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Review Article

REVIEW ARTICLE

Endo-anesthesia: a primer

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Abstract

Gastrointestinal (GI) endoscopy has witnessed a Cambrian explosion of techniques, indications, and expanding target populations. GI endoscopy encompasses traditional domains that include preventive measures, palliation, as alternative therapies in patients with prohibitive risks of more invasive procedures, and indicated primary treatments. But, it has expanded to include therapeutic and diagnostic interventional endosonography, luminal endoscopic resection, third space endotherapy, endohepatology, and endobariatrics. The lines between surgery and endoscopy are blurred on many occasions within this paradigm. Moreover, patients with high degrees of co-morbidity and complex physiology require more nuanced peri-endoscopic management. The rising demand for endoscopy services has resulted in the development of endoscopy referral centers that offer these invasive procedures as directly booked referrals for regional and rural patients. This further necessitates specialized programs to ensure appropriate evaluation, risk stratification, and optimization for safe sedation and general anesthesia if needed. This landscape is conducive to the organic evolution of endo-anesthesia to meet the needs of these focused and evolving practices. In this primer, we delineate important aspects of endo-anesthesia care and provide relevant clinical and logistical considerations pertaining to the breadth of procedures.

Key words: endoscopic procedures; endoscopy; anesthesia

Introduction

Over 57 million gastrointestinal (GI) endoscopies are performed yearly in the USA [1]. Although the majority of procedures are diagnostic, interventional and therapeutic endoscopies are increasing exponentially. This growth is driven by an evolving complexity of patients' medical conditions, necessitating creative minimally invasive solutions away from the operative suite. Even though gastroenterologist-directed sedation is common for patients with favorable American Society of Anesthesiologists physical status (ASA-PS) scores and low procedure complexity, anesthesia providers are increasingly called upon to provide services for endoscopic procedures due to patient preference [2]. In addition, anesthesia providers are essential for safe care of complex patients and procedures. On most

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occasions, these services are provided in non-operating room locations. Hybrid operating rooms have evolved to meet the demand for these advanced procedures and provide the infrastructure necessary for optimal anesthesia delivery. However, hybrid operating rooms remain limited to tertiary or quaternary care centers [3]. Non-operating room anesthesia (NORA) is a rapidly growing subspecialty of anesthesia [4]. Therefore, it is important to delineate best practices for anesthesiology care outside of the operating room, specifically in the GI endoscopy suite, and to provide relevant clinical and logistical considerations pertaining to the scope of the endoscopic procedures.

Logistical considerations

NORA is provided in hospitals but also occurs in ambulatory surgical centers. A recent French study revealed a significant overall unplanned admission rate of 1.8% after ambulatory surgery, where hospitalizations after GI endoscopic procedures and bronchoscopies were 1.1% (95% confidence interval: 0.3–1.9) [5]. In this study, age of >60 years and ASA-PS status of >2 were identified as risk factors. Closed-claims and other registry analyses show that endoscopic procedures account for a large number of NORA claims in anesthesia malpractice cases [6]. In a US registry study, the proportion of ASA-PS 3 and 4 patients who are offered office-based procedures rose from 19% and 0.03% in 2010 to 32% and 0.08% in 2014, respectively. [7]. While patients with serious co-morbidities (e.g. severe obesity, ventricular assist devices, cardiovascular implantable electronic devices) or ASA-PS >3 may be suitable for NORA in a hospital environment, those patients may not be appropriate for NORA in ambulatory surgical centers or office-based practices. It is perhaps the perception of endoscopy as a "low-risk" procedure that could explain the trend in providing these procedures in ambulatory surgical centers even for high-risk patients, as shown in registry data.

Outside the confines of the operating room, when envisaging the optimal procedural suite, planning patient care for anesthesia purposes should be an intentional process. For example, access to the patient's airway should not be impeded by endoscopy equipment, towers, fluoroscopy machines, endoscopic and fluoroscopic monitors, or preparation tables for endoscopic accessory devices. In interventional endoscopy cases, fluoroscopy is often used for upper, lower, or sinus-tract GI procedures. An ideal endoscopy suite has the capability and versatility of design to switch the location of the anesthesia equipment (including gas sources) in the room to allow rapid access to the patient's airway and an unhindered window to observe the patient, depending on the positioning of the patient. Moreover, the proximity and distance to the suite exit door should be considered in case of an emergency. While this may appear to be a simple task, it can be cumbersome in complex GI procedures and poorly designed endoscopy suites. Although rare, certain procedures may necessitate the use of two scope towers simultaneously in addition to fluoroscopy. Figure 1 shows a sketch of a proposed interventional endoscopy room that accommodates different permutations of endoscope tower positions in addition to anesthesia needs.

Care coordination considerations

We suggest scheduling high-risk patients or those requiring lengthy procedures early in the day to address unanticipated adverse events during optimal hours of the workday. We also recommend starting the day with the endoscopy and anesthesiology teams briefly reviewing the proposed endoscopy plans, anticipated anesthesia plans, and procedural equipment needs individually for each scheduled case [8]. This brief stand-up (huddle) meeting can optimize care coordination and provide effective planning for shared procedural goals and concerns [9]. Safety checklists are reviewed, such as the need for periprocedural antibiotics when indicated (e.g. endoscopic placement of percutaneous feeding tubes, biliary interventions in immunocompromised patients), and confirmation of periprocedural management of antithrombotic agents. Concerns arising from the preprocedural review such as anticipated adverse events, type of sedation most conducive for procedural success, patient positioning, and the potential need for positional changes during the procedure are discussed [10]. Additional important issues that may be discussed beforehand include relevant post-procedural diet orders (e.g. after post-enteral stenting), resumption of medications, or special post-discharge instructions.

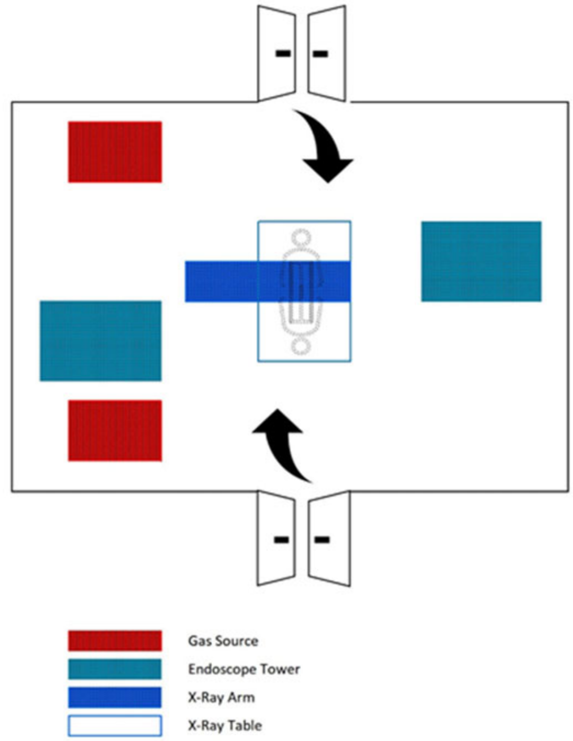

Figure 1. Schematic of a proposed interventional endoscopy room that accommodates different permutations of endoscope(s) tower positions, fluoroscopy equipment, in addition to anesthesia needs

Patient considerations

Risk profile

Every patient undergoing endoscopy needs a medical evaluation to assess acute and chronic conditions, medications, and allergies, and a focused physical examination. Using a form as shown in Supplement 1 or building similar questions into electronic health record tools can gather important information ahead of time and without an in-person visit. Moreover, because many interventional endoscopy procedures are offered to patients who are not surgical candidates, these patients are often acutely ill (ASA-PS 3–4). However, they often benefit from endoscopic options with acceptable outcomes [11]. Additionally, these debilitated patients having advanced procedures may be lumped in with low-risk endoscopies, such as diagnostic upper endoscopy or screening colonoscopy. The risk of anesthesia is likely proportionately increased in these individuals. The risk of perioperative events is heightened in certain endoscopic procedures, regardless of the patient's status, although a trend for increased events is observed with increasing ASA-PS [12].

Similarly, another study showed that increased ASA-PS class and procedures performed in non-university settings were associated with more unanticipated events [13]. The ASA-PS class is one component of pre-endo-anesthesia risk stratification but is not the only one. In addition, specific co-morbidities, especially pulmonary, cardiac, hepatic, and renal diseases, must be considered for patients undergoing endo-anesthesia evaluation. The patient's functional status is assessed and patients with above-average functional capacity generally have a low risk of cardiovascular adverse events.

Procedural purgative preparation considerations

Current colonoscopy preparation formulations should be tailored to individual patients weighing efficacy, tolerability, and possible adverse events. Certain low-volume formulations may not be appropriate for elderly patients or those with renal disease, heart failure, or advanced liver disease, given the risk of electrolyte perturbations, especially in the elderly [14]. On the other hand, safer larger-volume alternatives (e.g. $\geq$4 L of volume) may not be tolerated due to nausea and vomiting. Modern low-volume alternatives with promising results are available [15].

Anticoagulants and antiplatelets

Many patients are taking anticoagulants or antiplatelets. While they can be safely continued without interruption for many procedures, some interventions carry an increased risk of bleeding requiring preprocedural temporary discontinuation of antithrombotics and perhaps bridging with other agents [16–18]. Planning well in advance of endoscopy is ideal. However, this may not be possible in emergencies. In general, the decision to suspend an antithrombotic medication balances the risk of bleeding against the risk of thromboembolic events [19]. Antithrombotics should be temporarily stopped when maneuvers with a high-risk for GI hemorrhage are anticipated (e.g. biliary sphincterotomy). Individuals with an increased risk of thromboembolic adverse events can be bridged with a short-acting anticoagulant. Multidisciplinary management guides the approach to antithrombotic discontinuation and resumption in patients with high risk for thromboembolic adverse events and high risk for GI bleeding. The antithrombotic management perspectives shift with the introduction of new pharmacological agents and procedure-specific bleeding risk.

Cardiac co-morbidities

Historically, endoscopic procedures were deemed to be at low risk for perioperative cardiac events according to risk calculators such as the Revised Cardiac Risk Index, although its procedural domain is agnostic to the specifics of endoscopy. With rising complexity and advanced endoscopic interventions, this may not be accurate. Other important co-morbidities for consideration include heart failure and ventricular assist device dependency, significant arrhythmia, and severe valvular disease.

The management of cardiovascular implantable electronic devices (CIEDs) such as implantable cardiac defibrillators (ICDs) and pacemakers for endoscopy is not standardized [20, 21]. For routine endoscopies, most devices do not need any specific peri-procedural management [22]. However, patients who are pacemaker-dependent should be switched to asynchronous pacing if electrosurgery is anticipated [23]. When electrosurgical currents are used, an ICD needs to be inactivated with access to a defibrillator and continued electrocardiographic monitoring of the patient. Patients with an ICD who are pacemaker-dependent must have their CIED reprogrammed if electrosurgery is planned because a magnet will only inhibit the anti-tachycardia function of the device. Common examples when monopolar currents are used include snare resection of polyps, sphincterotomy, hot biopsy forceps, and argon plasma coagulation [24]. It is important to recognize that, given the advent of novel pacemakers and ICDs, indiscriminate management (e.g. placement of a magnet over the device) is discouraged by the American Society of Anesthesiologists, favoring an individualized approach for each patient according to their unique device [22, 23].

Other co-morbidities

Obesity is an important and common co-morbidity that poses significant procedural challenges [25]. Positioning and airway management can be more difficult in patients with obesity. When possible, having the patient assume the anticipated endoscopy position (semi-prone, left lateral, or supine) before induction and using a video laryngoscope for intubation in that position can be an option.

Other important co-morbidities for consideration include chronic obstructive pulmonary disease, pulmonary hypertension, end-stage liver disease, end-stage renal disease, and frailty. Recent data demonstrated that hospitalized patients with end-stage liver/renal disease have an increased risk for adverse events following endoscopic retrograde cholangiopancreatography (ERCP) [26, 27]. Similarly, elderly patients with an increased Charlson Comorbidity Index, a measure predicting mortality by weighing various comorbid conditions, experience more adverse outcomes when undergoing endoscopic resection of gastric lesions [28].

Directly booked (open-access) endoscopy

A significant proportion of GI endoscopic procedures are scheduled as directly booked (open-access) endoscopies [29]. Directly booked endoscopy is defined as a procedure that is scheduled without a preceding GI office visit. Directly booked endoscopies streamline access to colorectal cancer screening and surveillance, with additional savings in healthcare costs [30]. Furthermore, many tertiary care hospitals receive urgent endoscopy requests for rural or remote patients, who are unable to make multiple independent trips for office consultations and endoscopy. Directly booked endoscopies may be necessary to expedite the diagnosis of a malignancy, alleviate biliary obstruction, or treat symptomatic choledocholithiasis in a non-hospitalized setting [29]. Despite these advantages, directly booked endoscopies pose certain challenges to endoscopists and anesthesiologists in terms of risk stratification and pre-endoscopic evaluation to plan sedation. This is especially problematic when electronic health record systems from the patient's home institution and the endoscopy center are separate. An evaluation of directly booked endoscopy referrals at a major academic center showed that almost 9% of referrals included inaccurate medical information [31]. Importantly, all inaccuracies were ascribed to omission, such as missing information about allergies, significant co-morbidities, or drugs that are directly related to the safety of the procedure (e.g. antithrombotics) [31]. In addition to requesting updated allergy and medication lists from the referring team, we recommend the use of a preprocedural form to elicit critical medical information. This should be sent to the endoscopy practice at the time of referral, especially when the patient is receiving care from different health systems with different electronic record-keeping systems (Supplement 2).

Procedural considerations

Procedural risk stratification determines the need for pre-endo-anesthesia testing. Risk calculators assume all endoscopic interventions to be low-risk, which may not be valid with the rise in high-risk interventions [32]. In a meta-analysis of studies evaluating patients undergoing ERCP, the incidence of cardiac events and mortality was ~3.7 per 1,000 patients [33]. A large study of the American College of Surgeons National Surgical Quality Improvement Program demonstrated the continuum of intrinsic cardiac risk among operations [34]. Similar to the importance of a surgical operation's intrinsic risk, consideration of the intrinsic risk of an endoscopic procedure is necessary and future research is warranted.

Flexible endoscopy now includes natural orifice transluminal endoscopic surgery (NOTES). NOTES procedures may intervene beyond the first space (i.e. the gut lumen), at times intentionally violating the second space (i.e. peritoneal cavity) and third space (i.e. submucosal intramural space of the gut lumen) [35].

Certain endoscopic procedures can result in rare, but lethal, adverse events. Gas embolism is estimated to occur in ~0.57 per 100,000 of all endoscopic procedures [36]. This risk is increased several-fold depending on the procedure. For example, endoscopic drainage and debridement of walled-off necrosis, especially when prolonged, entails an elevated risk of introducing gas into the vascular system because of vascular compromise within the necrotic cavity [36]. Gas embolism may also occur during ERCP, especially intraductal cholangioscopy, or endoscopic interventional radiology-assisted biliary cannulation with percutaneous transhepatic biliary drains [36, 37]. Although insufflation with carbon dioxide decreases this risk, it does not completely eliminate it [37]. Gas embolisms can be asymptomatic, or lethal in severe cases, with rapid hemodynamic deterioration. Cardiovascular manifestations include acute right heart failure, tachy- or bradyarrhythmias, or even cardiac arrest. If gas embolism is suspected, the procedure should be immediately aborted, after adequate decompression of gas from the upper GI tract to decrease any pressure gradient favorable to gas introduction. Termination of the procedure should be the first step to prevent further gas entry, with concomitant hemodynamic and ventilatory support [38].

Subcutaneous emphysema, pneumomediastinum, pneumoperitoneum, or compartment syndromes may occur during necrotizing pancreatitis debridement, endoscopic submucosal dissection, polyp resection, peroral endoscopic myotomy of the lower esophageal sphincter, or gastric pylorus. These complications may occur when inadvertent luminal perforation occurs or during esophageal and gastric peroral endoscopic myotomy, or when creating intraluminal intestinal anastomoses. These events can be significant and cause hemodynamic or diaphragmatic compromise [37]. In such transluminal endoscopic procedures, the physician should be ready to treat any cardiopulmonary compromise using thoracic or abdominal needle decompression. A systematic review of endoscopic ultrasound-guided interventions estimated that pneumoperitoneum occurs in 5% of cases [39, 40]. In its most severe form, tension pneumoperitoneum is rare but lethal if unidentified. Sudden difficulties with ventilation, increased venous congestion with significant abdominal distension, rigidity, and tympanicity are suggestive of tension pneumoperitoneum. Abdominal needle decompression should be immediately performed and surgical consultation requested urgently. Endoscopic therapy of perforation should be attempted when technically feasible. Endoscopic abdominal exploration and washout have been described in the literature [41]. While blood typing and screening before elective endoscopy are not generally recommended, they should be considered when using endoscopy to evaluate and treat acute GI hemorrhage [42].

Airway management

In upper GI endoscopic procedures, the inevitable need to share the airway access with the endoscopist poses additional challenges. The laryngeal reflexes need to be suppressed and, as a result, the probability of apnea and hypoventilation increases. This increases the risk of hypoxemia and may require additional airway interventions such as placement of a nasal airway, high-flow nasal oxygenation, and occasional endotracheal intubation [43, 44]. Furthermore, certain patients, such as those with obesity or obstructive sleep apnea, are more likely to desaturate during endoscopy.

It is not unusual for the endoscopist to be asked to remove the endoscope to address changes in ventilation, airway obstruction, vocal-cord spasm, or aspiration during natural airway anesthetics. However, during certain procedural steps in complex endoscopic interventions, removal of the endoscope might be detrimental. If a complex procedure is planned, endotracheal intubation may be the best option regardless of other considerations [45]. If the trachea is not intubated, certain maneuvers can be applied to decrease the risk of aspiration and reverse transient hypoxia (e.g. suctioning, high-flow nasal cannulae, administering antisialogues such as glycopyrrolate) [46–48]. High-flow nasal oxygen (HFNO) delivers oxygen through a specialized nasal cannula—a technique described as transnasal humidified rapid insufflation ventilatory exchange. HFNO can deliver substantially higher oxygen delivery compared with a nasal cannula (up to 1.0 vs 0.4 with a nasal cannula at a flow rate of 6 L/min). The application of HFNO in patients at risk for hypoxemia during GI endoscopy significantly decreases deoxygenation [43]. A nasal airway can be placed even in the mouth to avoid nasal trauma. Attaching the plastic connector from the endotracheal tube to the nasal trumpet allows it to be connected to the anesthesia circuit. This modified technique allows the delivery of concentrated oxygen over the glottis and can facilitate positive pressure ventilation if needed. The endoscopist may request cricoid pressure to augment esophageal or gastric insufflation [49].

When large devices are used in upper endoscopy (e.g. endoscopic suturing or fundoplication devices) [50, 51], or when unusually large foreign bodies are extracted from the stomach [52], complete paralysis of the oropharyngeal muscles may be needed. It may be necessary to deflate the endotracheal tube balloon to facilitate device insertion or foreign-body removal.

Aspiration risk

When propofol sedation is used, the dose is titrated to maintain spontaneous ventilation and preserve laryngeal reflexes. Given the pharmacokinetic variability of medications, accurate titration of these medications may be difficult. In the event of regurgitation or vomiting, one aims to allow the patient to close their vocal cords and cough, thus minimizing the risk of significant aspiration. Nevertheless, clinically insignificant aspiration without desaturation may occur and such patients can often be safely discharged home.

Endoscopic procedures inherently increase the risk of aspiration, whether due to stimulation from the endoscope, gagging, gas insufflation, or due to the underlying pathology. For example, a patient may have a gastric or duodenal lesion requiring underwater immersion resection [53]—a technique that has been shown to decrease the risk of GI perforation, but requires adding water to the lumen of the gut [54]. Water infusion may also be used during endoscopic ultrasound to achieve better acoustic coupling [55] and thus better visualization of mucosal and submucosal lesions. Upper GI bleeding or foreign-body ingestions pose a risk of aspiration. Drainage of a pancreatic walled-off necrosis collection through the stomach may result in the egress of a large amount of liquid and solid debris suddenly into the stomach, significantly increasing the risk of aspiration. These procedures should always be performed with endotracheal intubation for airway protection.

Motility disorders, such as esophageal achalasia, where the esophagus is often filled with food also heighten the risk of aspiration. These patients may not be able to lie flat without having debris refluxing into their oropharynx. Rapid sequence induction with intubation, a pre-induction oro- or nasogastric tube placement, or awake intubation with the patient sitting up to keep the esophageal debris *in situ* may be necessary. Obstructions below the level of the lower esophageal sphincter are termed gastric outlet obstructions. Several liters of pressurized fluid can accumulate in the stomach. In this scenario, the safest approach is to insert a nasogastric tube before induction to remove the fluid and relieve the pressure. Non-decompressed gastric outlet obstructions carry a very high risk of aspiration during induction of anesthesia. Gastric outlet obstruction, which may occur secondary to peptic ulcer disease or malignancy, may necessitate GI luminal stenting or tube placement. These prostheses will allow the high-pressure gradient downstream from the obstruction to be transmitted backward and can result in severe regurgitation or vomiting. Small-bowel mechanical obstruction, ileus, and colonic mechanical or pseudo-obstruction carry similar risks.

Novel bariatric endoscopy procedures may include the placement of intragastric balloons, which significantly alter gastric motility. When endoscopic removal of the device is needed, we recommend endotracheal intubation to prevent aspiration in select patients with suspicion of dietary noncompliance, symptoms of delayed gastric emptying, or when a significant amount of food is found in the stomach during the endoscopy [56].

Lower GI endoscopic procedures such as colonoscopy or retrograde enteroscopy can lead to aspiration. In a prospective study to detect pulmonary aspiration during colonoscopy, 3% of patients undergoing colonoscopy with propofol anesthesia had scintigraphic evidence of pulmonary aspiration [57]. Serious aspiration events during colonoscopy are rare but have been reported, and risk factors include gastrointestinal obstruction, colonogastric fistulas, difficult cecal intubation with significant right-colon gas distention, position changes during the procedure, and application of external abdominal compression to facilitate scope insertion [58–60]. Table 1 relays different types of endoscopic procedures, with patient positioning, anesthesia type, procedural inherent aspiration risks, and other considerations.

Anesthesia

In the USA, a significant proportion of screening colonoscopies are performed with propofol as the sole anesthetic. The last decade has seen a paradigm shift in the use of sedation for GI endoscopic procedures, in terms of both the drugs and the personnel administering them. Until recently in the USA, the majority of screening and diagnostic GI procedures were performed using the popularly described intravenous conscious sedation using sedatives other than propofol. Conscious sedation can be administered by certified registered nurses under the supervision of an endoscopist. Presently, in the USA, propofol is administered by anesthesia providers and has significantly replaced nurse-administered sedation. As described by the ASA, deep sedation has four characteristics: purposeful response only following repeated or painful stimuli, need for airway interventions, the likelihood of inadequate spontaneous ventilation, and fairly stable cardiovascular function [61]. Considering that propofol administration can result in states that vary from moderate sedation to general anesthesia, deep sedation may easily become general anesthesia with an unprotected airway [62]. Nevertheless, there are significant regional variations using deep sedation compared with conscious sedation, the latter being used in a significantly higher proportion of patients on the West Coast of the USA [63].

When propofol is used, the anesthesia providers often administer small doses of fentanyl (50–75 ìg) followed by incremental boluses or infusions of propofol to achieve the appropriate depth of sedation.

As a general guide, the majority of patients require a bolus of 50–80 mg of propofol followed by an infusion of 80–120 ìg/(kg·min). Variability in patient response makes events such as laryngospasm and apnea challenging to eliminate and requires a proactive and attentive anesthesia provider. Patients with diminished cardiac reserve require careful titration of sedatives and may need hemodynamic support with vasopressors and inotropes.

Common sedative drugs used for endoscopy procedures are listed in Table 2 [60, 64, 65]. Muscle relaxation using neuromuscular blocking agents may be needed during certain advanced endoscopic interventions, for the introduction of large devices or extraction of large ingested foreign bodies, or to control ventilation. Endoscopic submucosal dissection procedures in the esophagus, duodenum, or transverse colon can be hampered by diaphragmatic excursions, and paralysis can facilitate resection. Some interventional endoscopic ultrasound procedures, especially when accessing small ducts (e.g. pancreatic duct access) or neurovascular therapies (e.g. angiotherapy with glue or coil delivery, celiac plexus interventions), may require complete immobility and cessation of diaphragmatic motion for accurate targeting. Immobility can be achieved with adequate anesthesia without neuromuscular blocking agents on many occasions.

Certain medications may be needed to facilitate the endoscopic procedure. Hyoscyamine, also known as scopolamine, is an antimuscarinic drug applied for an antispasmodic effect on smooth muscles during GI endoscopy. However, recent recommendations suggest against its use during gastroscopy or colonoscopy given the potential side effects, such as urinary retention or worsening of glaucoma. If used during ERCP, special caution should be given to patients with pre-existing cardiac conditions [66].

Glucagon is given to decrease intestinal motility and to facilitate endoscopic interventions. Glucagon is administered intravenously in doses of 0.25–1.0 mg and can cause vomiting, hyperglycemia, or provoke secretions from a

Table 1. Endo-anesthesia considerations in different endoscopic procedures

Procedure	Position	Typical anesthetic	Electrosurgery	Aspiration risk	Other considerations
Diagnostic EGD/EUS	Left lateral	Deep sedation	Rare	Rare Heightened in achalasia, esophageal cancer, gastric outlet obstruction	–
Therapeutic EGD (GI bleeding, endoscopic resection, stent deployment, stricture dilation, peroral endoscopic myotomy)	Left lateral Less common: change to right lateral or supine [69]	General anesthesia or deep sedation	Possible	Heightened in achalasia, esophageal cancer, gastric outlet obstruction Position changes during GI bleed management	–
Diagnostic/screening/surveillance colonoscopy	Left lateral	Light-Moderate Sedation	Possible	Position changes supine, prone to facilitate scope passage Abdominal pressure	–
Interventional colonoscopy (endoscopic resection)	Left lateral	Light-Moderate Sedation	Common	Position changes supine, prone to facilitate scope passage Abdominal pressure Prolonged procedure	Perforation and pneumoperitoneum requiring abdominal needle decompression and antibiotics
Interventional colonoscopy (colonic obstruction and stenting)	Left lateral	General anesthesia	Rare	High aspiration risk (gas insufflation in obstructed intestine)	Fluoroscopy may interfere with airway access Perforation and pneumoperitoneum requiring abdominal needle decompression and antibiotics
ERCP	Prone Less common: supine, left lateral	General anesthesia	Common	Position Prolonged procedure	Air embolism (very rare) Fluoroscopy arm position relative to airway access
Interventional EUS	Left lateral Less common: supine, prone [70]	General anesthesia,Possible need for paralysis	Common	Prolonged procedure Drainage of fluid-filled cavities refluxing to the stomach and esophagus	Air embolism (very rare) and hemorrhage in pancreas necrosis management High level of precision Endoscope, wire, and device exchanges
Deep enteroscopy (push, single balloon, double balloon)	Left lateral	Deep sedation or general anesthesia	Possible	Balloon-overtube use and frequent lubrication Prolonged procedure	–

EGD, esophagogastroduodenoscopy; EUS, endoscopic ultrasound; GI, gastrointestinal; ERCP, endoscopic retrograde cholangiopancreatography.

Table 2. Common endo-anesthesia sedation medications

Propofol	Sedative	Quick, smooth, and predictable duration of onset Antiemetic effect Suppresses seizure activity	Transient pain at site of injection Hypotension QT interval prolongation
Dexmedetomidine	Sedative + analgesic	No to minimal ventilatory depression [71] GI motility inhibition [72] Combined with propofol achieves higher satisfaction and provides cardiovascular stability [73] Decreased cough reflex [74]	Bradycardia [75] Less patient satisfaction compared with propofol [75]
Ketamine	Sedative + analgesic	Shorter recovery time compared with benzodiazepines [76] No cardiovascular depression [77]	Less reduction of gag reflex [78] Better recovery time with ketamine and propofol mixture compared with dexmedetomidine and propofol mixture [79]
Remimazolam	Sedative	Shorter recovery time compared with midazolam [80] Added to propofol in advanced endoscopy may shorten time to discharge [81]	High failure rate despite dose escalation [82] Ventilatory and cardiovascular depression when combined with fentanyl [82]
Remifentanil	Sedative + analgesic	Decreased cough reflex [74]	Significant ventilatory depression, emetic properties Narrow safety margin Unstable mixture when combined with propofol for procedures >30 minutes [83]

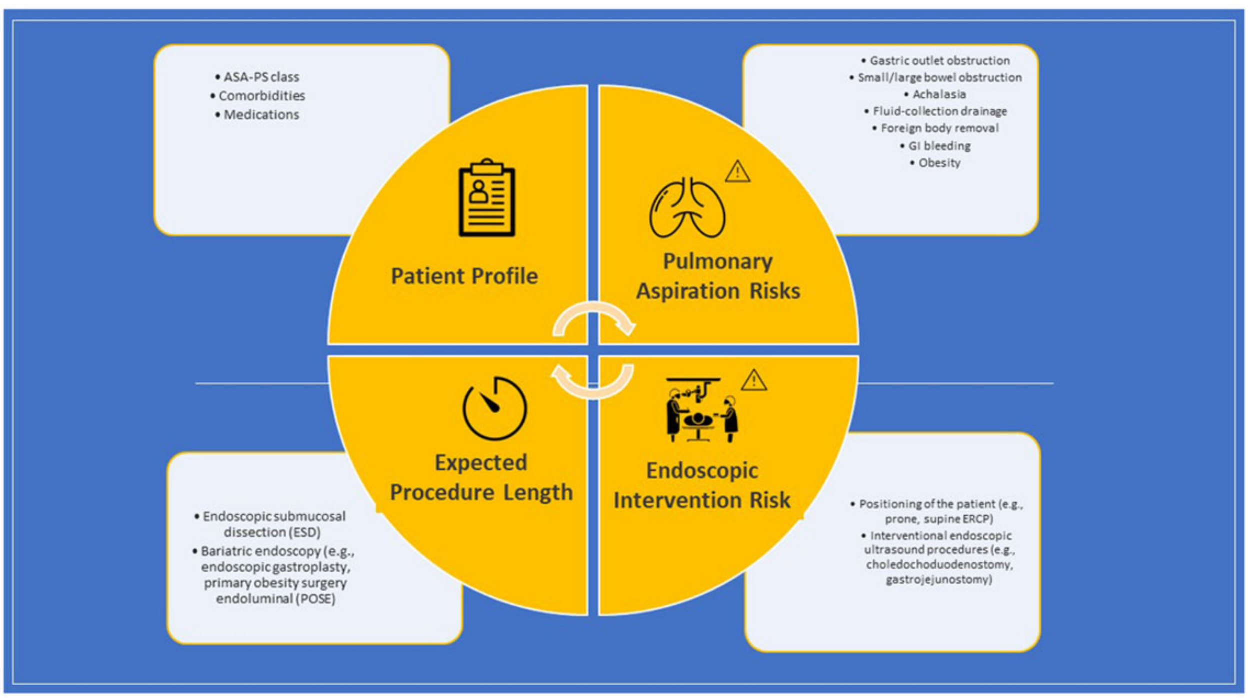

Figure 2. Framework for endo-anesthesia domains of risk

pheochromocytoma [67]. Secretin may be requested to facilitate pancreatic duct access, identify the minor papilla when interventions are needed in patients with pancreas divisum, or allow pancreatic secretion collection for pancreatic function testing or other research purposes. Additional endoscopically delivered medications can be associated with hemodynamic changes, albeit transient. Norepinephrine is used in a 1:10,000 mixture to treat actively bleeding lesions or in a 1:100,000–1:500,000 dilution prophylactically to decrease bleeding during intestinal lesion resections. An alcohol mixture may be administered during celiac plexus neurolysis. Endoscopists may request antibiotics for various indications [68].

Conclusion

Endo-anesthesia is a rapidly growing subspecialty. We suggest that anesthesiologists gauge the risk of endo-anesthesia based on four domains based principally on the patient's health profile, the type of endoscopic procedure, the length of the procedure, and the inherent risk of aspiration (Figure 2). The increasing complexity of patients and GI interventions necessitates careful planning to deliver safe care in modern endoscopy suites, especially in locations remote from the operating room.

Supplementary Data

Supplementary data is available at *Gastroenterology Report* online.

Authors' Contributions

F.B. conceived of the manuscript concept. F.B. and B.J.S. designed and wrote the manuscript. All authors critically revised the manuscript and approved the final version for submission.

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Conflict of Interest

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