Current Approaches to Sedation and Anesthesia in Endoscopy Units: Integrating Pharmacology, Monitoring, and Patient Safety

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ABSTRACT

Sedation and anesthesia practices in gastrointestinal endoscopy units play a critical role in enhancing patient comfort, improving procedural tolerance, and ensuring procedural success. However, increasing procedural complexity and the growing burden of patient comorbidities have heightened the importance of patient safety, particularly with respect to the cardiorespiratory risks associated with deep sedation. This review provides a comprehensive overview of current sedation and anesthesia practices in endoscopy units, with a focus on patient selection, risk stratification, pharmacological agents, monitoring standards, and complication management. Emphasis is placed on patient-centered and individualized sedation strategies that account for patient age, comorbidities, American Society of Anesthesiologists physical status classification, and procedural characteristics. Propofol remains the cornerstone of endoscopic sedation because of its rapid onset and favorable recovery profile. Nevertheless, newer agents such as remimazolam, ciprofol, and esketamine have emerged as promising alternatives either as primary sedative agents or as adjuvant drugs, offering improved pharmacokinetic predictability, greater hemodynamic stability, and potentially enhanced cardiorespiratory safety. Adjunctive agents, including opioids and ketamine, may further optimize analgesia and sedation quality when used appropriately. Standard monitoring modalities, including pulse oximetry, noninvasive blood pressure, and electrocardiography, are essential, whereas capnography offers significant advantages for the early detection of respiratory compromise. Effective complication management relies on early recognition, timely intervention, and adherence to structured safety protocols. Validated recovery and discharge scoring systems further contribute to safe postprocedural care. In conclusion, safe and effective sedation in gastrointestinal endoscopy units requires a multidisciplinary, protocol-driven approach that integrates individualized pharmacological strategies, appropriate monitoring, and experienced clinical teams.

Keywords: *Capnography, endoscopy units, nonoperating room anesthesia, patient safety, sedation*

INTRODUCTION

Endoscopic procedures have become indispensable for the diagnosis and treatment of gastrointestinal diseases, with a significant increase in their global utilization in recent years. Endoscopic interventions, which represent some of the most commonly performed procedures in endoscopy units, have become increasingly widespread and continue to grow in frequency over time.[1] Although classified as minimally invasive procedures, endoscopic interventions may be difficult for patients to tolerate because of symptoms such as pain, anxiety, gag reflex, and abdominal distension. In addition, modern gastrointestinal techniques and therapeutic procedures are longer in duration, lasting up to several hours, compared with those performed in the past. Sedation and anesthesia practices have therefore become essential components of endoscopic procedures, as they reduce patient anxiety, improve comfort both before and during the procedure, and help ensure safe and effective procedural completion.[2] Today, anesthesia support in endoscopy units is increasingly critical because of the aging patient population, the rising burden of comorbidities among patients, and the growing complexity of endoscopic interventions. Therefore, sedation and anesthesia practices in endoscopic procedures should be considered fundamental components of care that require a multidisciplinary approach to optimize patient safety and procedural quality.

Environments in which anesthesia is administered must meet specific standards for technical infrastructure, equipment, and organization; however, physical and functional differences exist between operating rooms and endoscopy units. Operating rooms are equipped with fully developed anesthesia workstations and comprehensive infrastructure, whereas endoscopy units represent

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nonoperating room anesthesia (NORA) settings that have become increasingly complex with the rapid growth of diagnostic and therapeutic procedures.[3] The high density of imaging equipment in these units necessitates different technical arrangements compared with operating rooms, particularly regarding the placement of anesthesia devices and access to the patient. In terms of team structure, unlike the broad multidisciplinary staffing model in operating rooms, collaboration in endoscopy units occurs within a more limited framework involving the gastroenterologist, endoscopy nurse, and anesthesia team. Sedation strategies that provide rapid onset and recovery are prioritized in these units because of high patient turnover; however, complete anesthetic recovery before discharge remains critical.[4] Limited access to equipment and the cardiopulmonary risks associated with advanced procedures such as endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic ultrasound present unique safety challenges and necessitate meticulous planning for the management of cardiopulmonary complications and airway control.[5] In this context, current guidelines emphasize that appropriate monitoring, availability of emergency airway equipment, and adherence to standard safety protocols are essential for ensuring patient safety.

Main Points

- *Sedation and anesthesia practices in endoscopy units are essential not only for improving patient comfort but also for ensuring the safe and successful completion of endoscopic procedures.*
- *The sedation strategy should be individualized, taking into account age, comorbidities, American Society of Anesthesiologists physical status classification, obesity, the presence of obstructive sleep apnea, and the expected duration and complexity of the procedure.*
- *Propofol remains one of the most commonly used agents for endoscopic sedation because of its rapid onset of action and favorable recovery profile, whereas newer agents such as remimazolam, ciprofol, and esketamine have emerged as promising alternatives because of their greater hemodynamic stability and improved respiratory safety.*
- *Standard monitoring modalities such as pulse oximetry, noninvasive blood pressure measurement, and electrocardiography should be used during sedation, particularly for moderate and deep sedation. Capnography should also be considered an important safety tool for the early detection of respiratory depression.*
- *Safe sedation in endoscopy units depends not only on appropriate drug selection but also on the presence of a trained clinical team, immediate availability of emergency airway equipment, implementation of standardized safety protocols, and use of objective recovery and discharge criteria.*

This review evaluates sedation and anesthesia approaches used in endoscopy units based on the current literature, with a focus on their impact on patient safety. Sedation methods used during endoscopic procedures, commonly used pharmacological agents, basic monitoring strategies, and safety approaches aimed at preventing potential complications are discussed. The current study aims to provide an up-to-date, comprehensive, and practice-oriented resource for anesthesiologists, gastroenterologists, anesthesia and endoscopy nurses, and other healthcare professionals involved in sedation and anesthesia practices in endoscopy units.

Fundamental Concepts of Anesthesia and Safety in the Endoscopy Unit

Patient Safety Culture: Patient safety, a cornerstone of modern healthcare delivery, is of critical importance, particularly in sedation–analgesia practices in endoscopy units. To prevent cardiopulmonary complications that may occur during endoscopic procedures, patient safety be approached not merely as an individual responsibility but as an institutional culture supported by clinical protocols.[6] International gastroenterology and anesthesiology societies emphasize the importance of preoperative evaluation, individualized sedation planning, and standard monitoring to ensure patient safety in endoscopy units.[2,4] In addition, strengthening team communication, implementing checklists, and establishing standard operating protocols are fundamental components of patient safety. Furthermore, systematic safety approaches including verification of patient identification, procedure confirmation, and complication management plans should be integrated into clinical practice to ensure safe implementation. In this framework, patient safety culture should be addressed as a holistic approach that encompasses not only technical equipment and monitoring but also team training, effective communication, and continuous quality improvement processes.

Environmental and System Safety of the Endoscopy Unit

Physical Infrastructure: Ensuring appropriate physical infrastructure is a prerequisite for safe sedation and anesthesia practices in endoscopy units. This infrastructure should include essential components such as a continuous oxygen supply, suction system, reliable electrical infrastructure, and adequate lighting. In patients undergoing sedation, the use of standard monitoring methods such as electrocardiography (ECG), noninvasive blood pressure (NIBP) measurement, and pulse oximetry is

recommended according to the level of sedoanalgesia.[7] Particularly in cases of deep sedation, the use of capnography significantly contributes to patient safety by enabling the early detection of respiratory depression.[4,8]

Emergency Preparedness: In sedation and anesthesia practices, emergency equipment must always be readily available to allow rapid and effective intervention in the event of potential complications. A comprehensive resuscitation unit should include the following essential components.[9]

- Basic airway equipment: This should include a continuous oxygen source, nasal oxygen cannulas and face masks in various sizes, and a bag-valve-mask (Ambu) system with appropriate capacity. Oropharyngeal airway devices (Guedel) in different sizes should be immediately available.
- Advanced airway management tools: These should include functional laryngoscope sets, endotracheal tubes, and laryngeal mask airway devices as rescue airway equipment. Videolaryngoscopy should be available within a reasonable time frame, typically within a few minutes.
- Cardiovascular support and defibrillation: This should include a cardiac defibrillator that complies with current algorithms and is maintained periodically. Personnel should receive regular training in the use of this equipment.
- Emergency pharmacology: These should include vasopressors and anticholinergics (epinephrine, norepinephrine, ephedrine, and atropine); specific antidotes (flumazenil and naloxone); antiarrhythmics (lidocaine); glucose-containing fluids, hydrocortisone, anti-allergic agents, and sodium bicarbonate.

Radiation Safety: Interventional endoscopic procedures performed under fluoroscopic guidance, particularly ERCP, expose both patients and healthcare personnel to ionizing radiation. To minimize this risk, personal protective equipment such as lead aprons, thyroid shields, and protective eyewear should be used, and fluoroscopy time should be kept to a minimum. In addition, radiation dose monitoring and regular staff training in radiation safety contribute to reducing radiation exposure.[10]

Documentation and Data Security: Accurate and complete documentation of procedures performed and the sedation and anesthesia protocols used in endoscopy units is essential for patient safety, quality management, and medicolegal processes. A comprehensive endoscopy report should include the type and indication of the procedure, the doses and timing of administered anesthetic agents, intraprocedural vital signs, and any complications that may occur. Today, standardized electronic reporting systems facilitate the systematic storage of clinical data while also improving communication among healthcare professionals and enhancing patient follow-up. Moreover, such systems contribute to the monitoring of quality indicators and the continuous improvement of endoscopy unit services.[11]

Patient Selection and Risk Stratification

Appropriate patient selection and risk stratification constitute fundamental steps in sedation and anesthesia practices performed in endoscopy units to ensure patient safety. As with other anesthesia practices, the preprocedural evaluation process should include a careful assessment of the patient's detailed medical history, existing comorbidities, chronic medication use, and previous anesthesia-related experiences (such as difficult airway, prolonged recovery, etc.). The presence of cardiovascular and respiratory diseases is particularly important because it may increase the risk of sedation-related complications. One of the most commonly used tools for assessing perioperative risk is the American Society of Anesthesiologists (ASA) physical status classification.[12] In clinical practice, major risk factors include advanced age, morbid obesity, and obstructive sleep apnea syndrome (OSAS). It should be noted that the risk of periprocedural apnea and airway obstruction is significantly increased, particularly in patients with a body mass index of ≥35 kg/m^2) and/or a diagnosis of OSAS.[4] Therefore, the presence of these risk factors should be taken into account during patient evaluation, and the sedation and anesthesia strategy should be individualized accordingly.[13]

Although sedation practices in endoscopy units worldwide may be performed by endoscopy nurses or gastroenterologists in addition to anesthesiologists, the involvement of an anesthesiologist is recommended, particularly for high-risk patients or procedures requiring deeper states of sedation and analgesia. In such cases, more advanced monitoring modalities might be indicated. Furthermore, adherence to fasting periods in accordance with current guidelines, airway assessment based on physical examination and individualized, preplanned determination of sedation depth are among the key components of safe sedation management.[2] Therefore, systematic patient evaluation and appropriate risk stratification form the foundation of safety strategies aimed at maximizing

patient safety during sedation and anesthesia practices for endoscopic procedures.

Sedation/Anesthesia Techniques and Drug Selection

The sedation and anesthesia strategy selected for endoscopic interventions should be determined dynamically according to the nature of the procedure (diagnostic/therapeutic), the anticipated duration, the level of invasiveness, and the individual risk profile of the patient. Sedation practices are classified as anxiolysis, minimal (light), moderate (conscious sedation), and deep sedation based on the level of consciousness and the patient's response to stimuli.[14]

- Minimal sedation: During minimal sedation, the patient responds normally to verbal stimuli, airway reflexes are preserved, and cardiorespiratory functions remain unaffected. This level is generally sufficient for simple diagnostic procedures.
- Moderate sedation: This is the level at which the patient responds to verbal or mild tactile stimuli, and spontaneous respiration is generally maintained. Careful airway monitoring is essential because of the risk of partial reduction in airway reflexes.
- Deep sedation: This is a high-risk level in which the patient responds only to repeated or painful stimuli, airway reflexes may be suppressed, and the need for ventilatory support may arise.[14] Frequently preferred for advanced endoscopic interventions, this level should be managed by personnel experienced in advanced airway management and with access to appropriate equipment.[4]

The question of who should perform sedation practices also represents an important area of discussion regarding patient safety. Although minimal and moderate sedation can be administered in many centers by nonanesthesiologist physicians or trained healthcare professionals, the risk of complications increases with increasing sedation depth.[14-16] Training of all healthcare professionals applying sedative drugs should be adequately documented within each department. Considering that sedation depth may progress to a deeper stage at any time (transition to a deeper-than-intended level of sedation) and that urgent airway/hemodynamic management may be required in such situations, the involvement of an anesthesiologist is recommended for all procedures requiring moderate-to-deep sedation.[16]

Furthermore, risk factors such as the patient's ASA physical status, comorbidities, obesity, and the presence of OSAS may directly influence the sedation plan and necessitate more advanced anesthesia support.[13] Accordingly, the sedation technique should not be selected on a procedure-based approach but through an "individualized" approach that considers the patient's physiological reserves and clinical conditions.

Sedative and Anesthetic Agents Used in the Endoscopy Unit

Gastrointestinal endoscopic interventions are widely performed for both diagnostic and therapeutic purposes. In these procedures, the primary aims of sedation and anesthesia are to maximize patient comfort, improve procedural tolerance, suppress motor movements when necessary, and optimize the technical quality of the intervention. The depth of sedation to be administered is directly related to the patient's ASA physical status, existing comorbidities, the anticipated duration of the procedure, and the level of invasiveness.[4]

In clinical practice, the ideal sedative agent is expected to have characteristics such as rapid onset of action, short duration of effect, a predictable dose–response relationship, minimal cardiorespiratory depression, a short half-life, and rapid recovery.

Since no single "ideal" agent possesses all these characteristics, drug selection is individualized using a "patient-specific" approach. In the sedation guideline of the European Society of Gastrointestinal Endoscopy, the most commonly used agents have been reported to be midazolam (82%) and propofol-based sedation (81.8%).[7] In a systematic review conducted by Dossa et al,[2] it was stated that there is no clear consensus regarding the optimal level of sedation or the preferred sedative agent.

Propofol: Propofol is a rapid-onset, short-acting intravenous anesthetic agent that exerts its effects via gamma-aminobutyric acid type A (GABA-A) receptors. It is widely preferred for moderate-to-deep sedation during endoscopic procedures because of its ability to provide faster induction than benzodiazepines, shorter recovery time, and a more predictable pharmacokinetic profile.[17] In a randomized study conducted by Padmanabhan et al,[18] among patients undergoing colonoscopy, the rate of intraprocedural awareness was reported to be only 2%, and 98.7% of patients considered the depth of sedation as "fully appropriate." In the same study, propofol was shown to be superior to the fentanyl/midazolam combination in terms of patient satisfaction and overall procedural experience. In a Cochrane review published by

Johnson et al,[19] propofol sedation was reported to be associated with shorter recovery time and higher patient satisfaction. Additionally, no significant difference was found between propofol and traditional sedative agents regarding hypoxemic events requiring healthcare provider intervention. However, the narrow therapeutic window of propofol and its potential for dose-dependent cardiorespiratory depression necessitate careful titration, particularly in geriatric and high-risk patients.

In conclusion, propofol continues to be one of the primary agents in endoscopic sedation because of its rapid onset and favorable recovery profile. However, because of its potential for cardiorespiratory depression, safe use requires close monitoring and the presence of an experienced team.

Midazolam: Midazolam, a short-acting benzodiazepine, has been widely used in endoscopic sedation for many years because of its potent anxiolytic, sedative, and amnestic properties. When administered alone or in combination with opioids, it can provide light-to-moderate sedation. Sedation with midazolam and fentanyl has been reported to reduce procedural discomfort, increase patient satisfaction compared with no sedation, and improve colonoscopy tolerability.[20] In a study of patients undergoing endoscopic submucosal dissection (ESD) who received propofol-based sedation, the addition of midazolam before the procedure was compared with placebo administration. The addition of midazolam significantly increased patients' preference for the same sedation method in future procedures. However, it did not provide significant advantages in terms of procedure duration, endoscopist satisfaction, or recovery time.[21] In comparison with propofol for upper gastrointestinal endoscopy, midazolam use has been reported to reduce propofol requirements without affecting the total procedure time.[22] However, it should be noted that the active metabolites of midazolam and its prolonged elimination half-life in elderly patients may increase the risk of delayed recovery and respiratory depression.

In conclusion, although midazolam provides a reliable and effective anxiolytic and sedative profile, it requires careful dose titration, particularly in elderly patients and those with comorbidities because of its slower recovery profile and potential for accumulation.

Ketamine: Ketamine has emerged as an effective alternative for sedation in endoscopic procedures, either alone or in combination with other agents. In a randomized controlled study, ketamine was reported to provide a level of sedation comparable to standard sedation regimens, with high levels of patient and physician satisfaction.[23] In studies evaluating its combination with propofol (ketofol), ketamine has been shown to maintain hemodynamic stability and may reduce the risk of respiratory depression. Although recovery time was longer in patients receiving ketamine, no significant difference was found.[24] Majidinejad et al[25] also demonstrated that, because of its analgesic effects, ketamine reduces pain and discomfort during the procedure, thereby increasing patient comfort. Concerns, although not strongly supported by evidence, regarding delirium, hallucinations, prolonged recovery times, and emergence reactions appear to have limited its use in procedural sedation and hindered its broader adoption.[26] These side effects might be less relevant with the use of esketamine.

In conclusion, ketamine is a valuable option for endoscopic sedation, particularly because of its ability to maintain hemodynamic stability and provide analgesia. However, it should be used with appropriate patient selection and individualized sedation strategies, considering its potential psychomimetic side effects and impact on recovery time.

Etomidate: Etomidate is a rapid-onset (5-15 seconds) and short-acting (5-15 minutes) intravenous hypnotic agent that exerts its effects via GABA-A receptors.[27] Because of its ability to largely preserve hemodynamic stability, it has long been preferred as an induction agent, particularly in patients with limited cardiovascular reserve and those at risk of hemodynamic instability. In the context of endoscopic procedures, a study by Kim et al[28] comparing etomidate and propofol in patients undergoing endoscopic ultrasonography reported no significant difference in overall cardiopulmonary adverse events. However, the incidence of oxygen desaturation and respiratory depression was significantly lower in the etomidate group. This finding suggests the potential safety of etomidate, particularly in patients with limited respiratory reserve. However, in the same study, myoclonus was observed in approximately 34% of patients receiving etomidate. Myoclonic movements may negatively affect procedural safety and operator comfort, particularly during advanced endoscopic interventions requiring delicate maneuvers. Additionally, evidence in the literature indicates that etomidate may cause adrenal suppression, and this effect may have clinical significance, particularly with repeated administration.[29] In a study comparing an etomidate–propofol combination with remimazolam, the induction time

was reported to be shorter in the combination group, whereas respiratory adverse effects were more frequent.[30] This finding suggests that the advantage of hemodynamic stability may be achieved at the expense of respiratory safety.

In conclusion, although etomidate is a valuable agent in patients with high cardiac risk because of its hemodynamic stability profile, it should not be considered a routine agent for procedural sedation. Rather, it should be used as an individualized alternative in selected cases because of the risk of myoclonus and its suppressive effects on adrenal function.

Dexmedetomidine: Dexmedetomidine is a selective α2-adrenergic receptor agonist that exerts its sedative, anxiolytic, and analgesic effects primarily through the locus coeruleus.[31] Its most notable advantage in sedation management is that it does not cause respiratory depression within the therapeutic dose range.[32] With this characteristic, dexmedetomidine is theoretically considered an ideal option for endoscopic sedation. In patients undergoing esophageal ESD, the use of dexmedetomidine has been reported to reduce the incidence of moderate-to-severe postoperative pain and morphine consumption in the postanesthesia care unit. Additionally, a lower incidence of postoperative nausea and vomiting has been demonstrated in these patients.[33] However, in a study by Eberl et al,[34] both patient and gastroenterologist satisfaction were reported to be significantly lower in the dexmedetomidine group than in the propofol group. In another study comparing propofol alone with a propofol–dexmedetomidine combination in patients undergoing colonoscopy, heart rate and systolic blood pressure were significantly lower in patients receiving dexmedetomidine, highlighting its potential to cause bradycardia and hypotension.[35] This finding indicates that the hemodynamic effects of dexmedetomidine should be carefully monitored, particularly when used in combination regimens.

In conclusion, although dexmedetomidine offers significant advantages in terms of respiratory safety, it should be used with caution, particularly in elderly patients and those with cardiac conduction disorders, because of its potential to cause bradycardia, hypotension, and delayed recovery.

Ciprofol: Ciprofol (HSK3486) is a novel intravenous anesthetic agent developed through structural modification of propofol, with a higher affinity for the GABA-A receptor.[36] The addition of a cyclopropyl-ethyl group to its molecular structure increases receptor binding strength, allowing similar sedative effects to be achieved at lower doses compared with propofol.[37] In a study conducted by Gao et al[38] in patients undergoing colonoscopy, no difference was found between ciprofol and propofol regarding sedation success rate, and a dose of 0.4 mg/kg ciprofol was shown to be equivalent to 2.0 mg/kg propofol. Moreover, the incidence of injection pain, respiratory depression, and hypotension was lower in the ciprofol group, whereas patient satisfaction was higher.[38] In the Respiratory-related Safety Trial study conducted in elderly patients, respiratory-related adverse events were significantly lower in the ciprofol group, and the risk of these events was reported to be 1.82 times higher in the propofol group.[39] In a study by Ding et al[40] in patients undergoing ERCP, the induction time was longer in the ciprofol group than in the propofol group; however, full recovery and discharge from the procedure room were achieved in a shorter time. Similarly, in a study by Xu et al[41] in elderly patients, the time to readiness for discharge was reported to be shorter in the ciprofol group.

In conclusion, although ciprofol provides sedative efficacy comparable to that of propofol, it appears to be a promising alternative agent, particularly in elderly and high-risk patient populations, because of its lower incidence of injection pain and more favorable respiratory safety profile.

Esketamine: Esketamine is the S-enantiomer of ketamine and acts as an N-methyl-D-aspartate receptor antagonist.[42] In addition to its analgesic properties, it has supportive effects on hemodynamic stability because of its sympathomimetic properties. When 0.2 mg/kg esketamine is added to propofol sedation, it has been shown to improve cognitive recovery on the third postprocedural day and increase patient satisfaction. Furthermore, this combination has been reported to significantly reduce the incidence of hypotension, bradycardia, and hypoxemia.[43] Similarly, another study demonstrated that the addition of esketamine to propofol reduced the incidence of desaturation and hypotension by 61% and decreased propofol requirements.[44] Compared with racemic ketamine, esketamine has been reported to shorten recovery and orientation times and to be generally well tolerated.[45]

In conclusion, esketamine can be considered an effective adjuvant anesthetic and analgesic agent, particularly when added to propofol-based sedation, because it

enhances hemodynamic stability, reduces propofol dose requirements, and may improve cognitive recovery.

Remimazolam: Remimazolam is an ultra–short-acting benzodiazepine that is rapidly metabolized by esterases and has a predictable recovery profile.[46] This pharmacokinetic property allows for safe dose titration, particularly in elderly and comorbid patients. In studies conducted in elderly patients, remimazolam has been reported to have lower rates of hypoxemia, reduced requirements for vasoactive agents, and a lower (or even absent) incidence of injection pain compared with propofol.[47]

When compared with propofol in patients undergoing colonoscopy, remimazolam has been reported to be associated with a lower risk of hypotension and bradycardia and higher patient satisfaction.[48] Compared with midazolam, it has been shown to provide faster induction of sedation and recovery.[49] Similar to midazolam, the potential side effects of remimazolam could be counteracted by flumazenil.

In conclusion, with its rapidly reversible effects, favorable hemodynamic stability profile, and lower incidence of injection pain, remimazolam is positioned as a strong alternative to propofol, particularly in elderly and high-risk patients.

Fentanyl: Fentanyl is one of the most commonly used opioid analgesics during gastrointestinal endoscopy because of its rapid onset and short duration of action. When used in combination with midazolam, fentanyl has been reported to improve sedation quality, enhance patient comfort during the procedure, and provide a more favorable procedural experience for both patients and the endoscopists.[50] In another study, the addition of fentanyl to standard sedation procedures was reported to provide sedation with fewer hypotensive episodes and shorter recovery and discharge times compared with propofol alone.[51] However, complications such as respiratory depression, airway obstruction, and muscle rigidity have been reported to occur more frequently in opioid-containing sedation regimens.[52] Compared with meperidine, fentanyl has been shown to have a faster onset of action and shorter duration of effect.[53]

In conclusion, fentanyl is an effective and commonly preferred analgesic agent in endoscopic sedation when used with appropriate dosing and careful monitoring. However, it should be used cautiously because of its potential adverse effects on the respiratory system.

Remifentanil: Remifentanil is one of the opioid agents frequently preferred for sedation–analgesia in endoscopic procedures because of its rapid onset and very short duration of action. In a randomized study conducted in patients undergoing upper gastrointestinal endoscopy, the combination of remifentanil and propofol was reported to provide adequate sedation, maintain stable hemodynamic parameters, and not increase the incidence of hypoxemia, while also shortening spontaneous eye-opening time and postanesthesia recovery.[54] In a prospective randomized study conducted in patients undergoing colonoscopy, propofol–remifentanil sedation was shown to provide significantly faster onset of sedation and recovery compared with the midazolam–fentanyl combination.[55] Recent randomized studies have reported that remifentanil-based sedation may be considered an ideal option for both diagnostic and therapeutic procedures requiring sedation and analgesia.[56] In pediatric patients undergoing colonoscopy, the combination of ketamine–remifentanil has been reported to provide better sedation scores compared to ketamine–propofol.[57]

In conclusion, remifentanil is an effective option for endoscopic procedures because of its rapid onset, short recovery time, and ability to provide adequate sedation–analgesia. However, optimal outcomes require appropriate combinations with other sedative agents and individualized approaches based on patient characteristics.

Although advances in pharmacological agents have improved sedation quality, prevention of complications is not determined solely by the properties of the drugs used. Patient selection, team experience, and the presence of systematic safety protocols are at least as important as the use of the most suitable pharmacological agents. Therefore, ensuring patient safety in the endoscopy unit requires a multidimensional and organization-based approach.

Nonanesthesiologist Sedation Practices in Endoscopy Units: Nonanesthesiologist healthcare professionals' sedation practices in endoscopy units have become increasingly widespread, particularly in European countries, to optimize resource utilization in response to the growing procedural workload. Recent studies have demonstrated that nurse-administered propofol sedation (NAPS), when performed according to appropriate training programs and standardized protocols, is a safe and effective approach for gastrointestinal endoscopic procedures, with notably low rates of serious complications.[15]

In the study conducted by Ferreira et al,[17] patients receiving NAPS were compared with those receiving anesthesiologist-administered sedation, and NAPS was found to be equivalent to anesthesiologist-administered sedation with respect to adverse event rates in a low-risk patient population. Furthermore, the sedation guideline published by the European Society of Gastrointestinal Endoscopy states that propofol sedation may be administered in selected centers by trained endoscopy nurses and non-anesthesiologist teams.[7]

Nevertheless, these practices vary according to the organization of national healthcare systems and existing legal regulations. In Türkiye, sedation management in current clinical practice is predominantly performed by anesthesiologists. Therefore, to facilitate the broader implementation of nurse-centered sedation practices in Türkiye, standardized training programs, appropriate legal frameworks, and multidisciplinary safety protocols need to be developed.

Monitoring and Respiratory Safety

Standard Monitoring: In patients undergoing sedation–analgesia in endoscopy units, standard monitoring should aim to provide continuous and systematic assessment of cardiorespiratory stability. Current international guidelines recommend continuous pulse oximetry (SpO_2) and intermittent NIBP measurements in all patients.[4,7] ECG monitoring is particularly important for the early detection of arrhythmia and ischemia, especially in patients with cardiac comorbidities or in the elderly population. In cases of moderate-to-deep sedation, ECG monitoring is recommended.[4]

This systematic approach enables early detection of physiological changes and facilitates timely intervention before they progress to serious complications.

Respiratory Monitoring and Capnography: Clinical assessment of respiration includes monitoring respiratory rate, chest movements, and level of consciousness and constitutes one of the fundamental components of sedation safety. The use of capnography (end-tidal CO_2 monitoring), particularly in cases of deep sedation and in prolonged, more complex procedures such as ERCP, is strongly recommended for the early detection of respiratory depression.[4,8] Corbett et al[58] demonstrated that the use of capnography during procedural sedation significantly reduces adverse events and is independently associated with a lower risk of complications. Wollner et al[59] reported that capnography allows earlier detection of hypoventilation and is associated with a reduction in desaturation events. The Turkish Society of Anesthesiology and Reanimation guideline for NORA recommends the use of capnography in all patients, regardless of the depth of anesthesia.[60] In contrast, in many European countries, capnography is strongly recommended during moderate and deep sedation, whereas its use during anxiolysis and minimal sedation is optional.

These findings indicate that capnography plays a critical role as an early warning system in situations in which pulse oximetry provides delayed findings. Therefore, its routine use in endoscopy units is considered an approach that directly enhances patient safety.

Oxygenation Strategies and Airway Preparedness: Hypoxia and apnea are among the most common adverse events associated with sedation. Conventional low-flow oxygen applications may be insufficient in some patients. Although the nasal cannula is the most commonly used method, the procedural oxygen mask (POM) has been defined as an effective alternative. Celik et al[61] reported that POM provides more effective oxygen support than the nasal cannula and is associated with greater hemodynamic stability. Similarly, high-flow nasal oxygen (HFNO) has been shown to reduce the incidence of hypoxemic events and to be beneficial during sedation, particularly in patients at high risk of hypoxia.[62,63] However, Gunel et al[64] found no significant difference between POM and HFNO in the incidence of hypoxemia in patients undergoing ERCP.

These data indicate that oxygenation strategies should be tailored to the patient's individual risk profile and that the availability of advanced airway management equipment and trained personnel is an integral component of patient safety.[4,7]

Monitoring of Sedation Depth: It has been reported that the use of Bispectral Index, a processed electroencephalogram-based monitoring method, does not provide significant clinical benefit regardless of the depth of sedation; therefore, its routine use is not recommended.[65]

Therefore, careful clinical assessment combined with observation of standard physiological monitoring parameters is considered a sufficient and safe approach for monitoring sedation depth in most patient populations.

Complications and Management: Complications related to sedation and anesthesia during endoscopic procedures may affect not only the respiratory system but also the cardiovascular and neurological systems. Hypoxemia, respiratory depression, and airway obstruction are the most commonly encountered respiratory problems. Both respiratory and cardiovascular complications occur more frequently, particularly during deep sedation.[2] In cases of respiratory depression associated with opioid or benzodiazepine use, administration of the appropriate antagonist agents (naloxone/flumazenil) is recommended. It is also recommended that cases requiring antagonist administration be reported and that these experiences be shared.[4] The use of capnography in addition to pulse oximetry has been shown to provide an advantage in the early detection of respiratory complications by enabling the identification of hypoventilation and apnea before the development of desaturation. It is strongly recommended for all procedures involving intended moderate-to-deep sedation.[58,59] Through this early detection, hypoxemia can be prevented by implementing stepwise interventions such as increasing oxygen flow, performing a chin lift, inserting an airway device, and applying positive pressure ventilation when necessary.[66] There are also studies indicating that sedation may increase the risk of pneumonia. In a small study including 250 hospitalized patients, sedation during endoscopy was reported to be associated with an increased risk of lower respiratory tract infection and pneumonia.[67]

Cardiovascular complications develop depending on the patient's underlying comorbid conditions and the doses of sedative agents administered, with hypotension and bradycardia being the most frequently observed findings.[2] When an adequate level of sedation cannot be achieved, hypertension and tachycardia may occur, whereas excessive sedation is associated predominantly with hypotension and bradycardia.[68] In a large-scale study conducted by Kim et al,[69] both advanced age and sedation were reported to have significant effects on cardiovascular and cerebrovascular events in patients undergoing sedated colonoscopy.[69] In cases of clinically significant hypotension and bradycardia, intravenous fluid replacement and vasopressor support may be administered.[70]

Neurological complications may manifest as agitation, delirium, and unexpected changes in the level of consciousness. Delirium and other neurological findings have been reported in association with sedation and anesthesia.[71] The presence of underlying comorbid diseases is among the major factors that increase the risk of these neurological complications.

Recovery and Discharge Safety: Safe recovery and discharge of patients following sedation and anesthesia in endoscopy units are fundamental components of patient safety. The use of objective and validated scoring systems is recommended to ensure safe discharge after sedation and anesthesia. In the recovery area, patients' level of consciousness, respiratory functions, and hemodynamic parameters should be closely monitored. Before discharge, a systematic assessment should be performed using predefined discharge criteria. The 2 most commonly used scoring systems for this purpose are the Modified Postanesthetic Discharge Scoring System (mPADSS) and the Aldrete scoring system.

- Modified Postanesthetic Discharge Scoring System**:** This system includes parameters such as stability of vital signs, ambulation, control of nausea and vomiting, and pain management. In a randomized controlled study conducted by De Benito Sanz et al,[72] the use of mPADSS was shown to be effective, safe, and associated with patient satisfaction.
- Aldrete Scoring System: Developed in 1970, the Aldrete scoring system is used to assess physiological recovery during the postanesthesia period. Its use has been reported to shorten the length of stay in the recovery area and provide a more standardized discharge process in endoscopy units.[73]

In a study comparing these 2 systems, Yamaguchi et al[74] demonstrated that the modified Aldrete score permits earlier discharge than the mPADSS; however, it is associated with a higher incidence of somnolence at the time of discharge. No significant difference was observed between the 2 scoring systems in the rate of adverse event rates within 24 hours after discharge.

These findings suggest that the balance between early discharge and complete neurocognitive recovery should be carefully considered. Accordingly, discharge decisions should be based not solely on time but on objective scoring systems, with priority given to the patient's clinical stability.

CONCLUSION

Sedation-analgesia administered in gastrointestinal endoscopy units is an indispensable component for improving patient comfort and procedural tolerance, as well as optimizing procedural success. However, the

increased risk of cardiorespiratory complications, particularly with deeper levels of sedation, necessitates careful planning and management of the process with close and continuous monitoring. The current literature indicates that propofol remains one of the primary agents used for endoscopic sedation because of its efficacy and widespread application, whereas newer agents such as remimazolam, esketamine, and ciprofol offer advantages including more predictable pharmacokinetic properties, greater hemodynamic stability, and improved respiratory safety. Nevertheless, no single sedative or anesthetic agent is ideal for all patient populations. Therefore, the choice of the agent should be individualized based on the patient's age, comorbidities, ASA physical status, airway characteristics, and the nature of the procedure.

Although pharmacological advancements have improved the quality of sedation, the prevention of complications is not determined solely by the choice of the sedative agent. Standard preoperative evaluation, appropriate risk stratification, adequate monitoring, risk-based oxygenation strategies, preparedness for airway management, the presence of a trained team, and the use of validated recovery and discharge criteria constitute the fundamental components of patient safety.

Standard preoperative evaluation, appropriate risk stratification, adequate monitoring, risk-based oxygenation strategies, preparedness for airway management, the availability of a trained team, and the application of validated recovery and discharge criteria constitute the fundamental components of patient safety. Particularly in patients undergoing deep sedation or those at high risk, early recognition of respiratory depression, safe airway management, and timely intervention for complications are critical determinants of patient outcomes. Therefore, anesthesia practices in endoscopy units should be structured within a patient-centered, multidisciplinary framework supported by systematic safety protocols.

In conclusion, a safe sedation approach in endoscopy units is based not on the search for a single "ideal agent" but on the integration of individualized pharmacological strategies, standardized monitoring, an experienced team approach, and an institutional culture of patient safety.

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