



Review

Advances in gastrointestinal surgical endoscopy

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ABSTRACT

Surgeons have a role in observing, detect abnormalities, disease, and other deficiencies in function which could be treated. Diagnosing and treating back days were challenging for many reasons. However, technology's innovation enhances surgeons' ability to treat their patients. The term *endoscopy* refers to the Greek prefix *endo-* ("within") and the verb *skopein* ("to view or observe"). Endoscopy is practical both in the diagnosis and treatment of various pathologies. Technological advances, especially in endoscopy, gradually progress and discover many possibilities which allow rapid advancement. Endoscopy development aims to assess human orifice that has not been inspected, probed, and examined over the centuries. Endoscopy over these decades is improving, which led to new problem solving using advanced technological approaches. Thus, a surgeon can solve any issues from examination, diagnosis, and treatment using progressive endoscopy evolution. This review delivers a brief history of advances in surgical endoscopy and describes current endoscopy development.

1. History

The earliest use of endoscopy was by Hippocrates (460–375 BC). It was used to observe the rectal fistula by using a rectal speculum (Fig. 1) [1–5]. The issue faced by this instrument was inadequate light and shallow depth of penetration; thus, Roman medicine produced a similar device and a three-bladed vaginal speculum discovered in the ruins of Pompeii (AD 70) [3].

Philipp Bozzini (1773–1809) deserved the most credit as the pioneer of modern endoscopy [2,3]. The Bozzini endoscopy is called *lichtleiter* (light conductor), a tin tube illuminated by a candle and reflected using an angled mirror (Fig. 2) [6]. This device was able to exam the urethra, bladder, and vagina [2,7]. In 1826, Pierre Ségalas applied the *lichtleiter* principle that the light reflected by a funnel made of polished silver. Therefore, he called it *the speculum urethro-cystique* [3,5]. Other development was done by Desormeaux in 1855 (Fig. 3); it was a better device although inadequate, even though light source came from lamp fueled with alcohol and turpentine [2,6].

Significant development of endoscopy is originated by Maximilian Nitze (1848–1906), a German urologist who collaborated with Wilhelm Deicke and Louis Beneche to produce a miniature telescope that magnified the image of the bladder using water-cooled platinum wire. Later in 1880, Thomas A. Edison's invention of light was being used by Maximilian to place a small lamp at the end of a cystoscope [5].

The semi-flexible tube endoscope, firstly developed by Georg Kelling in 1898, a surgeon, performed peritoneoscopy by placing a camera at the

endoscope's tip. Later, it was improved by Rudolf Schindler in collaborated with Georg Wolf and considered as the "father of gastroscopy." In 1957, Basil Hirschowitz produced a glass fiber gastroscope and upgraded it into a bundle of fiber called fiberoptic endoscopy (Table 1 & Fig. 4) [3].

2. Types of endoscopy

2.1. Per-oral endoscopic myotomy

The first endoscopic myotomy for achalasia was performed in 1980 by Ortega et al. For decades, this technique wasn't well improved, and there was no further report of the procedure. For the first time in Japan in 2008, Inoue et al. performed Per-Oral Endoscopic Myotomy (POEM) in a human being [8–11]. This technique is quite a novel minimally invasive, inspired by the concept of Natural Orifice Transluminal Endoscopic Surgery (NOTES) [9,12]. Initially, POEM was indicated only for nonsigmoid achalasia and later expanded to sigmoid achalasia following the successful procedure in the first five patients (Fig. 5) [8]. The alternative approach to treat achalasia is Heller myotomy; however, this technique is quite more invasive and has prominent adverse effects Table 2 [12].

In an earlier report by Inoue et al. in 2010, POEM was performed in 17 patients with achalasia and manifested significant results. Dysphagia symptoms score decreased from mean 10 to 1.3; $p < 0.0003$ and the resting lower esophageal sphincter (LES) pressure decreased from mean

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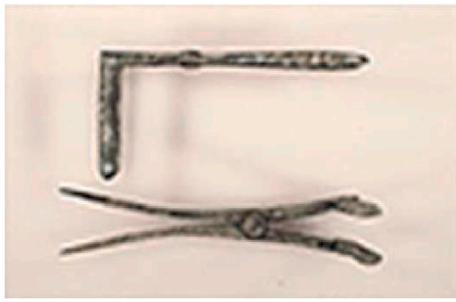


Fig. 1. Rectal speculum used by Hippocrates [5]. [Source: Historical Collections & Services, The Claude Moore Health Sciences Library, University of Virginia].

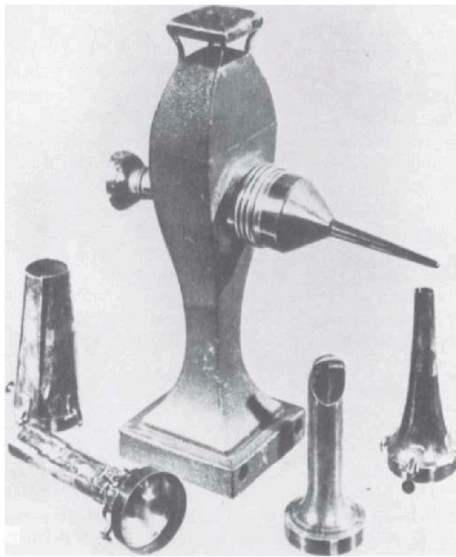


Fig. 2. *lichtleiter* [6] (Source: I. H. [Isaac Hayes], Instruments for illuminating dark cavities, *Philadelphia Journal of the Medical and Physical Sciences* 14 (1827):410; and Ernest Desnos, *L'Histoire de l'urologie* (1921), 285, Fig. 190).

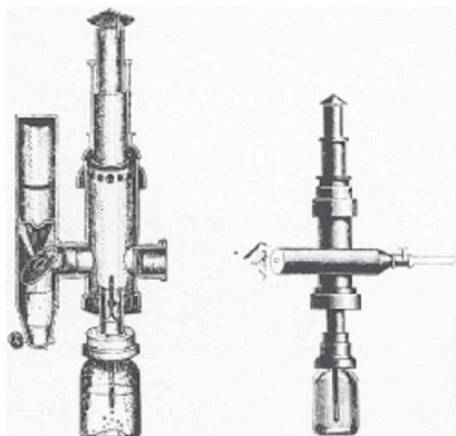


Fig. 3. Desormeaux's Endoscope [6]. (Source: Top, J. H. Gemrig, Illustrated catalogue of surgical instruments (ca. 1870), pI. xxx. Bottom, Robert Newman, the endoscope considered particularly in reference to diseases of the female bladder and urethra, *Transactions of the Medical Society of the State of New York for the Year 1870*, Fig. 2).

Table 1
Three periods in the history of gastrointestinal endoscopy [1].

Type	Period
Rigid Endoscopy	1805–1932
Semi-flexible Endoscopy	1932–1957
Fiberoptic Endoscopy	1957 - later

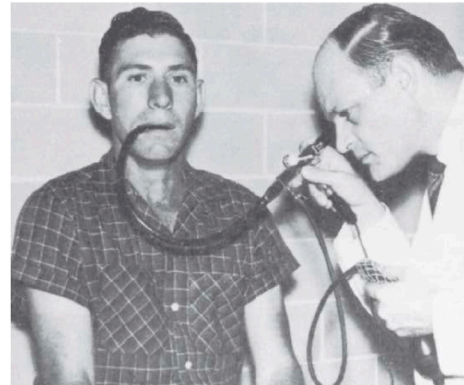


Fig. 4. Hirschowitz's fiberoptic endoscope [6]. (Source: Basil I. Hirschowitz, Endoscopic examination of the stomach and duodenal cap with the fiberscope, *Lancet* 1 (1961):1075, Fig. 2).

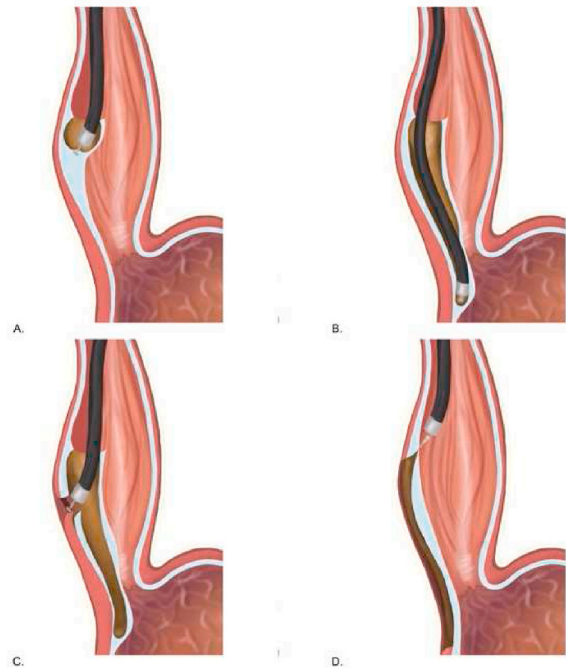


Fig. 5. Schematic procedure of POEM. (A) Entry to the submucosal space. (B) Dissecting along with the muscular layer beyond the gastroesophageal junction. (C) Myotomy of the circular esophageal and gastric muscle. (D) Closure of the mucosal entry site.

52.4 to 19.9 mmHg; $p < 0.0001$. The short-term outcome (5 months) of POEM was excellent, but further long-term studies are required [9,10]. Other studies of a series of 500 patients by Inoue et al. reported a successful outcome with adverse events found in 3.2% of patients. Significant reductions 2-month post-POEM in symptoms score (Eckardt score 6.0 ± 3.0 vs 1.0 ± 2.0 , $p < 0.0001$) and LES pressure (25.4 ± 17.1 vs 13.4 ± 5.9 mmHg, $p < 0.0001$) were achieved [13]. Akintoye et al. reported a meta-analysis of 36 studies involving 2373 patients with

significant results Eckardt score ≤ 3 was achieved in 98% patients post-surgery (95% confidence interval [CI] 97–100%). The mean Eckardt score decreased 6.9 ± 0.15 preoperatively to 0.77 ± 0.10 , 1.0 ± 0.10 , and 1.0 ± 0.008 within 1, 6 and 12 months of treatment respectively. A mean follow-up (8 months) showed the adverse effects of gastroesophageal reflux, esophagitis on esophagogastroduodenoscopy, and abnormal acid exposure were 8.5% (95 %CI 4.9%–13%), 13% (95 %CI 5.0%–23%), and 47% (95 %CI 21%–74%) respectively [12].

2.2. Percutaneous endoscopic gastrostomy

Placement of gastrostomy tube percutaneously guided with an endoscope introduced by Gauderer et al. in 1980 (Fig. 6) [14]. [15] Briefly, Percutaneous Endoscopic Gastrostomy (PEG) is a method to place a flexible tube through a temporary tunnel between the abdominal wall and gastric cavity, ensuring a direct passing of food into the patient's digestive tract [16].

This technique was originally developed for children, while nowadays, it is widely used for all ages of patients. Common disease states are responsible for these disorders, such as esophageal cancer, oropharyngeal cancer, esophageal dysmotility, and neurologic conditions (cerebral vascular accident or amyotrophic lateral sclerosis) that impairs or weakens swallowing [17]. Roughly, the two main indications of PEG insertion are enteral feeding and abdominal decompression [18]. Compared to a PEG tube, a nasogastric tube (NGT) results in additional complications, discomfort, and lower feeding efficacy. The advantages of PEG are the long-term use, up to 12–18 months with proper care, and minimal complications [16,18,19].

A review of 150 cases by Ponsky et al. described complications in 15 patients (10%). Superficial wound infections around the catheter were found in 7 patients. Nonetheless, administering a single preoperative dose of cephalosporin successfully prevented wound infections in 125 cases. Altogether of 150 PEGs, there were 0% mortality and 10% morbidity rates [20]. Another study by Miller et al. with 330 PEGs procedure obtained major complications in 2.1% patients, including five who developed peritonitis. However, no infection occurred at the gastrostomy site and the mortality rate was 0.6% [21]. Therefore, optimizing post-surgical care, preventive strategies, and treating early complications will maximize safety and effectiveness outcomes [22].

2.3. Endoscopic retrograde cholangiopancreatography

Endoscopic Retrograde Cholangiopancreatography (ERCP) was introduced in 1968 by Dr. William S. McCune, an obstetrician who performed ERCP using a fiber duodenoscope for a diagnostic tool. Later in 1972, Dr. Peter Cotton introduced cannulation in ERCP. In the

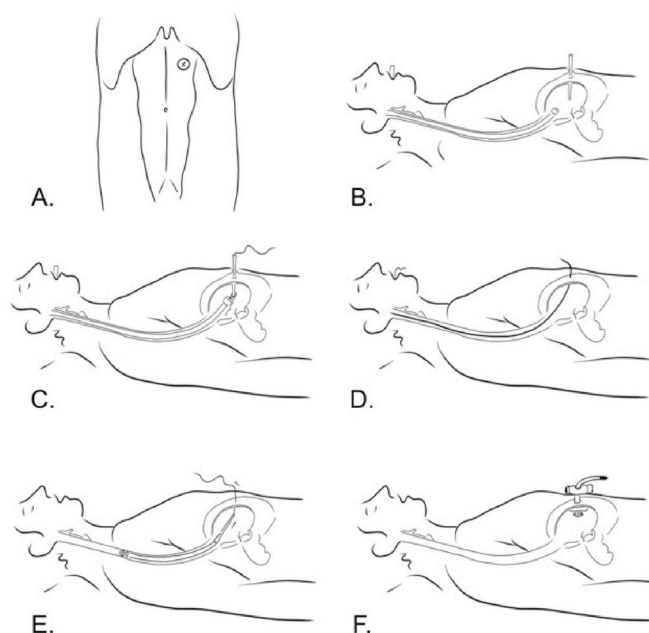


Fig. 6. (A) Site of PEG placement. (B) Insertion of the catheter into the gastric cavity. (C) A silk suture is passed through a catheter into the stomach. (D) The suture and gastroscop are removed through the patient's mouth. (E) The mushroom catheter is pulled down to the abdominal wall. (F) A second bumper is positioned in the outer part of the abdominal wall.

following years, Dr. Meinhard Classen in Germany and Keiichi Kawai in Japan discovered a therapeutic potential of ERCP with endoscopic sphincterotomy [23–25]. Briefly, ERCP (Fig. 7) combines endoscopy and fluoroscopy to treat pancreaticobiliary diseases. An endoscope is inserted until the ampulla of Vater is identified. A guidewire is then passed through the endoscope into the biliary or pancreatic ducts through the ampulla of Vater; this step is referred to as cannulation. Later, injection of contrast medium is performed under fluoroscopy to visualize the anatomy of biliary and pancreatic ducts [26].

The advances of high-resolution imaging modalities such as magnetic resonance imaging with magnetic resonance cholangiopancreatography (MRCP), pancreatic protocol computed tomography scans, endoscopic ultrasound (EUS) have substituted ERCP as a diagnostic tool. Thus, the therapeutic/interventional approach becomes the main focus of ERCP [25–27].

The indications of ERCP may vary in clinical situations. Most

Table 2

Advantages and disadvantages of each technique.

Types of Endoscopy	Year	Developer	Advantages	Disadvantages
Per-Oral Endoscopic Myotomy	2008	Inoue et al.	Less invasive, short- to long-term symptomatic relief, cheaper, shorter in duration	Higher complications rate, requires experienced endoscopists
Percutaneous Endoscopic Gastrostomy	1980	Gauderer et al.	Long-term use up to 12–18 months, minimal complications, lower mortality rate	Higher cost, requires complicated instrumentations
Endoscopic Retrograde Cholangiopancreatography	1968	Dr. William S. McCune	Acts as diagnostic & therapeutic modality, low complications rate	Invasive, limitation of visualization in the proximal ducts, operator dependent, requires sedation
Endoscopic Ultrasound	1980	Dimagno et al.	Low adverse events, high resolution imaging, less invasive, no radiation	Operator dependent, higher cost
Endoscopic Mucosal Resection	1955	Rosenberg	Noninvasive, lower cost, decreased hospitalization stay and procedural time	Higher risk of recurrence, no fibrotic lesions resection
Endoscopic Submucosal Dissection	1990s	Japan	Noninvasive, lower cost, achieves en bloc resection of lesions	Higher risk of recurrence, higher cost than EMR, longer procedural time
Colonic Decompression	1977	Kukora et al.	Safe technique, increase the operative time, decreased mortality	High risk of colonic perforation and fistula
Natural Orifice Transluminal Endoscopic Surgery	2003	Kaloo et al.	Lesser infection rate, minimal or no visible scar	Higher reconversion percentage, higher cost, suture problems
Endoscopic Sleeve Gastroplasty	2013	Abu Dayyeh et al.	Incision-less technique, safe procedure, no mortality	Micronutrients deficiency, high risk of bleeding & gastric fistula

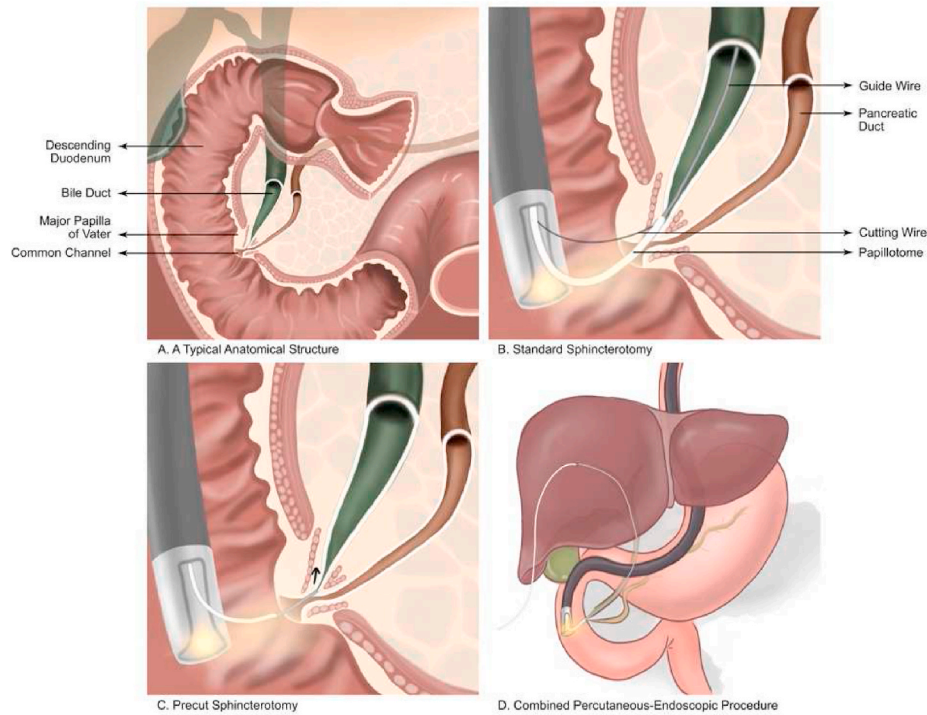


Fig. 7. (A) A typical anatomical structure, (B) Endoscopic biliary sphincterotomy, (C) A needle-knife precut method, (D) A transhepatic antegrade passage of a guidewire for completing the sphincterotomy.

commonly is used to treat biliary problems (choledocholithiasis, ascending cholangitis, strictures, biliary stenting, etc.) than pancreatic issues such as pancreatitis, pancreatic fistule, pancreatic fluid collections, etc. [26,28] Endoscopic retrograde cholangiopancreatography is contraindicated in uncooperative patients, bowel perforation, esophageal stenosis, coagulopathy and inability to sedate [26].

Various complications of ERCP might occur, such as post-ERCP pancreatitis (PEP), hemorrhage, perforation, cholangitis, cholecystitis, cardio-pulmonary depression, asymptomatic hyperamylasemia, aspiration, bleeding, hypoxia, sepsis, and death [24,27,28]. In a prospective, 2-year study of 2,347 patients from 17 institutions reported the most common complications, for example, PEP (9.8%), pancreatitis (5.4%), and hemorrhage (2%) [29]. Wang et al. performed 3,178 ERCP procedures in 2,691 patients and overall complications were developed in 213 (7.92%) patients, pancreatitis in 116 (4.31%), and asymptomatic hyperamylasemia in 396 (14.72%) [30]. Other report in the United Kingdom (UK) with data on 5264 ERCP, 230 patients (5%) suffered multiple complications such as pancreatitis in 74 (1.6%), cholangitis in 48 (1%), hemorrhage in 40 (0.9%), perforation in 20 (0.4%), and miscellaneous in 54 (1.2%) [31]. Study from Andriulli et al., involving 16,855 patients, ERCP-attributable complications are 1,154 (6.85%) with the following pancreatitis occurred in 585 patients (3.47%), infections in 242 (1.44%), bleeding in 216 (1.34%) and perforations in 101 (0.60%) [32].

2.4. Endoscopic ultrasound

Endoscopic ultrasound (EUS) has advanced from a diagnostic imaging modality discovered by Dimagno et al. in the 1980s to an interventional procedure [33–36]. The advantage of EUS is to visualize, interrogate and intervene gastrointestinal (GI) luminal, mural, or peri-mural structures and pathologies with minimal adverse events [37, 38].

Diagnostic EUS uses an echo-endoscope with several variants, such as radial or linear, and developed in 1991, referred to as EUS-fine-needle aspiration (EUS-FNA) [37]. On the other hand, interventional EUS has

evolved with many techniques, for example, EUS-guided drain-age (GD) of pancreatic fluids (PFCs), EUS-guided necrosectomy, EUS-guided cholangiography and biliary drainage (BD) (Fig. 8), EUS-guided pancreatography and pancreatic duct drainage (PDD), EUS-guided gallbladder drainage, EUS-GD of abdominal and pelvic fluid collections, EUS-guided celiac plexus block (CPB) and celiac plexus neurolysis (CPN), EUS-guided pancreatic cyst ablation, EUS-guided delivery of anti-tumoral agents and EUS-guided fiducial placement, brachytherapy and EUS-guided vascular interventions [34,38–40]. Most current literature suggests both diagnostic and interventional EUS as a feasible, safe, efficacious, and less invasive modality [37,41].

Current EUS with radial and linear echo-endoscope has a non-flexible transducer which produces a more rigid tip, 3–5 cm length, of echo-endoscope. Furthermore, an oblique endoscopic view, the echo-

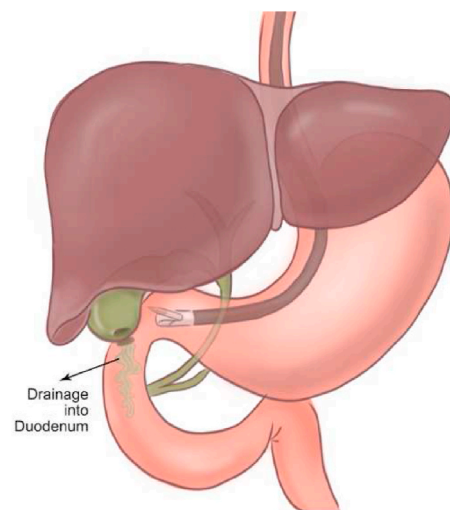


Fig. 8. Interventional EUS-guided gallbladder drainage through the duodenal wall.

endoscope insertion, and advancements of the instruments create a semi-manual maneuver; thus, adverse events, though rare, include perforation, bleeding, and infection. A study involving 43,852 subjects reported only 16 (0.03%) cervical esophageal perforation with only one death within the EUS procedures [37]. A prospective study by Bournet et al. reported zero death, no surgery, and three mild complications among patients who did diagnostic EUS. There were also five complications in interventional EUS, such as acute pancreatitis, duodenal perforation, upper digestive bleeding, and mediastinal infection with a mean delay of the occurrence is 30 h, and the mean duration of hospitalization is 7 days [42]. In comparison with diagnostic EUS, interventional EUS has a higher risk of complications due to operator-based experience and procedure difficulty. Nevertheless, interventional EUS has an overall success rate of more than 90% [43].

2.5. Endoscopic mucosal resection and endoscopic submucosal dissection

The history of endoscopic resection began in 1955 when Rosenberg introduced endoscopic mucosal resection (EMR) by creating a plane for fulguration of sigmoid and rectal polyps. Then in 1973, Dehyle utilized submucosal injection to the sessile or flat lesions for complete removal. At first, EMR was unpopular and regarded as a risky procedure. In the meantime, it became accepted in 1980, but sometimes EMR isn't dependable to ensure the complete resection of the tumors. Hence, endoscopic submucosal dissection (ESD) was developed in the 1990s for *en bloc* resection of lesions [44–47,85].

Endoscopic mucosal resection is a technique for removing sessile or flat lesions to the superficial layers of the gastrointestinal (GI) tract (Fig. 10). The maximum lesion diameter for resection is around 20 mm due to the physical size limitation of the operating snare. Therefore, lesions above 20 mm were removed by piecemeal resection with a higher chance of recurrence. The commonly used techniques are injection-, cap-, and ligation-assisted EMR (Fig. 9) [44,45,48–50,86,87]. The recent development is underwater EMR for salvaging EMR [51]. Injected-assisted EMR starts with injecting a solution into submucosal space, creating a “safety cushion.” Then the lesions are easily removed and minimize damage to gastrointestinal walls. This method can be further divided into the “inject-and-cut” technique and the “inject-lift-and-cut” technique [49]. The cap-assisted EMR requires a transparent plastic cup at the distal tip of the endoscope. The lesion is sucked into the

cap, and the snare is closed at the base of the lesion. Otherwise, in the ligation-assisted EMR, a rubber band is deployed at the base to create pseudo-polyp [46]. Endoscopic submucosal dissections developed for *en bloc* removal of large tumor above 20 mm and flat GI lesion (Fig. 11). Normal saline or sodium hyaluronate is injected into the submucosa layer of the lesion. The fluid-expanded submucosal space creates a precise resection control. Thus, achieving a radical excision of the lesions [45]. [51].

Both EMR and ESD are required for definitive therapy of early-stage (T1mN0) and malignant lesions of the GI tract. Another function of EMR and ESR is to obtain larger histological specimens and provide an accurate histologic T staging [45,49]. The major advantages of EMR are the relatively short time of the procedure (approximately 35 min for larger lesions), lower bleeding risk in 0.9%, and low perforation rate between 0.4 and 1.3% [52,53]. Fukami et al. also reported a higher complication rate in ESD with a bleeding risk of 4.8–5.7% compared with 2.3–3.5% in EMR. Perforation risk is 4.8% in ESD compared with 0.9–1.4% in EMR [54]. Meanwhile, ESD is superior in the *en bloc* resection, the complete resection, and the recurrence rates based on Lee et al. comparing EMR and ESR with a result of 42.9% vs 92.7%, 32.9% vs 87.6%, and 25.9% vs 0.8%, respectively [50]. Therefore, ESD is relatively superior to EMR and may prevent unnecessary surgery. Nevertheless, ESD requires highly trained operators and intensive training to reduce iatrogenic adverse events [46].

2.6. Colonic decompression

Acute colonic, such as acute colonic pseudo-obstruction (ACPO), colonic volvulus, and malignant obstruction, is a medical emergency with high morbidity and mortality. Colonic decompression is one of the established treatment strategies [55]. The first colonic decompression in 1977 by Kukora et al. with successful colonoscopic decompression in six patients for ACPO [56–58]. Following years later, Bernton et al. developed a new technique by including transanal colonic tubes with outstanding results [57]. In 2002, Morino et al. proposed a new minimally invasive procedure called endoscopic stent decompression. The result was quite promising, with zero complications [59]. Mainly, the goals of colonic decompression are to reduce the colon diameter, reduce wall tension, allow the blood to circulate, and restart peristaltic movement [55].

The advancing methods of colonic decompression expand the choices included radiologic placement of decompression tubes under fluoroscopy guidance and colonoscopic decompression with or without placement of a decompression tube. These techniques are recommended by the European Society of Gastrointestinal Endoscopy (ESGE) if the cecal diameter is more significant than 12 cm [55,60]. For performing colonic decompression, an endoscope is inserted through the site of obstruction. The obstructed lumen is identified by a black hole or tiny gas bubbles escaping from the block. A flexible guidewire is pushed through beyond the obstructed site. The endoscope is withdrawn, and a lubricated tube is advanced through the guidewire. The indications of successful insertion are immediate escape of air and liquid feces through the catheter [61].

A retrospective cohort study of 53 patients reported a clinical success rate of up to 92.5% and an additional decompression tube at an 86% success rate. The complication rate was 3.8% with one perforation [55]. Bode et al. described a series of 22 patients of ACPO who underwent colonic decompression. They summarized a 91% success rate in 20 of 22 patients, and a 4.5% complication rate resulted in the death of one patient [58]. Fischer et al. also narrated a promising result of successful endoscopic tube placement for 43 of 51 patients (84%) [62]. A comparative study of the standard medical therapy and colonic decompression groups included 61 and 83 patients who stated superiority of colonic decompression in several aspects, including complete resolution rate, readmission rate, and mortality, with overall results 19.9% vs 47.7%, 26.2% vs 15.7%, and 14.8% vs 8.4%, respectively [63].

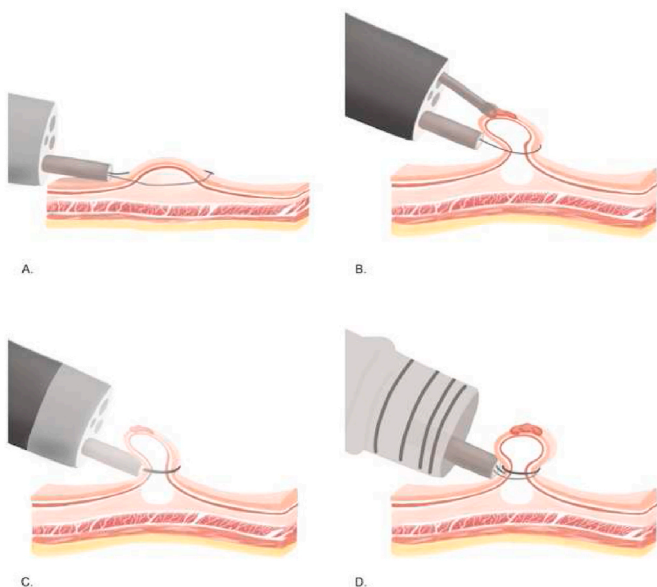


Fig. 9. Four techniques of EMR. (A) The Inject-and-cut technique. (B) The Inject-lift-and-cut technique. (C) The cap assisted EMR technique. (D) The ligation-assisted technique.

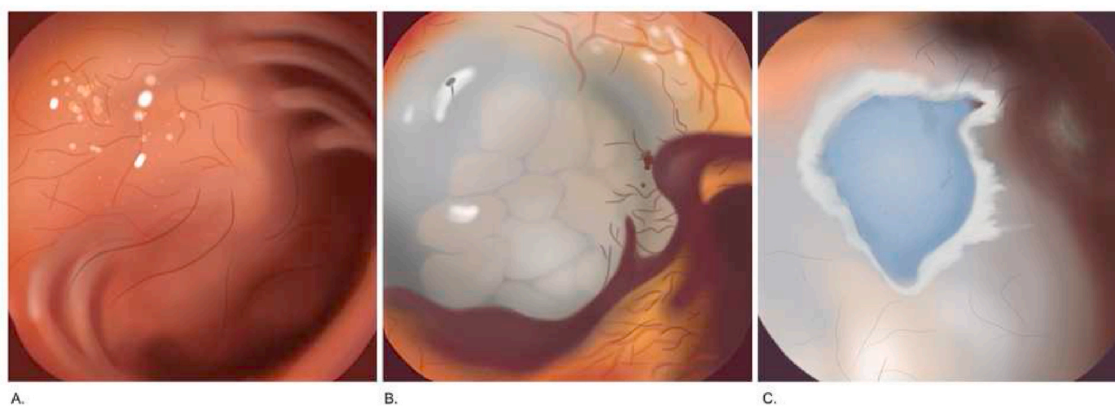


Fig. 10. Endoscopic mucosal resection. (A) Identification of flat lesion. (B) Injection of saline-tinted methylene blue dye solution. (C) Lesion appearance after EMR procedure and the muscular propia layer tinted with methylene blue dye. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

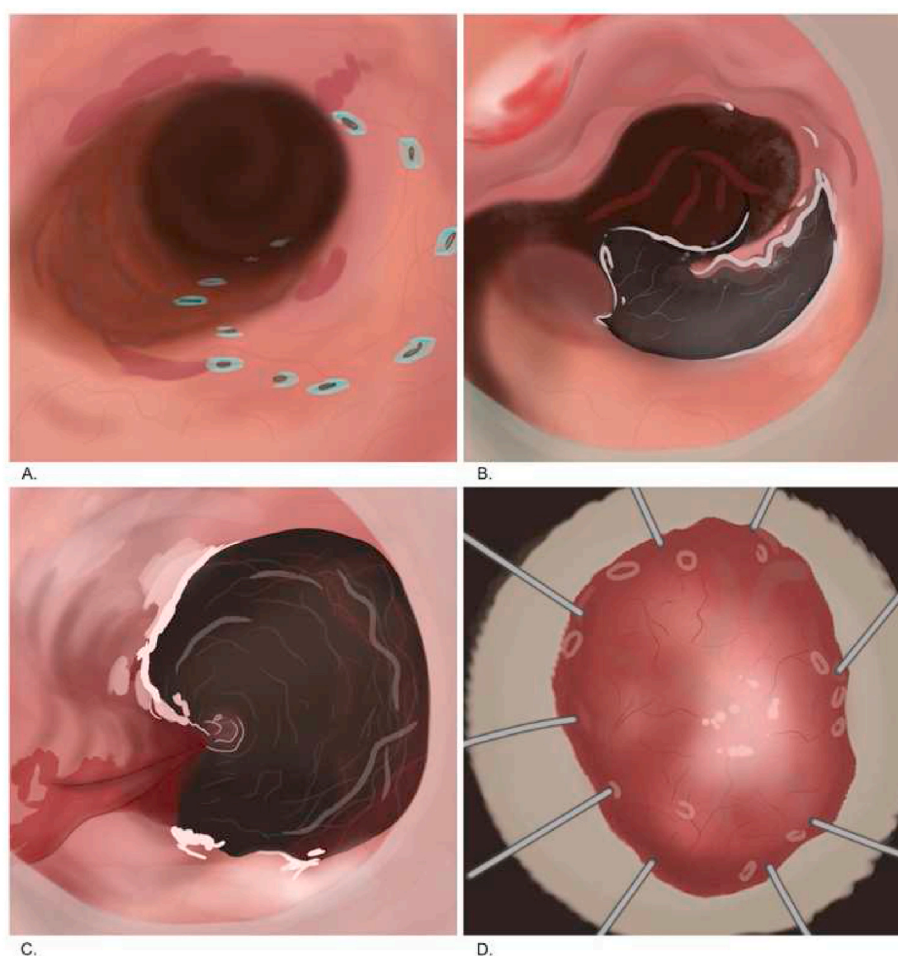


Fig. 11. Endoscopic submucosal dissection in early esophageal adenocarcinoma. (A) Marking. (B) Partial circumferential incision. (C) ESD mucosal defect. (D) Resected specimen.

In China, colonic decompression (Fig. 12) using the ileus tube was successfully performed in 45 of 46 patients (97.8%), with no leakage or stenosis occurred postoperatively [64]. All these studies stated above concluded the colonic decompression with or without decompression tube have proved to be safe, effective, and highly successful for treating colonic distention [55,58,62–64].

2.7. Natural orifice transluminal endoscopic surgery

Natural orifice transluminal endoscopic surgery (NOTES), widely known as a “scarless surgery,” has withdrawn attention in these recent years as a novel surgical method to develop minimally invasive surgery [65,66]. Kalloo et al. [67] is the pioneer of NOTES performed on swine. Later, the first human *trans*-gastric NOTES appendectomy was demonstrated by Rao and Reddy [68]. Originally, NOTES was used for

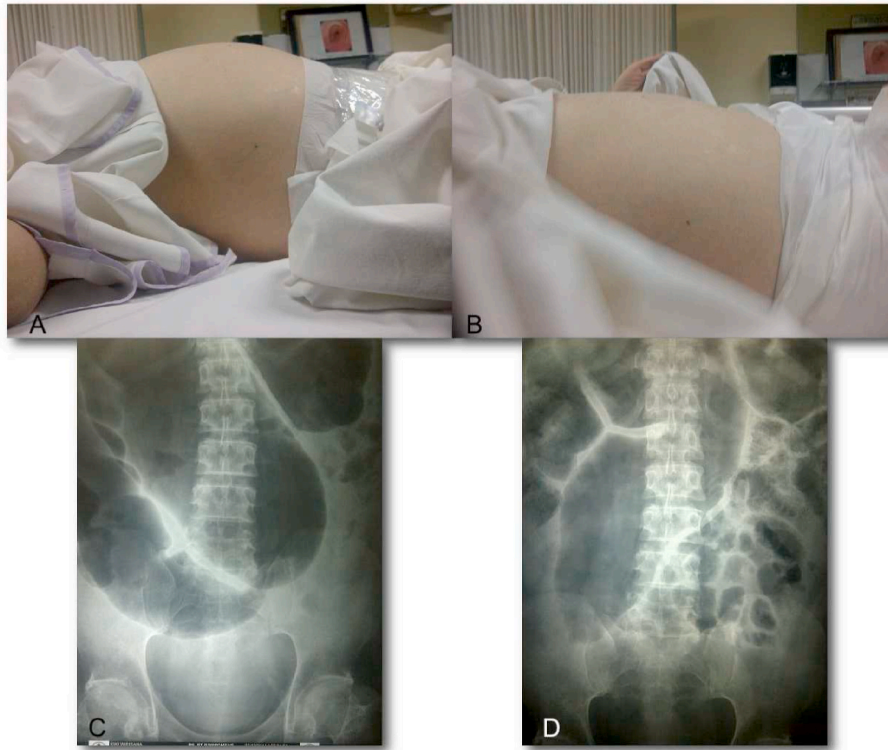


Fig. 12. (A) Clinical condition before ileus tube placement. (B) Seven days after colonic decompression. (C&D) Plain abdominal X-ray of the distended large bowel and an air-fluid level.

diagnosing and treating abdominal abnormalities, then improved to perform any surgery through natural orifices such as *trans*-esophageal, *trans*-gastric, *trans*-vaginal, *trans*-vesical, and *trans*-colonic. The main aims of the NOTES technique are to minimize cosmetic alteration, avoid abdominal incisions, and reduce invasiveness compared to traditional laparotomy or laparoscopic surgery [69–71].

The procedure begins with a standard single-channel gastroscopy and placement of an overtube. Clearance of the gastric contents by suction and gastric lavage, then flush the stomach with an antibiotic. Cefazolin is the recommended option for maximum results. The cleansing step has not been studied; however, this procedure is required to maintain the sterility of the peritoneal cavity. An incision is made in the anterior gastric wall as the most common site. Various instruments, including the needle-knife, insulation tipped (IT) knife, controlled radial expansion (CRE) balloon, or pull-type sphincterotome, can be used for gastrotomy. Subsequently, a gastroscope is inserted into the peritoneal cavity and visualizes abdominal organs (Figs. 13 and 14). Various procedures can be performed with many accessories of the endoscope (e.g., endoloops, endoclips, and biopsy). After the process is complete, the incision is closed with endoclips or suturing device [72].

As a novel method, NOTES provides many advantages compared to traditional laparotomies, such as zero incision and scar, less pain, injury, a reduced dosage of analgesic and anesthetic, rapid recovery, reduce hospitalization, and decrease inpatient complications (nosocomial infection, deep vein thrombosis, and pulmonary embolism) [69,73]. Consequently, NOTES will not accept widespread adoption until several limitations are solved. The endoscope is relatively small, making the retraction and dissection more challenging; hence, larger and solid instruments are necessary. Orientation also becomes a major challenge for NOTES due to the triangulation of laparoscopy is impossible. Some organs are difficult to localize (spleen and gallbladder); thus, EUS or mini probe (MP) aid is required. Closure and suturing are another main focus of NOTES because of the importance of minimizing perforation and infection risk. To date, animal studies of closure of the transluminal

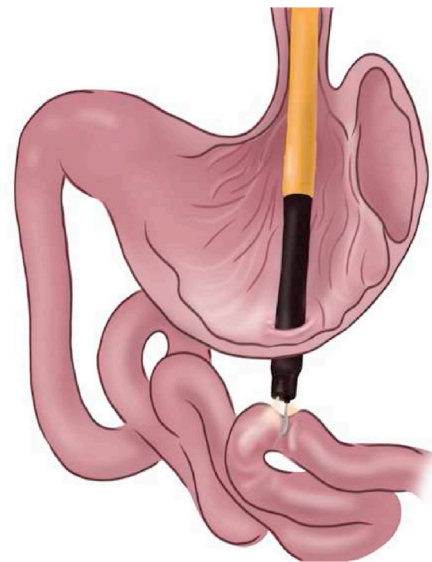


Fig. 13. Schematic view of endoscopic forceps grasps small bowel.

access were unsatisfactory due to microabscesses, peritonitis, and death. However, an available, safe, and simple closure instrument has not been found [74,88].

2.8. Endoscopic sleeve gastropasty

Obesity, type 2 diabetes mellitus, and cardiovascular disease dominate the epidemic proportions [75]. Bariatric surgery is a well-approved, proven, and effective solution for obesity and associated comorbidities [76,77]. Fogel et al. [78] in 2008 and Brethauer et al. [79] in 2010

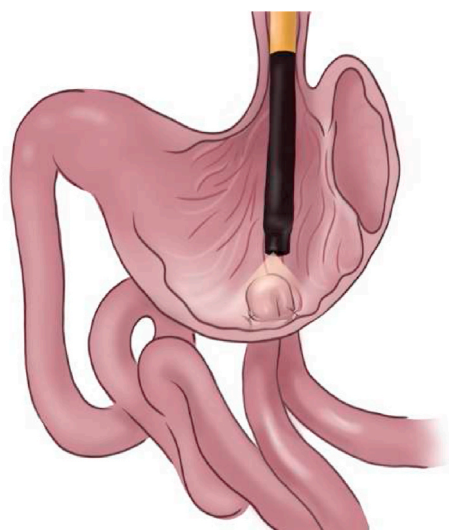


Fig. 14. Schematic view of small bowel fixed inside the gastric cavity with incisions.

demonstrated endoscopic gastric reduction using a superficial suturing device. Then, Abu Dayyeh et al. [75] performed the first endoscopic sleeve gastropasty (ESG) by creating a small diameter sleeve along the lesser curvature of the stomach.

Endoscopic sleeve gastropasty is an incision-less and minimally invasive technique that intentionally reduces the functional volume of the stomach by 80% using an interrupted triangular suture pattern created along the greater curvature of the stomach (Figs. 15 and 16) [76, 80,81]. Many studies proved ESG is an effective and safe method for reducing body weight and associated comorbidities. A prospective study of 91 patients with mean body mass index (BMI) $40.7 \pm 7 \text{ kg/m}^2$ had lost 14.4% of total BMI at the first six months, 17.6% at 12 months, and 20.9% at 24 months, alongside with significant reduction in hemoglobinA1c ($p = 0.01$), systolic blood pressure ($p = 0.02$), waist circumference ($p < 0.001$) and serum triglycerides ($p = 0.02$) [82]. Lopez-Nava et al. reported a mean BMI reduction in 50 patients from 37.7 ± 4.6 to $30.9 \pm 5.1 \text{ kg/m}^2$ at one year with no significant adverse events [83]. Other studies stated post-ESG results in 10 patients with a mean BMI of

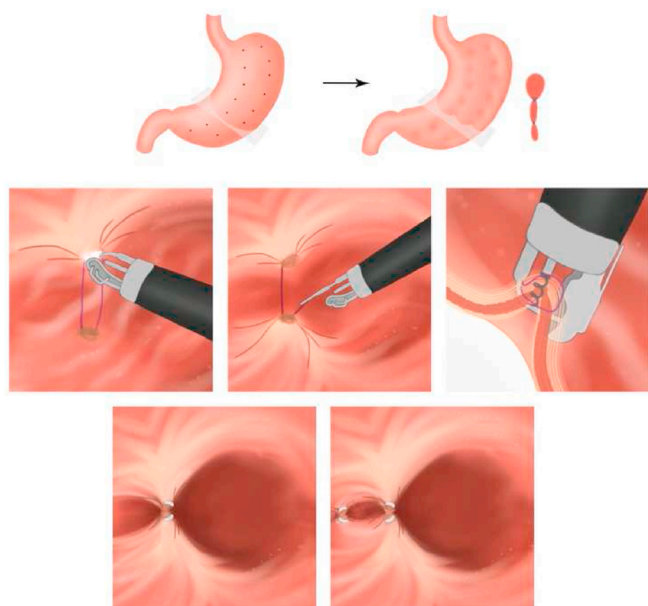


Fig. 15. Interrupted triangular suture technique in ESG.

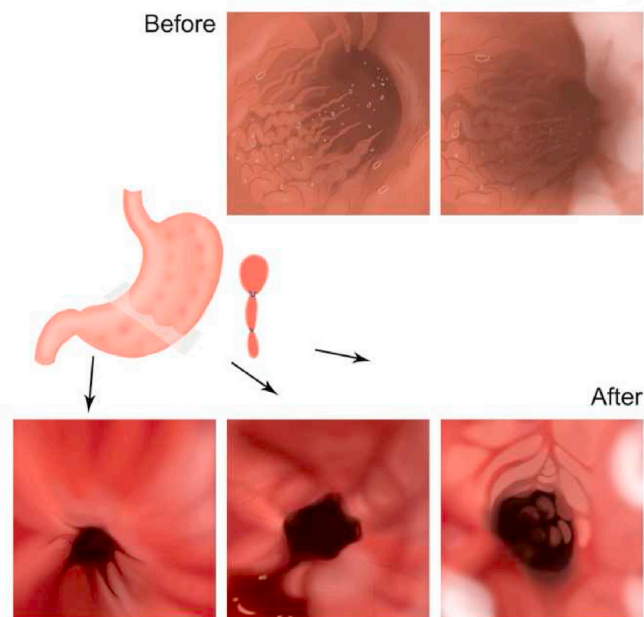


Fig. 16. Before and after ESG.

45.2 kg/m^2 after one month, three months, and six months mean weight loss of 11.5 kg, 19.4 kg, and 33 kg no adverse events noted [84]. Thus, ESG is a practical, reproducible, and safe procedure to decrease body weight and prevent further complications due to associated comorbidities.

3. Conclusions

Inventions and developments of surgical techniques in endoscopy have evolved within decades. Surgeons collaborate to generate something according to patient conditions to minimize adverse events, enhance life quality, and improve safety. Alongside technology's advancement and surgeons' capability, recent methods are improving and promising a genuine endoscopy; thus, each step ahead alters the function of endoscopy into branches.

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Author contributes in study concept, data collection, and writing the paper of this article.

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Reno Rudiman acts as the author and the guarantor of this article.

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Declaration of competing interest

Author declares no conflict of interest.

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References

- [1] K. Dolay, M. Hasbahçeci, The role of surgeons on the development and performance of endoscopy, *Turk. J. Surg.* 33 (2017) 1–4.
- [2] J.L. Achord, V.R. Muthusamy, The History of Gastrointestinal Endoscopy, Third Edit. Clinical Gastrointestinal Endoscopy. Elsevier Inc., 2019, 2-11.e1.
- [3] C.J. Davis, A history of endoscopic surgery, *Surg. Laparosc. Endosc.* 2 (1992) 16–23.
- [4] P. Valdastrì, M. Simi, R.J. Webster, Advanced technologies for gastrointestinal endoscopy, *Annu. Rev. Biomed. Eng.* 14 (2012) 397–429.
- [5] J. Shah, Endoscopy through the ages, *BJU Int.* 89 (2002) 645–652.
- [6] J.M. Edmonson, History of the instruments for gastrointestinal endoscopy, *Gastrointest. Endosc.* 37 (1991) S27–S56.
- [7] J.L. Ponsky, A.T. Strong, A history of flexible gastrointestinal endoscopy, *Surg. Clin. North Am.* 100 (2020) 971–992.
- [8] R. Bechara, H. Ikeda, H. Inoue, Peroral endoscopic myotomy: an evolving treatment for Achalasia, *Nat. Rev. Gastroenterol. Hepatol.* 12 (2015) 410–426.
- [9] H. Inoue, H. Minami, Y. Kobayashi, Y. Sato, M. Kaga, M. Suzuki, Per-Oral endoscopic myotomy (POEM) for esophageal achalasia, *Curr. Gastroenterol. Rep.* 16 (2014) 265–271.
- [10] H. Inoue, K.M. Tianle, H. Ikeda, T. Hosoya, M. Onimaru, A. Yoshida, et al., Peroral endoscopic myotomy for esophageal achalasia: technique, indication, and outcomes, *Thorac. Surg. Clin.* 21 (2011) 519–525.
- [11] R. Bechara, M. Onimaru, H. Ikeda, H. Inoue, Per-oral endoscopic myotomy, 1000 cases later: pearls, pitfalls, and practical considerations, *Gastrointest. Endosc.* 84 (2016) 330–338.
- [12] E. Akintoye, N. Kumar, I. Obaitan, Q.A. Alayo, Christopher C. Thompson, Peroral endoscopic myotomy, *Achalasia Diagnosis Treat.* (2015) 45–50.
- [13] H. Inoue, H. Sato, H. Ikeda, M. Onimaru, C. Sato, H. Minami, et al., Per-Oral endoscopic myotomy: a series of 500 patients, *J. Am. Coll. Surg.* 221 (2015) 256–264.
- [14] M.W.L. Gauderer, J.L. Ponsky, R.J. Izant, Gastrostomy without laparotomy: a percutaneous endoscopic technique, *J. Pediatr. Surg.* 15 (1980) 872–875.
- [15] J.L. Ponsky, M.W.L. Gauderer, Percutaneous endoscopic gastrostomy: a nonoperative technique for feeding gastrostomy, *Gastrointest. Endosc.* 27 (1981) 9–11.
- [16] A.B. Frigal-Ruiz, A.J. Lucendo, Percutaneous endoscopic gastrostomy: a practical overview on its indications, placement conditions, management, and nursing care, *Gastroenterol. Nurs.* 38 (2015) 354–366.
- [17] M.H. DeLegge, Percutaneous endoscopic gastrostomy, *Am. J. Gastroenterol.* 102 (2007) 2620–2623.
- [18] A.A. Rahnama-Azar, A.A. Rahnamaiazar, R. Naghshizadian, A. Kurtz, D.T. Farkas, Percutaneous endoscopic gastrostomy: indications, technique, complications, and management, *World J. Gastroenterol.* 20 (2014) 7739–7751.
- [19] S.P. Schrag, R. Sharma, N.P. Jaik, M.J. Seamon, J.J. Lukaszczuk, N.D. Martin, et al., Complications related to Percutaneous Endoscopic Gastrostomy (PEG) tubes. A comprehensive clinical review, *J. Gastrointest. Liver Dis.* 16 (2007) 407–418.
- [20] J.L. Ponsky, M.W.L. Gauderer, T.A. Stellato, Percutaneous endoscopic gastrostomy, *Arch. Surg.* (1983) 913–914.
- [21] R.E. Miller, B. Castlemain, F.J. Lacqua, D.P. Kotler, Percutaneous endoscopic gastrostomy, *Surg. Endosc.* (1989) 1123–1135.
- [22] A.J. Lucendo, A.B. Frigal-Ruiz, Percutaneous endoscopic Gastrostomy: an update on its indications, management, complications, and care, *Rev. Esp. Enferm. Dig.* 106 (2014) 529–539.
- [23] J.A. Søreide, L.N. Karlsen, G. Sandblom, L. Enochsson, Endoscopic retrograde cholangiopancreatography (ERCP): lessons learned from population-based national registries: a systematic review, *Surg. Endosc.* (2019), 0:0.
- [24] M. Pekgöz, Post-endoscopic retrograde cholangiopancreatography pancreatitis: a systematic review for prevention and treatment, *World J. Gastroenterol.* 25 (2019) 4019–4042.
- [25] R.A. Kozarek, Advances in endoscopy, *Gastroenterol. Hepatol.* (2017), 620–2.
- [26] G. Nallamothu, K. Hilden, D.G. Adler, Endoscopic retrograde cholangiopancreatography for non-gastroenterologists: what you need to know, *Hosp. Pract.* 39 (2011) 70–80, 1995.
- [27] T. Rustagi, P.A. Jamidar, Endoscopic retrograde cholangiopancreatography-related adverse events. General overview, *Gastrointest. Endosc. Clin. N. Am.* 25 (2015) 97–106.
- [28] N.M. Szary, F.H. Al-Kawas, Complications of endoscopic retrograde cholangiopancreatography: how to avoid and manage them, *Gastroenterol. Hepatol.* 9 (2013) 496–504.
- [29] M.L. Freeman, D.B. Nelson, S. Sherman, G.B. Haber, M.E. Herman, Complications of endoscopic biliary sphincterotomy, *N. Engl. J. Med.* (1996) 909–918.
- [30] P. Wang, Z.S. Li, F. Liu, X. Ren, N.H. Lu, Z.N. Fan, et al., Risk factors for ERCP-related complications: a prospective multicenter study, *Am. J. Gastroenterol.* 104 (2009) 31–40.
- [31] E.J. Williams, S. Taylor, A. Hamlyn, R.F. Logan, D. Martin, S.A. Riley, et al., Risk factors for complication following ERCP: results of a large-scale, prospective multicenter study, *Endoscopy* (2007) 793–801.
- [32] A. Andriulli, S. Loperfido, G. Napolitano, G. Niro, M.R. Valvano, F. Spirito, et al., Incidence rates of post-ERCP complications: a systematic survey of prospective studies, *Am. J. Gastroenterol.* 102 (2007) 1781–1788.
- [33] E.P. Dimagno, J.L. Buxton, P.T. Regan, R.R. Hattery, D.A. Wilson, J.R. Suarez, et al., Methods and Devices ULTRASONIC ENDOSCOPE, 1978, pp. 629–631.
- [34] C. Fabbri, C. Luigiano, A. Lisotti, V. Cennamo, C. Virgilio, G. Caletti, et al., Endoscopic ultrasound-guided treatments: are we getting evidence based - a systematic review, *World J. Gastroenterol.* 20 (2014) 8424–8448.
- [35] M.I. Costache, S. Iordache, J.G. Karstensen, A. Săftoiu, P. Vilmann, Endoscopic ultrasound-guided fine needle aspiration: from the past to the future, *Endosc. Ultrasound* 2 (2013) 77–85.
- [36] K. Yamao, A. Sawaki, N. Mizuno, Y. Shimizu, Y. Yatabe, T. Koshikawa, Endoscopic ultrasound-guided fine-needle aspiration biopsy (EUS-FNAB): past, present, and future, *J. Gastroenterol.* 40 (2005) 1013–1023.
- [37] S. Lakhtakia, Complications of diagnostic and therapeutic endoscopic ultrasound, *Best Pract. Res. Clin. Gastroenterol.* 30 (2016) 807–823.
- [38] V. Sharma, S.S. Rana, D.K. Bhasin, Endoscopic ultrasound guided interventional procedures, *World J. Gastrointest. Endosc.* (2015) 628–642.
- [39] S. Ryozaawa, N. Fujita, A. Irisawa, Y. Hirooka, T. Mine, Current status of interventional endoscopic ultrasound, *Dig. Endosc.* 29 (2017) 559–566.
- [40] C.R. Simons-Linares, P. Chahal, Advances in interventional endoscopic ultrasound (EUS): a technical review, *J. Clin. Gastroenterol.* 54 (2020) 579–590.
- [41] C. Jenssen, M.V. Alvarez-Sánchez, B. Napoléon, S. Faiss, Diagnostic endoscopic ultrasonography: assessment of safety and prevention of complications, *World J. Gastroenterol.* 18 (2012) 4659–4676.
- [42] B. Bournet, I. Miguères, M. Delacroix, D. Vigouroux, J.-L. Bornet, J. Escourrou, et al., Early morbidity of endoscopic ultrasound: 13 years' experience at a referral center, *Endoscopy* (2005) 349–354.
- [43] M. Saumoy, M. Kahaleh, Safety and complications of interventional endoscopic ultrasound, *Clin. Endosc.* 51 (2018) 235–238.
- [44] P. Kandel, M.B. Wallace, Colorectal endoscopic mucosal resection (EMR), *Best Pract. Res. Clin. Gastroenterol.* 31 (2017) 455–471.
- [45] M.D. Landin, A.D. Guerrero, Endoscopic mucosal resection and endoscopic submucosal dissection, *Surg. Clin. North Am.* 100 (2020) 1069–1078.
- [46] T. Nishizawa, N. Yahagi, Endoscopic mucosal resection and endoscopic submucosal dissection: technique and new directions, *Curr. Opin. Gastroenterol.* 33 (2017) 315–319.
- [47] Y. Cao, C. Liao, A. Tan, Y. Gao, Z. Mo, F. Gao, Meta-analysis of endoscopic submucosal dissection versus endoscopic mucosal resection for tumors of the gastrointestinal tract, *Endoscopy* 41 (2009) 751–757.
- [48] J.H. Hwang, V. Konda, B.K. Abu Dayyeh, S.S. Chauhan, B.K. Enestvedt, L.L. Fujii-Lau, et al., Endoscopic mucosal resection, *Gastrointest. Endosc.* 82 (2015) 215–226.
- [49] S.V. Kantsevov, D.G. Adler, J.D. Conway, D.L. Diehl, F.A. Farraye, R. Kwon, et al., Endoscopic mucosal resection and endoscopic submucosal dissection, *Gastrointest. Endosc.* 68 (2008) 11–18.
- [50] E.J. Lee, J.B. Lee, S.H. Lee, E.G. Youk, Endoscopic treatment of large colorectal tumors: comparison of endoscopic mucosal resection, endoscopic mucosal resection-precutting, and endoscopic submucosal dissection, *Surg. Endosc.* 26 (2012) 2220–2230.
- [51] S. Tanaka, H. Kashida, Y. Saito, N. Yahagi, H. Yamano, S. Saito, et al., Japan Gastroenterological Endoscopy Society guidelines for colorectal endoscopic submucosal dissection/endoscopic mucosal resection, *Dig. Endosc.* 32 (2020) 219–239.
- [52] F.L. Dumoulin, R. Hildenbrand, Endoscopic resection techniques for colorectal neoplasia: current developments, *World J. Gastroenterol.* 25 (2019) 300–307.
- [53] M. Tao, X. Zhou, M. Hu, J. Pan, Endoscopic submucosal dissection versus endoscopic mucosal resection for patients with early gastric cancer: a meta-analysis, *BMJ Open* 9 (2019) 1–13.
- [54] N. Fukami, Surgery versus endoscopic mucosal resection versus endoscopic submucosal dissection for large polyps: making sense of when to use which approach, *Gastrointest. Endosc. Clin. N. Am.* 29 (2019) 675–685.
- [55] S. Belle, Endoscopic decompression in colonic distension, *Vis. Med.* 37 (2021) 142–148.

- [56] J.S. Kukora, T.L. Dent, Colonoscopic decompression of massive nonobstructive cecal dilation, *Arch. Surg.* 112 (1977) 512–517.
- [57] E. Bernton, R. Myers, T. Reyna, Pseudoobstruction of the colon: case report including a new endoscopic treatment, *Gastrointest. Endosc.* 28 (1982) 90–92.
- [58] W.E. Bode, R.W. Beart, R.J. Spencer, C.E. Cuij, B.G. Wolff, B.M. Taylor, Colonoscopic decompression for acute pseudo-obstruction of the colon (Ogilvie's syndrome). Report of 22 cases and review of the literature, *Am. J. Surg.* 147 (1984) 243–245.
- [59] M. Morino, A. Bertello, A. Garbarini, G. Rozzio, A. Repici, Malignant colonic obstruction managed by endoscopic stent decompression followed by laparoscopic resections, *Surg. Endosc. Other Interv. Tech.* 16 (2002) 1483–1487.
- [60] M.E. Harrison, M.A. Anderson, V. Appalaneni, S. Banerjee, T. Ben-Menachem, B. D. Cash, et al., The role of endoscopy in the management of patients with known and suspected colonic obstruction and pseudo-obstruction, *Gastrointest. Endosc.* 71 (2010) 669–679.
- [61] S. Lelcuk, J.M. Klausner, A. Merhav, J. Ratan, Y. Skornich, R.R. Rozin, Endoscopic decompression of acute colonic obstruction, *Ann. Surg.* (1986) 292–294.
- [62] A. Fischer, H.J. Schrag, M. Goos, R. Obermaier, U.T. Hopt, P.K. Baier, Transanal endoscopic tube decompression of acute colonic obstruction: experience with 51 cases, *Surg. Endosc. Other Interv. Tech.* 22 (2008) 683–688.
- [63] G.N. Mankaney, S. Sarvepalli, Z. Arora, A. Kamal, R. Lopez, J.J. Vargo, et al., Colonic decompression reduces proximal acute colonic pseudo-obstruction and related symptoms, *Dis. Colon Rectum* 63 (2020) 60–67.
- [64] M. Xu, Y. Zhong, L. Yao, J. Xu, P. Zhou, P. Wang, et al., Endoscopic decompression using a transanal drainage tube for acute obstruction of the rectum and left colon as a bridge to curative surgery, *Colorectal Dis.* 11 (2009) 405–409.
- [65] S. Ling Li, E. Zhao, L. Zhao, Z. Kai Wang, W. Li, Transvaginal natural orifice transluminal endoscopic surgery in the diagnosis of ascites of unknown origin, *Gastrointest. Endosc.* 89 (2019) 872–877.
- [66] R. Rudiman, E. Wiradisuria, Initial experience with laparoscopic-assisted transvaginal cholecystectomy: a hybrid approach to natural orifice surgery, *Int. Surg.* 94 (2009) 258–261.
- [67] A.N. Kalloo, V.K. Singh, S.B. Jagannath, H. Niiyama, S.L. Hill, C.A. Vaughn, et al., Flexible transgastric peritoneoscopy: a novel approach to diagnostic and therapeutic interventions in the peritoneal cavity, *Gastrointest. Endosc.* 60 (2004) 114–117.
- [68] P. Rao, N. Reddy, Per oral transgastric endoscopic appendectomy in human, *Proc. 45th Annu. Conf. Soc. Gastrointest. Endosc. India* (2004) 28–29.
- [69] J. Wang, L. Zhang, W. Wu, Current progress on natural orifice transluminal endoscopic surgery (NOTES), *Front. Med. China* 6 (2012) 187–194.
- [70] A. Arezzo, C. Zornig, H. Mofid, K.H. Fuchs, W. Breithaupt, J. Noguera, et al., The EURO-NOTES clinical registry for natural orifice transluminal endoscopic surgery: a 2-year activity report, *Surg. Endosc.* 27 (2013) 3073–3084.
- [71] R. Autorino, R. Yakoubi, W.M. White, M. Gettman, M. De Sio, C. Quattrone, et al., Natural orifice transluminal endoscopic surgery (NOTES): where are we going? A bibliometric assessment, *BJU Int.* 111 (2013) 11–16.
- [72] M.S. Wagh, C.C. Thompson, Surgery Insight: natural orifice transluminal endoscopic surgery - an analysis of work to date, *Nat. Clin. Pract. Gastroenterol. Hepatol.* 4 (2007) 386–392.
- [73] M.F. McGee, M.J. Rosen, J. Marks, R.P. Onders, A. Chak, A. Faulx, et al., A primer on natural orifice transluminal endoscopic surgery: building a new paradigm, *Surg. Innovat.* 13 (2006) 86–93.
- [74] C. Huang, R.X. Huang, Z.J. Qiu, Natural orifice transluminal endoscopic surgery: new Minimally invasive surgery come of age, *World J. Gastroenterol.* 17 (2011) 4382–4388.
- [75] B.K. Abu Dayyeh, E. Rajan, C.J. Gostout, Endoscopic sleeve gastrectomy: a potential endoscopic alternative to surgical sleeve gastrectomy for treatment of obesity, *Gastrointest. Endosc.* 78 (2013) 530–535.
- [76] A. Alqahtani, A. Al-Darwish, A.E. Mahmoud, Y.A. Alqahtani, M. Elahmedi, Short-term outcomes of endoscopic sleeve gastrectomy in 1000 consecutive patients, *Gastrointest. Endosc.* 89 (2019) 1132–1138.
- [77] G. Lopez-Nava, M. Galvao, I. Bautista-Castaño, J. Fernandez-Corbelle, M. Trell, Endoscopic sleeve gastrectomy with 1-year follow-up: factors predictive of success, *Endosc. Int. Open* 4 (2016) E222–E227.
- [78] R. Fogel, J. De Fogel, Y. Bonilla, R. De La Fuente, Clinical experience of transoral suturing for an endoluminal vertical gastrectomy: 1-year follow-up in 64 patients, *Gastrointest. Endosc.* 68 (2008) 51–58.
- [79] S.A. Brethauer, B. Chand, P.R. Schauer, C.C. Thompson, Transoral gastric volume reduction for weight management: technique and feasibility in 18 patients, *Surg. Obes. Relat. Dis.* 6 (2010) 689–694.
- [80] B.K. Abu Dayyeh, A. Acosta, M. Camilleri, M.S. Mundi, E. Rajan, M.D. Topazian, et al., Endoscopic sleeve gastrectomy alters gastric physiology and induces loss of body weight in obese individuals, *Clin. Gastroenterol. Hepatol.* 15 (2017) 37–43. e1.
- [81] G. Lopez-Nava, R.Z. Sharaiha, E.J. Vargas, F. Bazerbachi, G.N. Manoel, I. Bautista-Castaño, et al., Endoscopic sleeve gastrectomy for obesity: a multicenter study of 248 patients with 24 Months follow-up, *Obes. Surg.* 27 (2017) 2649–2655.
- [82] R.Z. Sharaiha, N.A. Kumta, M. Saumoy, A.P. Desai, A.M. Sarkisian, A. Benevenuto, et al., Endoscopic sleeve gastrectomy significantly reduces body mass index and metabolic complications in obese patients, *Clin. Gastroenterol. Hepatol.* 15 (2017) 504–510.
- [83] G. Lopez-Nava, M.P. Galvão, I. Bautista-Castaño, A. Jimenez-Baños, J. P. Fernandez-Corbelle, Endoscopic sleeve gastrectomy: how I do it? *Obes. Surg.* 25 (2015) 1534–1538.
- [84] R.Z. Sharaiha, P. Kedia, N. Kumta, E.M. Defilippis, M. Gaidhane, A. Shukla, et al., Initial experience with endoscopic sleeve gastrectomy: technical success and reproducibility in the bariatric population, *Endoscopy* 2012 (2014).
- [85] R.M. Soetikno, T. Gotoda, Y. Nakanishi, N. Soehendra, Endoscopic mucosal resection, *Gastrointest. Endosc.* 57 (2003) 567–579.
- [86] N.A. Ahmad, M.L. Kochman, W.B. Long, E.E. Furth, G.G. Ginsberg, Efficacy, safety, and clinical outcomes of endoscopic mucosal resection: a study of 101 cases, *Gastrointest. Endosc.* 55 (2002) 390–396.
- [87] A. Bhatt, S. Abe, A. Kumaravel, J. Vargo, Y. Saito, Indications and techniques for endoscopic submucosal dissection, *Am. J. Gastroenterol.* 110 (2015) 784–791.
- [88] S.V. Kantsevov, S.B. Jagannath, H. Niiyama, S.S.C. Chung, P.B. Cotton, C. J. Gostout, et al., Endoscopic gastrojejunostomy with survival in a porcine model, *Gastrointest. Endosc.* 62 (2005) 287–292.