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Dr. Erin Amey Ivan
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Srinivas Nishtala
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Ravi Varma
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Parul Dubey
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Marilyn Mathew
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Ayyanar Sakthivel Pachiappan
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Hany Fawzi Wahib Greiss
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Dr. Osama Maki AL Ani
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Corresponding Author:
Dr. Erin Amey Ivan
Department of Anaesthesiology, Rashid Hospital and Trauma Centre, Dubai, United Arab Emirates

Anaesthetic strategies and risk mitigation in GI endoscopic procedures

Erin Amey Ivan, Srinivas Nishtala, Ravi Varma, Parul Dubey, Marilyn Mathew, Ayyanar Sakthivel Pachiappan, Hany Fawzi Wahib Greiss and Osama Maki AL Ani

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Abstract
Gastrointestinal (GI) endoscopic procedures often require sedation and analgesia to improve patient comfort and procedural success, yet they pose significant anesthetic risks, including hypoxemia, pulmonary aspiration, apnea, bradycardia, and cardiac arrest.This article examines the critical role of preoperative evaluation, risk stratification, and tailored intraoperative anesthesia strategies in minimizing complications such as bleeding, visceral perforation, and venous air embolism. Key procedures requiring sedation, such as Endoscopic Retrograde Cholangiopancreatography (ERCP), Endoscopic Submucosal Dissection (ESD), and Peroral Endoscopic Myotomy (POEM), are detailed alongside tools like the Airway Protection Score (APS), Revised Cardiac Risk Index (RCRI), and Glasgow-Blatchford Bleeding Score (GBS) for risk assessment. The article addresses challenges in morbidly obese patients, including altered pharmacokinetics and respiratory risks, and emphasizes perioperative monitoring with point-of-care testing (POCT) and capnography. Management of intraprocedural complications, including airway management and aspiration prevention, is discussed, with evidence supporting high-flow nasal oxygen (HFNO) and endotracheal intubation. The multidisciplinary approach involving anesthesiologists, gastroenterologists, and nurses is highlighted to optimize outcomes.

Keywords: GI endoscopy, sedation, anesthesia, airway management, risk stratification, perioperative monitoring, obese patients, aspiration prevention, cardiovascular complications, multidisciplinary care

Introduction
Endoscopic procedures frequently require varying levels of sedation and analgesia to ensure patient comfort and procedural success. However, anesthesia-directed sedation can lead to complications such as hypoxemia, pulmonary aspiration, apnea, bradycardia, and even cardiac arrest [1]. Additionally, the procedures themselves carry inherent risks, including bleeding, visceral perforation, venous air embolism, pneumothorax and pneumomediastinum [1]. Thorough preoperative assessment, appropriate risk stratification, and optimization of the patient's condition are critical to minimizing these complications [1]. Enhancing perioperative monitoring and tailoring intraoperative anesthesia strategies to each patient's specific needs can further reduce the incidence of adverse events [1].
Common endoscopic procedures necessitating sedation include Endoscopic Retrograde Cholangiopancreatography (ERCP), Endoscopic Ultrasound (EUS)-guided drainage of peripancreatic fluid collections, Peroral Endoscopic Myotomy (POEM), Endoscopic Submucosal Dissection (ESD), Endoscopic Sleeve Gastroplasty (ESG), insertion or removal of intragastric balloons, and diagnostic procedures such as screening and biopsy of gastrointestinal lesions [1].

Preoperative Evaluation in GI Endoscopy
A meticulous preoperative evaluation is vital for ensuring patient safety and optimizing procedural outcomes [2]. This process helps identify underlying medical conditions such as cardiovascular disease, respiratory disorders, and coagulopathies that may increase the risk of complications during sedation and endoscopy [2]. Assessing anesthesia risk through airway evaluation, prior anesthesia history, and sedation tolerance enables individualized sedation planning and appropriate monitoring [2].

Furthermore, this evaluation ensures optimization of existing health issues like uncontrolled hypertension, diabetes, or electrolyte imbalances, thereby reducing perioperative complications [2]. Lastly, it aids in preventing procedural complications, such as bleeding due to anticoagulant use or perforation from anatomical challenges, and facilitates informed communication between clinicians and patients [2].

Patients undergoing GI endoscopy, particularly those requiring deep sedation or general anesthesia, may face an increased risk of airway compromise [3]. Pardo *et al.* developed a decision tree to assist clinicians in stratifying patients based on risk factors such as age, body mass index (BMI), obstructive sleep apnea (OSA), difficult airway history, cardiovascular disease, and pulmonary function [3]. This structured approach aids in determining the appropriate anesthesia technique (e.g., moderate sedation vs. general anesthesia with airway protection), selecting the procedural setting (endoscopy suite vs. operating room), and planning for potential complications like hypoxemia, apnea, aspiration, arrhythmias, or hemodynamic instability [3]. Airway protection is recommended based on the Airway Protection Score (APS), detailed below.

Airway Protection Score (APS) for GI Endoscopy

The Airway Protection Score (APS) stratifies patients to guide airway management during GI endoscopy [3].

Risk Factor	Points
Obesity (BMI > 35)	1
Severe OSA or Home CPAP Use	1
Baseline SpO_2 < 90%	2
Severe Pulmonary Disease (e.g., COPD)	2
Aspiration Risk (e.g., Gastroparesis, GERD)	2
Emergency Procedure (ICU, GI Bleed)	2
Procedure Duration > 60 Min	1
Prone Positioning (e.g., ERCP)	1
Deep Sedation/Anesthesia Needed	2

Score Interpretation

Score	Interpretation
< 4	Safe for deep sedation
≥ 4	Consider airway protection (ETI)
≥ 6	Strong recommendation for intubation

All patients require a pre-procedural evaluation to assess their risk for sedation and manage potential issues related to pre-existing conditions [4]. A history and focused physical examination at the time of the procedure are necessary, with key historical elements including a history of snoring, stridor, or sleep apnea; drug allergies and current medications with potential interactions; prior adverse reactions to sedation or anesthesia time and contents of the last oral intake and a history of tobacco, alcohol, or substance use [4]. The physical examination includes vital sign measurements, auscultation of the heart and lungs, and assessment of baseline consciousness and airway anatomy [4]. Additionally, pregnancy testing should be conducted for women of childbearing age in appropriate clinical settings, as some sedatives may be teratogenic [4].

Morbidly obese patients undergoing endoscopic bariatric procedures face elevated risks due to their increased likelihood of metabolic syndrome, which includes central obesity, hypertension, insulin resistance, and hypercholesterolemia [5]. These individuals are more susceptible to coronary artery disease, heart failure, and cardiac arrhythmias [5]. Obesity also heightens the risk of respiratory challenges, such as obstructive sleep apnea, diminished lung capacity, and postoperative complications like pneumonia and respiratory failure [5]. Compared to non-obese individuals, obese patients exhibit higher residual gastric volumes (>25 mL) and lower gastric fluid pH (<2.5) [5].

Cardiac Risk Stratification in GI Endoscopy

Assessing cardiac risk is crucial before GI endoscopy, especially in high-risk patients [7]. The Revised Cardiac Risk Index (RCRI) estimates the likelihood of major adverse cardiac events (MACE) and can be enhanced with cardiac biomarkers (e.g., NT-proBNP) for improved prediction [7]. The RCRI is detailed below.

Risk Factors and Points

Risk Factor	Points
High-Risk Surgery (e.g., Intraperitoneal)	1
Ischemic Heart Disease	1
Congestive Heart Failure	1
Cerebrovascular Disease (Stroke/TIA)	1
Diabetes Requiring Insulin	1
Creatinine ≥ 2.0 mg/dL	1

Score Interpretation (Risk of MACE)

Score	Risk of MACE
0	0.40%
1	0.90%
2	6.60%
≥ 3	11%

Elderly patients or those with cardiovascular disease benefit from combining RCRI and biomarker screening for better stratification [7].

Risk Stratification in Upper GI Bleeding

For patients with upper GI bleeding, the Glasgow-Blatchford Bleeding Score (GBS) assesses severity and predicts the need for urgent intervention [8]. The GBS is presented below.

Risk Parameters and Scores

Parameter	Score
Blood Urea Nitrogen (mg/dL)	
18.2-22.3	2
22.4-28.0	3
28.1-70.0	4
>70.0	6
Hemoglobin (g/dL)-Men	
12.0-13.0	1
10.0-11.9	3
<10.0	6
Hemoglobin (g/dL)-Women	
10.0-11.9	1
<10.0	6
Systolic BP (mmHg)	
100-109	1
90-99	2
<90	3
Other Factors	
Heart Rate > 100 bpm	1
Melena	1
Syncope	2
Hepatic Disease	2
Cardiac Failure	2

Score Interpretation

Score	Interpretation
0	Very low risk, outpatient possible
≥ 1	Higher risk, consider admission
≥ 7	High risk, urgent intervention

Analysis of the Clinical Outcomes Research Initiative database has shown that increasing ASA class is associated with an elevated risk of unplanned cardiopulmonary events during endoscopy [9, 10]. A retrospective study of over 1 million patients confirmed that ASA class correlates with adverse event risk during GI procedures [9].

The Mallampati Classification, which identifies potential obstructive sleep apnea and predicts difficulty with endotracheal intubation. This classification, based on structures visualized with maximal mouth opening and tongue protrusion, is complemented by considerations of prior anesthesia issues, stridor, snoring, sleep apnea, dysmorphic facial features, oral abnormalities, neck abnormalities, and jaw abnormalities [11].

Preoperative Concerns

Intravenous (IV) cannulation is challenging in endoscopic bariatric patients due to excess subcutaneous fat, which increases tissue thickness, distorts veins, and hinders visibility [13]. Additional complicating factors include being bedridden, extremes of age, hypovolemia, a history of drug abuse, vasculopathy, chemotherapy, multiple hospitalizations and edema [13]. These challenges necessitate alternative techniques and precautions, with ultrasound guidance and vein visualization systems increasingly utilized [14-17].

Bowel preparation for colonoscopic procedures may cause electrolyte imbalances, heightening cardiovascular complication risks, especially in the elderly or those with heart conditions, necessitating a thorough assessment of electrolyte and volume status [18].

Informed Consent

Patients must provide informed consent for sedation, involving a thorough discussion of benefits, risks, limitations, and alternatives to the sedation plan(19). The targeted sedation level should align with the patient's expectations and the requirements for a safe, effective procedure [19].

Perioperative Monitoring

Point of Care Testing (POCT) bedside ultrasound for gastric volume assessment during endoscopy under deep sedation enhances patient safety by detecting a "full stomach" (e.g., solid material or fluid >1.5 mL/kg), allowing adjustments to sedation plans, procedure delays, or airway protection measures like endotracheal intubation [20]. Assessing the inferior vena cava diameter (IVCD) via ultrasound, where IVCDmax < 1.25 cm predicts hypotension and evaluates blood volume noninvasively [21]. When IVCDmax < 1.25 cm, intravenous fluids or oral carbohydrate regimens can support circulatory stability and reduce postoperative nausea and vomiting, though they do not prevent hypotension [21, 22].

During deep sedation, careful monitoring of vital parameters and sedation levels is essential [23]. Pulse oximetry detects hypoxemia from respiratory depression, while an electrocardiogram (ECG) identifies arrhythmias or cardiac events [23]. Non Invasive Blood Pressure (NIBP) ensures hemodynamic stability, and capnography provides real-time end-tidal CO_2 and respiratory rate feedback to detect hypoventilation [23]. Respiratory rate may be monitored manually or with capnography, while optional Bispectral Index (BIS) monitoring titrates sedation in complex cases, and core temperature monitoring prevents hypothermia(23). Frequent blood gas analysis is recommended for high-risk or prolonged procedures [23]. A pre-procedural assessment and a "time out" pause before sedation initiation verify patient identity and sedation plans [24].

Intraprocedural Management

Sedative agent choice depends on patient characteristics, procedure complexity, and desired sedation depth, prioritizing rapid onset, short duration, and minimal adverse effects [26]. Propofol, the cornerstone of deep sedation, has a 30-45-second onset and 4-8-minute duration (0.3-0.4 mg/kg boluses or 100 mcg/kg/min infusion), offering antiemetic benefits but risking hypotension and respiratory depression, requiring careful titration [26]. Midazolam (0.5-2 mg initial boluses, 2-5-minute onset, 15-80-minute duration) suits light sedation with opioids but risks delirium and prolonged sedation in patients over 60-65 [26]. Fentanyl (1.5-2 mcg/kg, 2-5-minute onset, 45-60-minute duration) and remifentanil (0.04-0.16 mcg/kg/min, ongoing infusion) are used for analgesia, with similar onset profiles [26].

Obese patients under deep sedation require careful drug dosing due to altered pharmacokinetics, respiratory depression risks, and comorbidities like OSA [27]. Propofol induction uses lean body weight (LBW) to avoid overdose, with maintenance on total body weight (TBW) or modified fat-free mass (MFFM) [27]. Midazolam dosing uses ideal body weight (IBW) to prevent excessive sedation [27]). Fentanyl and remifentanil are dosed on LBW and MFFM, respectively, to mitigate respiratory risks [27].

Dexmedetomidine uses TBW, while ketamine and etomidate use IBW and LBW, respectively, with individualized titration and monitoring [27].

Procedures Requiring General Anesthesia (GA) and Deep Sedation

Procedures requiring general anesthesia include Primary Obesity Surgery Endoluminal (POSE), Endoscopic Sleeve Gastroplasty (ESG), Peroral Endoscopic Myotomy (POEM), Revisional Endobariatric Procedures (e.g., Transoral Outlet Reduction [TORe], Restorative Obesity Surgery Endoluminal [ROSE]), Endoscopic Submucosal Dissection (ESD) for upper GI lesions, EUS-guided drainage of large pancreatic pseudocysts with necrosectomy, and removal of fluid-filled intragastric balloons [28]. Procedures manageable under deep sedation include ESD for lower GI lesions, insertion/removal of intragastric balloons, AspireAssist device insertion/removal, gastric botulinum toxin injection, argon plasma coagulation for revisional procedures, uncomplicated ERCP, and uncomplicated EUS cases [28].

Managing Intraprocedural Complications

Endoscopy under deep anesthesia, while generally safe, can lead to various complications, among which airway complications are the most common [29].

Airway Complications and Management

During GI endoscopy under deep sedation, hypotonia of

upper airway muscles and desaturation from sedative-induced respiratory depression and obstruction are common [29]. Maneuvers like chin lift, jaw thrust, neck extension, left lateral decubitus positioning, increased oxygen flow (10-15 L/min), bag-mask ventilation, and lung recruitment maneuvers address these issues, especially in obese patients [29]. Airway adjuncts include nasopharyngeal airways (6-8 L/min oxygen), high-flow nasal cannulas (50-60 L/min), nasal CPAP masks, standard nasal cannulas (2-6 L/min), and face masks with endoscope ports, enhancing oxygenation and airway patency [29].

Aspiration Risk and Prevention Across GI Procedures

Aspiration risk is a critical concern across GI endoscopy, spanning upper GI procedures where shared airway access between the endoscopist and anesthesiologist heightens the potential for hypoxemia and aspiration pneumonia and lower GI procedures like colonoscopy and retrograde enteroscopy, where sedation and procedural factors contribute to pulmonary complications [31]. In upper GI endoscopy, suppressing laryngeal reflexes can lead to apnea and hypoventilation, increasing aspiration risk, particularly in patients with obesity or obstructive sleep apnea who are more prone to desaturation [29], while complex interventions such as endoscopic retrograde cholangiopancreatography (ERCP) and peroral endoscopic myotomy (POEM) may necessitate endoscope removal to manage airway obstruction due to their duration and intricacy [30]. Similarly, a prospective study found that 3% of patients undergoing colonoscopy with propofol anesthesia exhibited scintigraphic evidence of pulmonary aspiration, with rare but reported serious events linked to factors like gastrointestinal obstruction, colonogastric fistulas, difficult cecal intubation causing right-colon gas distention, positional changes, and external abdominal compression [34]. Standard fasting protocols, though routinely applied, may not fully eliminate residual gastric contents, underscoring the need for vigilant monitoring and tailored airway management to prevent aspiration-related adverse outcomes in both upper and lower GI endoscopy settings [23, 31].

Tailored Strategies for Aspiration Management

Effective management of aspiration risk in GI endoscopy relies on customized strategies addressing patient-specific and procedural challenges across upper and lower GI contexts. High-flow nasal oxygen (HFNO) and nasal airway placement maintain oxygenation and reduce hypoxia, with evidence supporting their efficacy during sedation for both upper GI procedures and lower GI cases involving patients with risk factors like obesity or pulmonary disease [32]. Endotracheal intubation offers a proactive airway-securing option for high-risk upper GI interventions like POEM, despite potential procedural interruptions [30]. Real-time suctioning can clear gastric liquid during esophagogastroduodenoscopy (EGD) to avert aspiration [31] and similar vigilance mitigates risks from gas distention or secretions in prolonged colonoscopy cases, enhanced by antisialogogues like glycopyrrolate to minimize secretion-related hazards [33]. Preprocedural evaluation assessing ASA-PS status, comorbidities, and procedural factors such as position changes or abdominal compression in colonoscopy combined with these techniques, provides a comprehensive framework to enhance safety and minimize aspiration complications throughout the spectrum of GI endoscopy [33].

Cardiovascular Complications and Prevention

Cardiovascular complications include hypotension due to vasodilation or reduced cardiac output, particularly in patients with pre-existing conditions, arrhythmias from vagal stimulation or anesthetic side effects, and myocardial ischemia in those with coronary artery disease triggered by procedural stress [31]. Prevention involves thorough preoperative assessments (e.g., ECG), titrated anesthetic dosing to avoid hypotension or arrhythmias, continuous monitoring of vitals with interventions like fluids or vasopressors, and prophylactic anticholinergics (e.g., atropine) for vagal responses [32].

Embolism

Gas embolism, a rare but serious complication, occurs in approximately 0.57 per 100,000 endoscopic procedures, with risk escalating during complex interventions like endoscopic drainage and debridement of walled-off necrosis or ERCP, particularly with intraductal cholangioscopy or radiology-assisted biliary cannulation using percutaneous transhepatic drains [42]. Prolonged procedures heighten the chance of gas entering the vascular system due to compromised vasculature, even with carbon dioxide insufflation, which reduces but does not eliminate the danger [42]. Gas embolisms may be silent or catastrophic, potentially triggering acute right heart failure, tachy or bradyarrhythmias, or cardiac arrest. If suspected, the procedure must stop immediately, with gas decompressed from the upper GI tract to halt further entry, followed by hemodynamic and ventilatory support [43]. Meanwhile, subcutaneous emphysema, pneumomediastinum, pneumoperitoneum, or compartment syndromes can arise during necrotizing pancreatitis debridement, endoscopic submucosal dissection, polyp resection, or peroral endoscopic myotomy of the esophagus or pylorus, often due to luminal perforation or anastomosis creation. These complications may impair hemodynamics or diaphragmatic function, requiring thoracic or abdominal needle decompression. Pneumoperitoneum affects 5% of endoscopic ultrasound-guided interventions, with tension pneumoperitoneum a rare, lethal form marked by ventilation struggles, venous congestion, and abdominal rigidity. Immediate decompression and surgical consultation are critical, alongside endoscopic perforation repair if feasible, with blood typing recommended for acute GI hemorrhage cases [44].

Gastrointestinal Complications and Mitigation

Gastrointestinal complications encompass rare perforations of the esophagus, stomach, or intestines that may cause peritonitis or sepsis, bleeding from mucosal injuries or biopsies, and gastric aspiration leading to pneumonitis or infection [28]. These are mitigated by training endoscopists for gentle techniques, enforcing a 6-8-hour fast, preparing hemostatic tools (e.g., clips, cautery), and careful patient selection to avoid unnecessary procedures in high-risk cases [37].

Neurological Complications and Management

Neurological complications include sedation overdose causing prolonged recovery or confusion, and rare seizures possibly linked to hypoxia or drugs, managed through

weight-based dosing with reversal agents (e.g., flumazenil, naloxone), extended post-anesthesia care unit (PACU) observation, and sedation scales to prevent overdose [37, 38].

Allergic Reactions and Response

Allergic reactions, ranging from rashes to anaphylaxis from anesthetics or contrast media, are addressed by allergy screening, keeping emergency drugs (e.g., epinephrine) on hand, and using non-allergenic alternatives [39].

Metabolic and Systemic Effects Prevention

Metabolic and systemic effects like hypothermia and electrolyte imbalances, common in lengthy procedures or vulnerable patients, are prevented with warmed fluids, adjusted fluid management, and minimizing procedure duration [39, 40].

Infection Risks and Control

Infection risks, such as transient bacteremia leading to endocarditis or device-related infections from poor sterilization, are reduced with strict sterilization protocols, antibiotic prophylaxis for high-risk patients, and aseptic techniques(41).

Musculoskeletal Injuries and Prevention

Musculoskeletal injuries, such as nerve compression or muscle strain from prolonged immobility, are avoided with padded supports, proper positioning, and staff training to recognize early signs.

The frequency and severity of these complications depend on patient factors (e.g., age, comorbidities), procedure type (e.g., upper GI vs. colonoscopy), and anesthetic technique, underscoring the need for tailored preventive measures. A multidisciplinary team involving anesthesiologists, gastroenterologists, and nurses ensures comprehensive care, while patient education on fasting, medication adjustments, and post-procedure follow-up helps detect delayed issues like bleeding or infection [39].

Conclusion

The management of anesthetic considerations for Gastrointestinal (GI) endoscopic procedures demands a multifaceted approach to ensure patient safety and procedural efficacy. Preoperative evaluation, utilizing tools like the Airway Protection Score (APS), Revised Cardiac Risk Index (RCRI), and Glasgow-Blatchford Bleeding Score (GBS), enables precise risk stratification and individualized planning, especially for high-risk groups such as the elderly, obese patients, and those with cardiovascular disease. The complexity of procedures like Endoscopic Retrograde Cholangiopancreatography (ERCP), Peroral Endoscopic Myotomy (POEM) and Endoscopic Submucosal Dissection (ESD), combined with the challenges of deep sedation and general anesthesia, requires advanced monitoring techniques including point-of-care ultrasound, capnography, and pulse oximetry. Tailored sedative dosing, adjusted for lean body weight (LBW) and ideal body weight (IBW) in obese patients, minimizes risks such as respiratory depression and hypotension. Intraprocedural complications, notably airway management and aspiration prevention, necessitate proactive strategies like high-flow nasal oxygen (HFNO), endotracheal intubation, and real-time suctioning, supported by evidence from trials. A multidisciplinary team of anesthesiologists, gastroenterologists, and nurses employs preventive measures titrated anesthetics, hemostatic tools, and sterilization protocols while patient education on fasting and post-procedure care aids in detecting delayed issues. Despite progress, challenges like variable sedation responses persist, highlighting the need for refined risk models, AI-driven monitoring, and standardized training to address growing procedural complexity and ensure GI endoscopy remains a safe, effective tool.

Conflict of Interest

Not available

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Not available

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