the studies took into account a small number of patients with a high variability (from 1 to 380 patients). Only six collected studies took into account more than 40 patients. The follow-up time was not homogeneous among the different studies. In most of the articles, comorbidities of patients were not taken into account. It was not possible to identify a statistically significant correlation between technique and complication rate. Each author in fact described the use of his personal surgical technique and clinical results, without uniformity.

Discussion and conclusion

In case of GERD, accurate identification of the GEJ is essential to the construction of an effective fundoplication. In fact, a wrap created around the stomach ("slipped") is a common cause of failure. Another cause of failure is hiatal herniation. To avoid this complication, the GEJ must first be identified precisely so the length of intraabdominal esophagus can be accurately determined. This will help to identify an otherwise unrecognized short esophagus and prevent these potential postoperative problems (16).

Regarding Achalasia, intraoperative endoscopy during Heller myotomy guides the extent and adequacy of myotomy, minimizing the postoperative dysphagia and allowing the possibility to evaluate intraoperatively the mucosal integrity (10, 13). It also allows evaluating the mucosal hermeticity, identifying eventual perforations that can occur (4).

In case of DO, intraoperative endoscopy did not change surgical management and duodeno-duodenostomy was the first-choice technique; endoscopy allowed accurate identification of obstruction position and etiology and recognized the Vater papilla making the surgical approach easier, avoiding biliary tract lesions and reducing post-operative morbidity and

mortality (25). Regarding GI bleeding, this report describes the successful use of intraoperative endoscopy to identify the source of bleeding, that was, in this case, beyond the reach of standard endoscopic attempts (24).

In case of Peutz-Jeghers syndrome, the distribution of PJS polyps throughout the GI tract makes surveillance and treatment challenging, particularly for polyps located within the small intestine. This approach offers a single, minimally invasive approach to the diagnosis and the treatment of small-bowel PJS polyps (19). A combined endoscopic and operative polypectomy achieves a clean intestine and may allow relatively long asymptomatic periods, reducing the need for emergency surgery with extensive intestinal resection (21,22).

In conclusion, intraoperative endoscopy is an indispensable tool for GI surgery. With experienced endoscopist surgeon and operating room staffs, intraoperative endoscopy can be done without added morbidity in time-efficient manner, while providing value in diagnosis and treatment (8).

The literature about intraoperative endoscopy demonstrates that this combined procedure is becoming an increasingly valuable tool in the operating room. Clearly, intraoperative endoscopy can be of significant benefit in solving a wide variety of gastrointestinal tract problems, independently from their complexity.

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