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Emergencies after endoscopic procedures

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A B S T R A C T

Endoscopy adverse events (AEs), or complications, are a rising concern on the quality of endoscopic care, given the technical advances and the crescent complexity of therapeutic procedures, over the entire gastrointestinal and bilio-pancreatic tract. In a small percentage, not established, there can be real emergency conditions, as perforation, severe bleeding, embolization or infection. Distinct variables interfere in its occurrence, although, the awareness of the operator for their potential, early recognition, and local organized facilities for immediate handling, makes all the difference in the subsequent outcome. This review outlines general AEs' frequencies, important predisposing factors and putative prophylactic measures for specific procedures (from conventional endoscopy to endoscopic cholangio-pancreatography and ultra-sonography), with comprehensive approaches to the management of emergent bleeding and perforation.

Introduction

Both patients and practitioners expect their endoscopy procedures go according to plan. However, for several reasons some patients experience complications or, as correctly mentioned, adverse events

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(AEs) [1]. Even though there is substantial literature describing series of AEs, well-designed prospective trials and a standardized nomenclature with agreed-on definitions are lacking [1–3].

Recently an AE was defined as a situation that prevents completion of the planned procedure and/or results in admission to hospital, prolongation of existing hospital stay, another procedure (needing sedation/anesthesia), or subsequent medical consultation. AEs are distinct from incidents, also unplanned events, but that do not interfere with completion of the procedure; an example of this includes bleeding that stops spontaneously or with endoscopic therapy during the procedure. Concerning the timing, AEs can occur pre-, intra- (from entering the preparation area through leaving the endoscopy room), post- (up to 14 days), and late-procedure (any time after 14 days, usually up to 30 days) [1,2].

In this manuscript, we will discuss emergent AEs after endoscopic procedures – serious and unexpected situations that demands immediate action. Although cardiopulmonary and sedation-related events account for more than 50% of the severe morbidity and mortality related to gastrointestinal (GI) endoscopy [4], this document will focus only on major AEs related to endoscopic equipment direct harm, mainly haemorrhage, perforation, infection and embolization. Even though no sufficient consensus exists in most cases, we outlined the predisposing factors and putative prophylactic measures with comprehensive approaches to their management.

AEs during diagnostic *vs* therapeutic GI endoscopy

Diagnostic GI endoscopy is generally safe. For upper GI endoscopy, the overall AEs and mortality rates were reported as 0.13% and 0.004% respectively, being 10 times higher for therapeutic interventions [5]. General AEs in diagnostic *colonoscopy* ranges from 0.02% to 0.07% [6]. See Table 1 which summarizes the frequencies, described in literature, of severe/emergent AEs. Considering the main complications under discussion, although there is no question about the emergent character of perforation, we are not able to discriminate the real severity of haemorrhage rates reported in literature; this fact is even more remarkable when looking for infection and embolization as a result of its rarity.

Haemorrhage

Haemorrhage is rare in diagnostic procedures. In upper GI endoscopy, Mallory–Weiss tears cause bleeding in less than 0.5% when excessive retching and struggling occur, however those are not

Table 1
Available frequencies of severe/emergent AEs (%).

	Haemorrhage	Perforation	Infection[a]	Embolization
Diagnostic GI endoscopy				
Upper GI	0.002–0.06	0.0009–0.04	–	–
Colonoscopy	0–0.03	0.005–0.2	–	–
Therapeutic procedures				
Polipectomy (upper/lower)	3.4–10.0/0.26–6.1	0.06–1.1	–	–
ESD (upper/lower)	1.8–15.6/0–12.0	1.3–4.0/1.4–10.4	–	–
Stenting (upper/lower)	0–3.9	0–0.8/3.8–10.0	–	–
Dilation	–	0–4.0	–	–
Gastrostomy (jejunostomy)	0–1.0	–	7.0–47.0	–
Variceal ligation/sclerosis	–	0–0.7/2.0–5.0	–	0–1.0
APC/RFA ablation	0–4.0/0–2.0	0–2.0	–	–
Enteroscopy				
Diagnostic	0–0.8	0–0.3	–	–
Therapeutic	0–3.0	0–4.0	–	–
ERCP				
Diagnostic	0	0.11	–	–
Therapeutic	0.49–2.0	0.3–0.8	0.5–3.0	Rare reports
EUS				
Diagnostic plus FNB	0.15–3.7	0.03–0.86	0–16.0	–

ESD – endoscopic submucosal dissection; APC – argon plasma coagulation; RFA – radiofrequency; FNB – fine needle biopsy.
[a] Infection – rates resolved under adequate antibiotic prophylaxis for specific procedures.

clinically significant [7]. Globally, it may be more likely in individuals with thrombocytopaenia and/or coagulopathy. Therefore, some authors recommend that diagnostic endoscopy can be performed when the platelet level is 20,000/ml or greater and that a threshold of 50,000/ml should be considered before performing biopsies [3,8].

Perforation

Perforation may occur in less than 0.04% of the diagnostic upper GI endoscopy, and is usually associated to operator inexperience and some patient-related risk factors, such as: cervical osteophytosis, Zenker's or duodenal diverticulum, pharyngeal pouches, malignant/benign strictures and eosinophilic oesophagitis [9–12]. In colonoscopy the risk of perforation ranges from 0.11% in diagnostic, up to 10% in therapeutic procedures [6,13–15]. There are three main mechanisms for the occurrence: pneumatic/barotrauma, mechanical pressure, and post-therapeutic fragile wall. The patient-related risk factors contributing to perforation are well established and include: advanced age, female sex, diverticular disease, previous abdominal surgery, colonic strictures and therapeutic procedures [13,16]. The main location is the rectosigmoid in more than 2/3 of perforations [16,17].

Infection

Infection is a rare AE that can result from the procedure itself (translocation or failure to follow guidelines for the reprocessing) or the use of endoscopic devices and accessories. Transient bacteraemia has been reported at high rates, but the frequency of endocarditis or other clinical infections is extremely low [18–20]. Antibiotic prophylactic regimens are only recommended for specific interventions and should be strictly followed: suspected incomplete biliary drainage, puncture of fluid collections or cysts, percutaneous endoscopic feeding tube placement, and cirrhotic patients with upper GI bleeding [21].

Embolization

Embolization is mainly related to specific therapeutic interventions. Variceal sclerosis may cause extension of thrombus into the portal and mesenteric venous systems [22] and cyanoacrylate injection has been reported as a cause of systemic emboli to lung, spleen and portal vein [23,24]. ERCP-induced air embolism is extremely rare although severe fatal complications, causing immediate cardiopulmonary collapse have been reported [25].

Specific therapeutic procedures

Polypectomy

The main AE in polypectomy is bleeding. Usually intra-procedure in gastric lesions, occurring in 3.4% to 7.2% and delayed in duodenum, reported in 3.1%–22% of patients [2,26]. In colorectal polypectomy, bleeding occurs in 0.3% to 6.1% [27]. Evidence that aspirin or NSAIDs increase the risk of bleeding after polypectomy is lacking. The reader is referred to guidelines concerning the management of anticoagulation and antiaggregant therapy during endoscopy [28]. The bleeding risk also depends on the type and the size of the polyp and the technique of polypectomy. Immediate bleeding can be prevented by the use of pure coagulation, epinephrine injection, clipping or endolooping the stalk, but no prophylactic measures have proved to be efficient in preventing delayed bleeding [5].

Endoscopic mucosal resection (EMR)/endoscopic submucosal dissection (ESD)

EMR (snare, cap, and ligature) is used to resect focal lesions of the mucosa up to the submucosal layer. The overall incidence of serious AEs such as bleeding, perforation and stricture was estimated to be between 0.5% and 5% [29]. Bleeding occurs more often with multifocal EMR and gastric EMR, however delayed bleeding is rare (<5%) in these locations comparing to duodenum which rates

between 4% and 33% [30]. It can be prevented by revision of the site of resection at the end of the procedure, coagulating any visible vessel, closing mucosal defects with clips and by therapy with proton pump inhibitor (PPI). Gastric EMR perforation is reported more frequently than in oesophageal EMR, possibly because of larger lesions in the stomach [31].

In ESD AEs are similar to those described for EMR, although with greater frequency given the larger areas of resection. The overall incidence of bleeding and perforation with ESD is 11% and 6% respectively [32–34]. Due to the widespread acceptance of gastric and oesophageal ESDs, the number of medical facilities that perform colorectal ESDs grew in recent years [35,36]. The reported rate of perforation is 1.4–10.4% which is associated with large tumour size (>30 mm) and the presence of fibrosis. In order to reduce the perforation rate for colorectal EDS, the use of specialized knives, distal attachments and hypertonic solutions, is recommended because of the thinner colonic wall [35].

Dilation

The most common AEs related to dilation are perforation, haemorrhage, aspiration and bacteraemia. Aspiration of retained food and fluid can be an emergency, thus it should be prevented by prolonged fasting, suction, drainage, an anti-Trendelenburg position, or airway tube protection. Bleeding is usually self-limited. Despite the high frequency of bacteraemia, infectious sequelae are rare [37,38]. Thus, perforation is the most relevant AE in dilation.

In the oesophagus, the risk of perforation in malignant, radiation-induced and post-caustic-ingestion strictures is twice that of peptic strictures. Complex strictures (asymmetric, longer, <12 mm in diameter) are also associated with increased rates of complications [39]. Dilation of eosinophilic oesophagitis is frequently associated with mucosal tears, but not perforation [40]. Although the wire-guided polyvinyl dilators and through-the-scope balloons have similar rates of efficacy and AEs, the operator's experience level alters significantly the perforation risk [9]. Stepwise increase of balloon diameter may help reducing the risk. In achalasia, perforation rates up to 4% were described for pneumatic dilation. These rates may be reduced by starting with a 30 mm balloon, progressing only if symptoms do not improve and never using a balloon larger than 35 mm [41]. Perforation rates in benign gastric outlet obstruction are high as 7.4%, risk factors are dilation in the setting of active ulceration and balloon size greater than 15 mm [42]. In lower gastrointestinal strictures' dilation, mostly in anastomosis and in Crohn's disease, the perforation is more often reported with 25 mm balloons [43,44].

Stenting

Stents can be deployed in any part of the GI tract and are currently used for malignant, benign stenosis, and closing fistulas [45]. Immediate AEs of oesophageal self-expandable metal stents (SEMSs) occur in 2–12% of patients and include aspiration, pain, respiratory compromise and improper positioning. These AEs may be minimized by adequate patient preparation and positioning, familiarity with the stent, use of soft-tipped guide-wires, and avoidance of aggressive dilation [46]. Late AEs occur in 20–40% of patients: regurgitation when the gastro-oesophageal junction is bridged, occlusion, migration and perforation. The risk of late perforation and bleeding seems to be higher with larger stents, although larger stents decrease the rate of migration and tumour ingrowth [47]. Pre-treatment with chemoradiotherapy was reported to increase the incidence of AEs by some authors, but not by others. Gastroduodenal stents are associated with similar AEs, and severe events as bleeding and perforation occur in 1–5% of patients [48,49]. Also colonic stents have similar particularities; they are applied in acute malignant obstruction as bridge to surgery, with a high rate of clinical (6.9%) and silent (14%) perforation [50], and as long term palliation where perforation, and migration, have also been reported; bevacizumab therapy increases the risk of perforation in these cases [51].

Variceal ligation/sclerosis

The overall AEs from endoscopic variceal sclerotherapy (EVS) have been estimated between 35% and 78%, with a mortality rate of 1–5% [52]. Significant immediate and delayed bleeding, stricture

formation, perforation, systemic bacterial infection, or even portal thrombosis, were reported [53]. However, endoscopic band ligation (EBL) was progressively considered the treatment of choice, with significant lower rates of AEs [54,55]. Effective endoscopic treatment for gastric varices is still a sclerosant, properly the cyanoacrylate. Although considered relatively safe and effective, it is associated with systemic embolization, end-organ infarction, visceral fistula, abscess formation and bacteraemia [23,24]. Recent studies highlight only 1% rate of severe complications, as embolization [56]. It seems that the severity of AEs is related to pre-existing liver condition and infections complications [57].

Percutaneous endoscopic gastric and jejunal (PEG/PEJ) access

Serious AEs occur in 1.5 to 9.4% of PEG procedures and include bleeding, injury of internal organs, perforation, 'buried bumper syndrome', wound infection, and necrotizing fasciitis [58]. Peristomal wound infections occur in 7–47% of patients receiving placebo in clinical trials, a single dose of cephalosporin or penicillin-based prophylaxis resulted in a significant reduction [59]. Pneumoperitoneum is a benign and frequent occurrence. Bleeding from gastric or abdominal wall vessels is reported in less than 1% of procedures, it is important to reverse or held anticoagulants before. Prevention of injury to internal organs may be best achieved by ensuring adequate transillumination and finger indentation, and by use of the 'safe-tract' technique. AEs associated with PEJ are similar to those of standard PEG placement, although their rate is higher [60].

Ablation techniques

Argon plasma coagulation (APC) is frequently used to treat vascular ectasia or for mucosal lesions ablation, as Barrett's oesophagus. Randomized trials report up to 4% of bleeding, 2% of oesophageal perforation and 6% of stricture formation in oesophagus [61]. Colonic use of APC, can be associated with a rare but dreaded event – colon explosion – that may lead to perforation and emergency surgery. Meticulous full bowel cleansing with preparation without sugar compounds should be carried out before any APC in the colon [62].

Radiofrequency ablation (RFA) of Barrett's epithelium has a relatively favourable profile. Bleeding requiring endoscopic therapy occur in less than 2% and strictures in 2–8%, perforation has also been reported [63,64].

Endoscopic submucosal tunnelling procedures

Peroral endoscopic myotomy (POEM) and subepithelial lesions resection

Common described complications include subcutaneous and mediastinal emphysema, pneumothorax, pneumoperitoneum, immediate or delayed haemorrhage, and infection. Caution should be taken when implementing these techniques. There are no specific recommendations until now [65,66].

Enteroscopy

Enteroscopy using double-balloon (DBE), single-balloon or spiral enteroscopy have the potential for unique AEs. A meta-analysis of 9047 DBE found major AEs in 0.7% (perforation, pancreatitis, bleeding) [67]. The mechanisms of pancreatitis remain poorly understood, and the main way to prevent it is avoiding balloon inflation at duodenal level. The AEs rate is higher for therapeutic (4.3%) than for diagnostic DBE (0.8%). The rate of bleeding or perforation may be as high as 10.8% for patients undergoing polypectomy during DBE [67,68].

Endoscopic retrograde cholangiopancreatography (ERCP)

ERCP is a demanding procedure associated with significant morbidity (6.85% of AEs) and occasional mortality (0.33%) [69–71]. AEs can be divided into general (in common with upper GI endoscopy) and specifically related to bilio-pancreatic handling (bleeding, perforation, infection

and pancreatitis). Factors modulating the risk of complications are the indication for ERCP and type of intervention, case-volume of operator, age and co-morbidities of the patient [72]. Pancreatitis is the most prevalent cause of morbidity and mortality after ERCP, but it will not be discussed in this issue.

Bleeding is mainly linked to sphincterotomy and in half of the cases is recognized immediately [69]. Clinically significant haemorrhage occurs in 0.1%–2% of sphincterotomies. It can be attenuated by identifying patients at risk and adapting the sphincterotomy technique-limiting pure-cut current, using endocut mode or balloon sphincteroplasty, according to situations.

Perforation occurs in 0.6% of procedures, with an estimated mortality rate of 0.06% [69], however delayed diagnosis and intervention increase mortality up to 23%. The most commonly used classification of ERCP-induced perforation was suggested by Stapfer et al according to that, perforations can be categorized into four types. Bowel perforation is more frequent in patients with Billroth II gastrectomy or Roux-en-Y operation, duodenal stricture, parapapillar diverticulum, while sphincterotomy perforation is more common during needle knife precut [25,73]. It can be prevented by ensuring the correct orientation of the cutting wire during sphincterectomy, following a step-by-step incision, tailoring the size of the papilla and bile ducts, and using balloon dilation of the papilla after a small sphincterotomy in cases of large stones [5].

Cholangitis and cholecystitis are potential infectious AEs. Risk factors for cholangitis are failed or incomplete biliary drainage or combined percutaneous-endoscopic procedures [70]. Prophylactic antibiotics can reduce the rate of bacteraemia but few studies showed a reduction in clinical sepsis [74]. Therefore the main recommendation regarding prevention and treatment of cholangitis is successful and complete biliary drainage. Post-ERCP acute cholecystitis has an incidence rate of $<$0.5% and can be related to the non-sterile introduction of contrast medium. The use of cleaned and disinfected scopes, sterile contrast medium and temporary bile duct drainage when definitive drainage cannot be achieved are required. Antibiotic prophylaxis has proven to be effective in patients at risk for infective endocarditis, in patients with pancreatic pseudocyst and in patients with cholestasis or enlarged bile ducts [5].

ERCP-induced air embolism is a rare but severe complication [25] that possibly occurs due to sphincterotomy or high intra-mural pressure of insufflated air, disrupting the gastrointestinal or hepatobiliary structure and creating connection to the veins in the duodenal walls. Other reported mechanisms include portal vein puncture due to guide-wire cannulation and erroneous placement of nasobiliary drainage tube to the portal vein [75,76]. Special care should be taken for possible air embolism in relation to the recent wide application of peroral cholangioscopy [77]. Other potential very rare complications are splenic injury, hepatic haematoma, pneumothorax and basket impactation [25].

Endoscopic ultrasound (EUS)

The non-interventional diagnostic EUS AEs rate of 0.03% to 0.15% is comparable to that of upper GI diagnostic endoscopy. Although due to specific mechanical and optical properties of echoendoscopes, the risk of oesophageal or duodenal perforation seems somewhat higher. Patients undergoing EUS-fine needle biopsy (EUS-FNB) are approximately ten times more likely to develop AEs [78]. In a recent systematic review the overall complication rate and mortality was 0.98% and 0.02% respectively. Significant AEs were acute pancreatitis (34%), fever and infectious complications (16%), bleeding (13%) and perforation or bile/pancreatic leaks (3%). Serious infections were described in published reports following biopsy of mediastinal lymph nodes, cystic lesions, ascitis or pleural fluid [78]. Antibiotic prophylaxis should be administered in patients undergoing EUS-FNB of cystic lesions and fluid collections [79]. Self-limited mild intraluminal bleeding was reported in up to 4% and extraluminal bleeding in 1.3% of cases, the last can be visualized clearly by EUS [80]. Patients with highly vascularized lesions (mesenchymal, neuroendocrine tumours, and some metastases) and cystic lesions may be at greater risk [78]. According to guidelines, EUS-FNB of solid masses and lymph nodes may be performed in patients taking acetyl salicylic acid (ASA) or NSAIDs, but not in patients receiving other anticoagulant or antiaggregant drugs. However, EUS-FNB of cystic lesions should be avoided in patients taking any antiplatelet agent [28,81].

At this moment, EUS is an increasing reference for a range of therapeutic procedures with specific complications risk, as drainage of pancreatic pseudocysts, abscess and necrosis debridement [82,83], celiac plexus neurolysis [84], biliary drainage [85], or even research vascular procedures [86].

Detection and management of the two main emergencies

Haemorrhage

Bleeding during therapeutic endoscopy can be a part of the procedure, especially during polypectomies, EMR or ESD [5]. Immediate and late bleeding (by definition is haematemesis and/or melena or haemoglobin drop >2 g) [1] can be controlled with conventional haemostatic tools (Fig. 1), under simultaneous attention to resuscitation and conservative management. Reader is referred to the chapter of acute non-variceal bleeding in this volume.

Patients with upper GI resection of tumoral lesions should be treated with intravenous PPI as for Forrest IIa ulcers [5]: High-dose PPI therapy improves healing rates and reduces the risk of delayed bleeding [33]. There are small successful series of over-the-scope-clips (OTSC) use in acute GI bleeding unresponsive to conventional methods, which is becoming a consistent approach [87]. The hemospray, a highly absorptive powder that when in contact with blood becomes cohesive and forms a stable mechanical plug, is also a promising haemostatic agent as demonstrated in early studies [88].

Also in post-sphincterotomy bleeding, the first line treatment is injection of dilute epinephrine. Balloon-tamponade using standard dilating balloons for temporary control of bleeding and improve visualization of the bleeding point. Thermal therapy or placement of clips can follow the initial measures. Caution should be taken to avoid thermal injury or clip closure over the pancreatic sphincter [74]. Self-expandable metal stents have also been used as a rescue technique if other methods fail [89]. Very rarely, angiography or surgery is required for refractory bleeding.

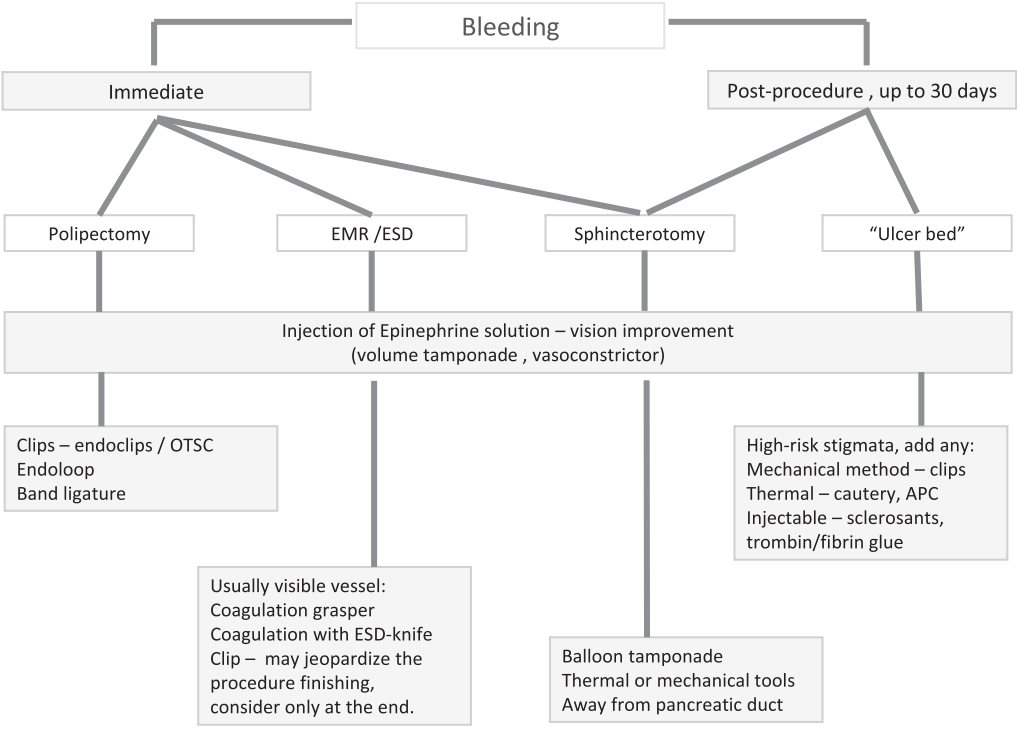

Fig. 1. Management of post-endoscopic procedures' bleeding.

Perforation

Luminal perforation still is the most feared AEs of GI endoscopy, even after some advances and demystification brought by natural orifices transluminal endoscopic surgery (NOTES). The rationale for that is multifactorial [1,90]. A recent review by Baron et al pointed out some main commandments of acute endoscopic perforation: (1) prompt recognition (preferably during the procedure) is essential to improve outcome; (2) extraluminal air does not automatically mean the need for surgery as it is not infectious and is not necessarily proportional to the size of the perforation; (3) extraluminal air under pressure is a medical emergency; (4) residual extraluminal air may persist without clinical significance; (5) perforations tend to close after drainage or diversion of luminal contents; (6) failed endoscopic closure generally requires surgical intervention.

General approach

In therapeutic procedures, it is very important a final careful examination, in this case diagnosis or suspicious is frequently immediate and allows prompt closure attempt. In certain circumstances symptoms may be masked, as in sedated or elderly patients with multiple co-morbidities, small perforations, or in case of transmural burn syndrome with progressive wall fragility. Whenever there is a clinical deterioration hours after an endoscopic procedure, delayed perforation should be considered. Late recognition may be from one hour to several weeks later. Clinical suspicious should be heightened in the presence of ongoing abdominal distension/pain, chest pain, shortness of breath, subcutaneous emphysema or fever [91]. Once suspected, besides closure attempt, immediate general measures should take place, as administration of intravenous broad-spectrum antibiotics, vital signs monitorization, blood tests, surgeon contact and counselling, placement of a nasogastric tube (except in oesophageal perforation, because it may exit the perforated site), and cessation of oral intake. At the same time, if periprocedure perforation, switch as much as possible to CO_2 insufflation. If perforation is suspected later, an initial imaging assessment should include a chest and flat/upright abdominal radiography, if unrevealing computerized tomography CT with water-soluble contrast (orally, via nasogastric or nasoduodenal tube, or per rectum) may show contained or free contrast material extravasation. Endoscopic closure should then be attempted if feasible (Figs. 2 and 3) [5,90,92].

An essential and lifesaving attitude is emergent decompression when extraluminal air is under pressure. Tension pneumothorax requires immediate needle catheter inserted along the midclavicular line in the second intercostal space of the affected side. Then a chest tube should be placed. Subcutaneous emphysema usually resolve spontaneously, however attention should be given when massive air is tracking into soft tissues of the neck as it can result in airway obstruction, needing endotracheal intubation. Avoid abdominal compartment syndrome (drop in blood-pressure levels, related to a decreased cardiac preload caused by peritoneal hypertension) in tension pneumoperitoneum, with a 18 or 20 gauge trocar needle in either lower abdominal quadrants, just at or inferior to the umbilicus. The needle should be removed but the plastic sheath is left in situ to allow continuous decompression of the peritoneal cavity, while the procedure resumes and endoscopic intervention is ongoing even under air insufflation (Fig. 4) [5,90,93].

Endoscopic closure methods

Endoscopic closure methods include clips, stents and suturing devices. Its selection relies on defect location, dimension and conformation, occurrence situation, equipment availability and operator preference. Through-the-scope endoclips (QuickClip – Olympus®, Resolution Clip – Boston Scientific®, Tri-clip – Cook Medical®) are the most used and currently the standard method for endoscopic closure of perforations [94]. It has been suggested that for defects smaller than the width of the open clip it should be clipped in a 'side to center' manner; when the defect is slightly larger than the width of the open clip, the diameter can be reduced by air suction. In case of large defects, the first clip is the most critical and a recent proposal for certain cases is to perform small incisions around to provide a better grip for the clip [95]. Combined methods are also a good approach for larger defects, for instances, hemoclips plus Endoloop [96,97], plus omental patch [93] or plus band ligation [98]. OTSC system, initially developed for haemostasis, but extensively explored for 'otomies' closure in NOTES [99] are

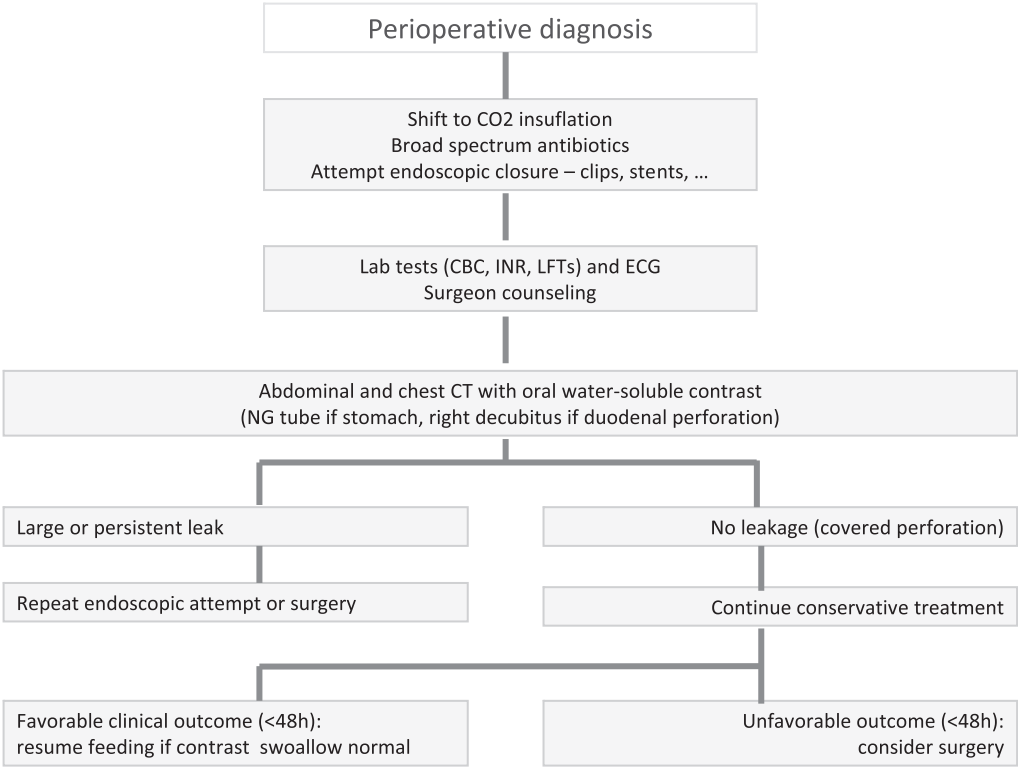

Fig. 2. Management of upper GI perforations. Adapted from Blero D, Devière J. Nat Rev Gastroenterol Hepatol. 2012.

ultimately applied in perforation's closure, using or not specific grasping or anchoring devices to approximate margins before clip release. Stents are an alternative method (fully or partially covered metal stents and plastic stents) for luminal diversion, mainly in oesophageal malignant rupture. Stents can also be used in benign perforation, and removed 4–12 weeks later. Several endoscopic suturing prototypes were developed in the context of NOTES, anti-reflux and bariatric procedures [90,100] namely: T-tags (Ethicon Endo-Surgery and Cook Endoscopy), Overstitch (Apollo Endosurgery), pursed-string-suturing device (LSI Solutions), flexible endostitch (Covidien), NDO plicator (NDO-SurgicalInc), flexible stapler (Power Medical Interventions), nevertheless its application remains limited in humans, and some of them only tested in animal models.

Location particularities

In *oesophagus*, non-surgical treatment is indicated only in highly well selected [101]. Primary repair is feasible if without intrinsic oesophageal disease, absence of sepsis, and especially when the time interval is less than 24 h [102]. Endoscopic stenting represents a successful treatment option in perforated non-resectable oesophageal malignancy. In cases of benign rupture, the stent placement for a period of 5–6 weeks is effective in 76% of patients, with no significant difference between stents [103]. Nevertheless, complication rate can be as high as 20–72%, thus the stent choice should depend on expected risk of stent migration (mostly with fully covered SEMSs, and less frequent in presence of any stricture) and to a minor degree, on expected risk of tissue in- or overgrowth (mostly with partially covered SMESs). In this situation a fully covered stent of the same diameter can be placed inside (stent-in-stent method) allowing uneventful removal of both after 10–14 days. This can also be precluded with the initial application of large diameters fully covered stents (22–23 in the body) [103]. Finally, standard through-the-scope clips are successful in the closure of perforations up to 12 mm, in a pooled

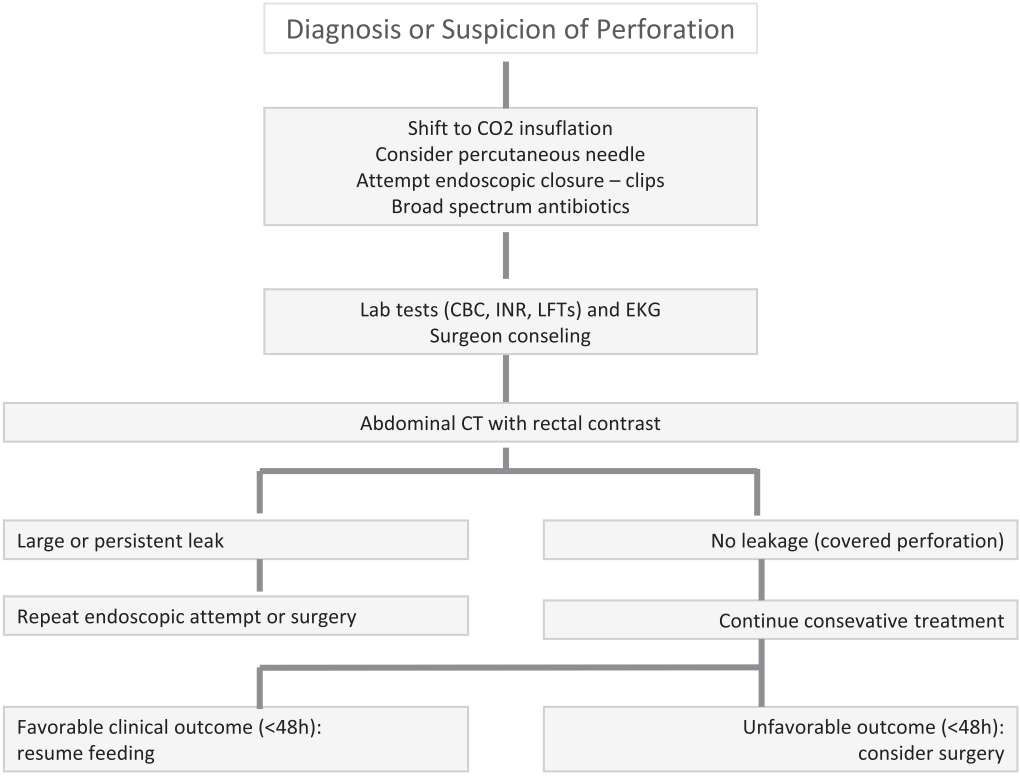

Fig. 3. Management of lower GI perforations. Adapted from Blero D, Devière J. Nat Rev Gastroenterol Hepatol. 2012.

analysis where the median healing time was 18 days [104]. Vacuum-assisted therapy is also a possible technique [105]. OTSC brings technical difficulties in oesophageal application because of narrow lumen and oblique orientation [106].

In *gastric* perforations, the main closure approach is endoclipping alone or in combination, which can achieve 98% of success if immediate diagnosis [93]. Shi et al described a new combination technique of metallic clips and endoloops as interrupted suture after endoscopic full-thickness resection of gastric submucosal tumours in 20 patients [97]; when the defect is large (25 mm) it can as well be managed by the omental-patch method or the OTSC system [93,106].

In ERCP-related *duodenal* perforations, different approaches are made according to the type and the severity of the leak and clinical manifestations [107]. In type I and type II perforations, surgical treatment was generally recommended, although recent successful reports of endoscopic closure with endoclips [108], combined clips and endoloops or OTSC were published [109]; particularly in type II perforations, self-expandable metal stents seems to be effective [110]. Type III and IV perforations tend to be a controlled retroperitoneal perforation; in case of leak with fluid collection, the recognizing and quick plastic stents placing for appropriate drainage, associated with antibiotics are essential [107]. In retroperitoneal perforations, 87.9% of patients recovered with conservative treatment (total mortality was 2.9%), and 80.8% of patients with free air peritoneal perforations received surgery (total mortality was 24.7%).

Small bowel enteroscopy related perforations often lead to surgical management.

In *colon* perforations, endoscopic closure in association with conservative management is successful in 60–100% of patients, avoiding the morbidity of surgery and shortening the length of hospital stay, provided that perforation is immediately recognized and closed. Initial series showed success with

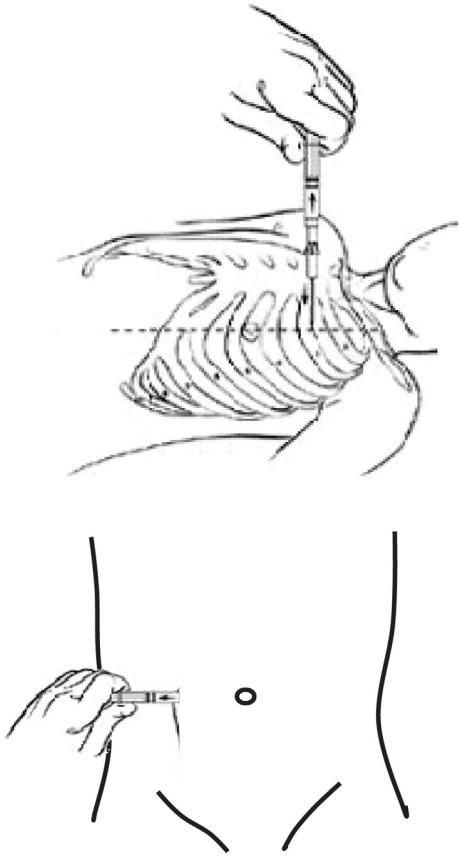

Fig. 4. Acute decompression of tension pneumothorax and pneumoperitoneum.

endoclips for small perforations [111,112], in the absence of peritoneal irritation. Subsequently also diagnostic, large perforations, in the presence of free air or moderately inflammatory signs, were also successfully treated with multiple clipping, OTSC or even band ligation [90]. Bowel preparation status is in general an important factor that may influence clinical management. In delayed recognition, clipping should be considered only if the patient is stable and a specific site is highly suspected, mainly in rectosigmoid location [112]. When comparing diagnostic and therapeutic colonoscopy-associated perforation, the former is usually larger, irregular and sometimes not immediately recognized in terms of location, thus it is more prompt for surgical approach [113]. Surgery is indicated in patients with large perforations, generalized peritonitis or ongoing sepsis as well as in patients with concomitant pathology, such as a large sessile polyp likely to be a carcinoma, unremitting colitis, or obstructing colonic lesion. Although rare, extraperitoneal colonic perforation (subcutaneous emphysema, pneumoretroperitoneum, pneumomediastinum, pneumopericardium) should be managed conservatively, and the air is commonly reabsorbed within 72 h [114]. In rectum, located below the peritoneal reflection air leakage can develop through next or distal soft tissues. Penetration to perirectal tissue is a better designation and is treated with broad-spectrum antibiotics and nothing by mouth even though endoscopic clips can also be applied [90].

In all these cases a coordinated surveillance by the surgical and medical team is essential in the first 48 h. In case of no improvement or any sign of deterioration, surgery should be considered in a case-by-case decision.

Conclusion

Endoscopic complications are a pertinent feature of patient care that has been receiving great attention, due to increased technical advances and complexity of therapeutic endoscopy. Three main factors contribute to endoscopic adverse events – patient, operator, and type of procedure. Thus a comprehensive knowledge of the techniques and materials, experience acquisition and maintenance in specific procedures, standardization of treatments and training are important issues for prevention of AEs. When facing an AE, early recognition and prompt approach by endoscopic or multidisciplinary management, are essential for a successful outcome. No rule suits all, hence endoscopic complication approach must be customized to individual patients.

Practice points

- Adverse event (AE) is a situation that prevents completion of the planned procedure.
- Be prepared for the endoscopic procedure and furthermore its possible AEs – theoretical knowledge, equipment, team, and environment conditions.
- According to indications prevent infection and bleeding risk.
- Early recognition is a determining factor of the general outcome results.
- Bleeding (early and delayed) is usually controlled by endoscopic haemostasis.
- In perforation, an endoscopic plus conservative treatment, under multidisciplinary surveillance should always be attempted, if possible.
- Emergent needle decompression is an essential and lifesaving attitude when extraluminal air is under tension.
- Review AEs as part of continuing quality improvement.

Research agenda

- Multicenter studies to define associated risk factors of AEs for each newly-introduced procedure.
- Comparative studies between the newly appearing tools for haemostasis and closure.
- Effective, user-friendly and cheaper suture devices for endoscopy.
- Safer tools for endoluminal dissection (knifes and coagulation graspers).
- Increment biodegradable tools – protective plug, spray and stents.
- Image fusion systems for safer approach in more aggressive procedures.

Disclosure statement

Regarding this manuscript – 'EMERGENCIES AFTER ENDOSCOPIC PROCEDURES' – none of the authors (Carla Rolanda, Ana C. Caetano e Mário Dinis-Ribeiro) have any disclosures to make.

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