Sedation Strategies for Procedures Outside the Operating Room

Youn Yi Jo and Hyun Jeong Kwak
Department of Anesthesiology and Pain Medicine, Gil Medical Center, Gachon University College of Medicine, Incheon, Korea.

With the rapid development of diagnostic and therapeutic procedures performed outside the operating room (OR), the need for appropriate sedation care has emerged in importance to ensure the safety and comfort of patients and clinicians. The preparation and administration of sedatives and sedation care outside the OR require careful attention, proper monitoring systems, and clinically useful sedation guidelines. This literature review addresses proper monitoring and selection of sedatives for diagnostic and interventional procedures outside the OR. As the depth of sedation increases, respiratory depression and cardiovascular suppression become serious, necessitating careful surveillance using appropriate monitoring equipment.

**Key Words:** Sedation, procedure, monitoring, capnography, dexmedetomidine, remifentanil

**INTRODUCTION**

With the rapid development of diagnostic and therapeutic procedures performed outside the operating room (OR), patient needs for sedation or monitored anesthesia care have been increasing. Sedation relaxes anxiety, discomfort, and pain during a procedure. This makes the patient comfortable and allows children or uncooperative adults to undergo procedures without body movement.1 In an analysis of 63000 diagnostic or therapeutic procedures performed under sedation or monitored anesthesia care, 41% of sedations was performed by non-anesthesiologists.2 The most common procedures performed under non-anesthesia sedation are gastrointestinal endoscopy (64%) and cardiovascular procedures (30.5%).2

The depth of sedation depends on the type and purpose of the procedure, and possible complications are closely associated with the depth of sedation. According to a report by the Pediatric Sedation Research Consortium in 2009, pulmonary complications, such as apnea, aspiration, or desaturation, occurred 235 times per 10000 sedation/anesthesia administrations outside the OR.3 Many non-anesthesiologists practice anesthesia and sedation in their field, and while some of them are anxious when performing these, others perform these without any awareness of the dangers. Moreover, despite the recommendation of a standard anesthesia setup, including an anesthesia machine, standard monitoring, anesthesia cart, and suction apparatus at the endoscopy location, great variations are observed in the arrangement of equipment in each clinical field.1,4,5

This review serves as a general guide focusing on sedation procedures outside the OR and describes pre-procedure patient evaluation, intra-procedure monitoring, and administration strategies for sedatives and analgesics that are needed to provide safe and satisfactory sedation outside the OR.

**PRE-PROCEDURE EVALUATION AND PREPARATION**

Clinicians should be aware of the following: 1) reviewing previous medical records and interviewing the patients or caregiver for knowing underlying medical conditions (e.g., abnormalities of major organ systems, allergies); 2) previous experience or adverse events with sedation and anesthesia, sensitivity to sedatives or analgesics, and pain tolerance; and 3) current medical history and exposure to psychotropic drug.1
PATIENT MONITORING

An analysis of the ASA Closed Claims database demonstrated that respiratory depression caused by an overdose of sedatives or opioids was responsible for 21% of monitored anesthesia care-related claims, and about half of these claims were judged as preventable with better monitoring with vigilance.

### Hemodynamic monitoring

For hemodynamic monitoring, the Standards of Practice Committee of the American Society for Gastrointestinal Endoscopy recommended the monitoring of blood pressure and heart rate during sedation. In addition, other organizations of anesthesiologists have suggested that procedural sedation should require hemodynamic monitoring for the assessment of blood pressure, heart rate, and electrocardiography. Unless monitoring interferes with procedures, such as magnetic resonance imaging, it is recommended to check blood pressure before sedation, and then continuously monitor blood pressure (e.g., at 5 min intervals), heart rate, and electrocardiography during moderate sedation, especially in patients with significant cardiovascular disease or dysrythmias.

### Monitoring the depth of sedation

Sedation levels can be evaluated by the clinician. Evaluating the depth of sedation is very important because the greater the depth of sedation, the greater the impact on cardiopulmonary function.

The depth of sedation is classified as follows: minimal sedation (anxiolysis), normal response to verbal commands and unaffected cardiopulmonary function; moderate sedation/analgesia (conscious sedation), purposeful response to verbal commands and intact airway and cardiopulmonary functions; deep sedation/analgesia, response to painful stimulation and requirement of assistance for proper ventilation and airway.
patency; and general anesthesia. Clinicians sometimes prefer the digitalized form because it is more convenient than clinical observations.

The bispectral index (BIS) monitor (BIS vista monitor revision 3.0; Aspect Medical Systems, Norwood, MA, USA) is the most widely used monitoring instrument and is based on the interpretation of electroencephalograms (Fig. 1). It can be applied simply by attaching a single patch on the forehead to the temporal region of the head. BIS presents values between 90 and 100 for ‘awaken’, between 70 and 90 for ‘light to moderate sedation’, between 60 and 70 for ‘superficial anesthesia’, and between 45 and 60 for ‘general anesthesia’. Previous clinical studies did not provide satisfactory results for applying the BIS for short procedural sedation. In a previous clinical study, the Spearman correlation between the BIS and the observer’s assessment of alertness/sedation was 0.59 [95% confidence interval (CI), 0.44–0.74] and that between the BIS and the continuum of depth of sedation was 0.53 (95% CI, 0.36–0.70). The correlations were not strong enough, and no clinical relevance was observed in the sedation complications regardless of the BIS. Moreover, in a comparative study between the BIS and conventional clinical assessment during short procedures, no significant differences were observed in propofol dosage, oxygen desaturation, and requirement of hemodynamic and respiratory support between groups of patients undergoing bronchoscopy under propofol sedation. In contrast, during long procedures that required moderate sedation, BIS monitoring provided some clinical benefits. In a comparison between the BIS and invisible groups during deep sedation for ERCP, BIS monitoring led to a reduction in the required propofol dose. Another study on ERCP also reported an improvement in recovery time, but did not report a reduction in cardiopulmonary complications.

**Designated individual for patient monitoring**

ASA guidelines emphasize the presence of a designated individual other than the practitioner or procedural team to monitor the patient throughout the procedure. The designated individual should be trained to recognize apnea and airway obstruction and to check the level of sedation and vital signs.

**SEDATIVES AND ANALGESICS**

For procedures outside the OR, the use of inhalation agents is limited, and hence, most institutes prefer the use of intravenous agents. The dosage and side effects of individual sedative or analgesic agents commonly used are listed in Table 2.

**Midazolam**

Midazolam is the most frequently used benzodiazepine because of the rapid onset of and short duration for procedural sedation. It provides proper anxiolysis and antegrade amnesia. It enables respiratory depression and obtuse responses to carbon dioxide retention via central respiratory depression. In particular, rapid intravenous administration might increase respiratory depression. The dose requirements decrease with increasing age, which results in prolonged and profound drug responses in older adults. Because it is a central nervous system depressant, geriatric patients and those with severe illness and compromised cardiopulmonary reserves have to be closely monitored. Because midazolam has no analgesic effect, it is often used in combination with opioids, such as fentanyl; however, the combined use thereof can increase the risk of respiratory depression and severe hypotension.

The administration of midazolam sometimes induces paradoxical reactions (disinhibitory reactions), including uncontrolled aggressiveness, agitation, or hallucinations. Paradoxical reactions are manifested within 5 min of intravenous midazolam administration and are preceded by transient sedation before sudden agitation. The paradoxical reactions are related to genetic factors, alcohol abuse, or psychological disturbance, and are assumed to be due to the loss of cortical resistance caused by the inhibitory reaction of midazolam and reduced serotonin control. Flumazenil, an antidote to benzodiazepines, and haloperidol are helpful to attenuate paradoxical reactions after midazolam administration.
**Table 2. Summary of Sedation Drugs Commonly Used**

| Drug            | Intravenous dosage                                                                 | Analgesic effect | Onset | Duration | Side effects                                                                 |
|-----------------|------------------------------------------------------------------------------------|------------------|-------|----------|------------------------------------------------------------------------------|
| Midazolam       | Bolus for deep sedation: 0.1–0.4 mg/kg                                             | -                | 1–5 min | <2 h     | Paradoxical excitement (occasionally), hypotension, bradypnea                |
|                 | Bolus for moderate sedation: 0.01–0.1 mg/kg                                        |                  |        |          |                                                                               |
| Propofol        | Bolus for deep sedation: 1–2.5 mg/kg                                               | -                | <1 min | 5–10 min | Hypotension, bradypnea/apnea                                                  |
|                 | Infusion for moderate sedation: 25–100 μg/kg/min                                    |                  |        |          |                                                                               |
| Dexmedetomidine | Bolus for deep sedation: 1 μg/kg over 10 min                                        | ++               | 10–15 min | ~30 min  | Biphasic hemodynamic effect: bolus administration has been associated with hypertension |
|                 | Infusion for moderate sedation: 0.2–0.7 μg/kg/h                                     |                  |        |          |                                                                               |
| Remifentanil    | Infusion for moderate sedation: 0.05–2 μg/kg/min                                    | +++              | <1 min | 5–10 min | Hypotension, bradypnea/apnea, bradycardia                                    |
| Etomidate       | Bolus for deep sedation: 0.2–0.5 mg/kg                                             | -                | <1 min | 3–5 min  | Adrenocortical dysfunction, especially in continuous IV administration       |
| Ketamine        | Bolus for deep sedation: 0.5–2 mg/kg                                               | ++               | <1 min | 12–25 min| Dissociative hallucination, increased ICP and IOP, tachycardia, and hypertension |
|                 | Bolus for moderate sedation: 0.2–0.8 mg/kg                                         |                  |        |          |                                                                               |
|                 | Infusion for moderate sedation: 10–20 μg/kg/min                                     |                  |        |          |                                                                               |

ICP, intracranial pressure; IOP, intraocular pressure; IV, intravenous.

Moderate sedation (conscious sedation): purposeful response to verbal commands and intact airway and cardiopulmonary functions; deep sedation: response to painful stimulation and requirement of assistance for proper ventilation and airway patency.

**Propofol**

Propofol is a white-colored formula with benefits of rapid onset of anesthesia and a short recovery time. It provides smoother recovery than do other intravenous sedatives, and enables quicker recovery of psychomotor performance and lower incidence of postoperative nausea and vomiting than do other regimens.41 Because propofol has no analgesic effect, it can be combined with opioids. Owing to its fast onset and recovery profiles, it is also used for sedation in pediatric patients undergoing MRI.42,43 When combined with ketamine, it has lower depressive effects and can reduce propofol-injection pain.

Propofol sedation has been shown to cause euphoria in over 40% of patients undergoing gastroenteroscopy45 and is associated with a risk of drug addiction or abuse. Since propofol addiction was first reported in 1992, many people have become aware of the danger of addiction; the biggest event was the death of popstar Michael Jackson in 2009 due to propofol misuse. Propofol was designated as a controlled substance in Korea in February, 2011 (the first in the world), as there is a potential risk of abuse and propofol abusers are increasing. Because injection pain is the most frequent side effect of propofol, the concomitant use of lidocaine is recommended.46,47 Propofol induces respiratory depression and exerts a greater effect on cardiovascular depression with profound hypotension than do other intravenous agents.48,49 Rapid injection of the sedative formula, old age, and poor physical status results in the debilitation of patients, especially those vulnerable to catastrophic cardiorespiratory effects.48,49 Because propofol is a lipid-based formula, rapid bacterial contamination might easily develop and induce life-threatening sepsis.48,50 and hence, sterile and aseptic handling is important. Although very rare, propofol infusion syndrome, which involves severe metabolic acidosis, renal failure, rhabdomyolysis, and cardiac failure, may develop in cases of single administration of propofol.51

**Dexmedetomidine**

Dexmedetomidine is a selective α₂-receptor agonist and provides anxiolytic, sedative, and analgesic effects.52,53 Dexmedetomidine reduces norepinephrine release and inhibits sympathetic outflow in the central nervous system; therefore, it can cause profound bradycardia, especially in young patients with a high vagal tone.52,54 If transient hypertension occurs during the infusion of loading dose, a reduction of infusion rate should be considered.52 Meanwhile, hypotension may also occur, especially in geriatric patients or patients with diabetes mellitus or chronic hypertension.52,53

A feature of dexmedetomidine is that it has analgesic properties in addition to its role as a hypnotic, while being opioid sparing; thus, it is not associated with significant respiratory depression. Dexmedetomidine is most often used in the intensive care unit for light to moderate sedation. An earlier study suggested that using dexmedetomidine for sedation in mechanically ventilated adults may reduce the time to extubation and intensive care unit stay.55 It should not be administered over 24 h,52 because it induces potential withdrawal responses, such as agitation and an abrupt increase in blood pressure.

Patients on dexmedetomidine can be cooperative, which are beneficial in some procedures, such as blepharoplasty. Previous clinical studies demonstrated that dexmedetomidine provides less respiratory depression with better analgesic efficacy and deeper sedation level than does midazolam for double-balloon enteroscopy26 and ablation for atrial fibrillation.7 It can be used in combination with other sedatives, like
propofol, opioids, and benzodiazepines, to enhance sedation and to help maintain hemodynamic stability by decreasing the requirement for other sedatives.36,59 Because dexmedetomidine has a late onset of 10–15 min, combined administration of small doses of midazolam (1.5–2 mg) for rapid hypnosis or fentanyl (25–50 µg) for rapid analgesia when starting sedation with infusion of dexmedetomidine at a rate of 0.5±0.3 µg/kg/min is generally favored. Dexmedetomidine is also used for procedural sedation in children.60 However, it should be noted that the use of dexmedetomidine for procedural sedation in pediatric patients has not been well evaluated and its use is not currently approved in children in any country.

**Opioids**

Some clinicians prefer to use additional opioids with hypnotics. An addition of opioids effectively reduces the hypnotic requirements and controls procedure-induced discomfort. However, it should be noted that respiratory depression and hemodynamic suppression might be possible even when low doses of sedatives are used with opioids; therefore, special attention should be paid.

Intravenous fentanyl has an onset of 5 min and a duration of 30–60 min. A previous study demonstrated that the combined use of fentanyl could reduce propofol requirements for procedural sedation without any delay in recovery time for patients undergoing elective EUS.61

Remifentanil, an ultra-short-acting opioid is preferred for use in combination with sedatives because of its rapid recovery. Remifentanil has been reportedly used as a component of conscious sedation in patients undergoing painful medical procedures.62 Remifentanil infusion at a rate of 0.5±0.3 µg/kg/min provided sufficient analgesia, but was accompanied by a high incidence of respiratory depression at subtherapeutic levels.62 Because of its significant respiratory depression, careful monitoring of capnography during remifentanil infusion is recommended.

Morphine and meperidine might induce bronchospasm related with histamine release. Rapid administration of opioids, especially fentanyl, alfentanil, sufentanil, and remifentanil, might induce chest wall rigidity, which can disturb proper ventilation.28

**Etomidate**

Etomidate has unique characteristics, including an easy dosing profile, limited suppression of ventilation, lack of histamine liberation, and protection from myocardial and cerebral ischemia.63 It is frequently used for procedural sedation41 and as an induction agent for rapid sequence intubation42 in the emergency department. In addition, etomidate is a good induction agent for hemodynamically unstable patients.40 Etomidate is also used in patients with traumatic brain injury, because it is one of the only anesthetic agents able to decrease intracranial pressure and maintain a normal arterial pressure.

Despite its numerous cardiovascular and respiratory advantages, etomidate has a notable side effect of adrenocortical suppression. It is possible even in single administration, and sometimes, exogenous glucocorticoid supply is required during the postoperative period.40 Moreover, etomidate has disadvantages, such as pain at the injection site, myoclonus, and frequent nausea, which have led to its decreased usage as an anesthetic, and it not being recommend for elective sedation.27,67

**Ketamine**

Unlike most sedatives, including midazolam and propofol, that potentiate the inhibitory action of γ-aminobutyric acid, ketamine is an antagonist of N-methyl-D-aspartate receptor.27 The unique characteristic of ketamine is dissociative anesthesia, which is a status in which the patients appear conscious with eye opening but have catatonia that prevent them from responding to external stimuli.27 Ketamine induces psychomimetic effects, such as hallucinations or dysphoria.27 Unlike other sedatives, ketamine has a central sympathomimetic effect and can transiently increase blood pressure and heart rate.60 However, when catecholamines are depleted, ketamine exhibits negative cardiovascular responses.27,60 Ketamine preserves the airway reflex and respiratory drive, but increases oral secretion, which might increase the incidence of laryngospasms.66 Because of the above-mentioned characteristics of ketamine, even sub-anesthetic ketamine administration is contraindicated in cases of high-risk coronary disease, uncontrolled hypertension, increased intracranial pressure, increased intraocular pressure, psychosis, and hepatic dysfunction.70

**SPECIAL CONSIDERATIONS FOR INDIVIDUAL PROCEDURES**

**Gastrointestinal procedures**

Endoscopic therapeutic procedures, such as hemostasis, biopsy, stent dilation, endoscopic mucosal dissection, and endoscopic submucosal dissection, are potentially stimulating and often require sedation/analgesia. Endoscopic submucosal dissection, continuous infusion of propofol and remifentanil by an anesthesiologist might increase the satisfaction of the endoscopist and reduce patient movement than does the administration of an intermittent bolus of midazolam/propofol by an endoscopist; however, the patient satisfaction scores were significantly higher in the intermittent bolus of midazolam/propofol group.72 This result was likely because of the amnestic property of midazolam. Amnesia may have affected the patient’s satisfaction levels, and it is considered one of the goals of sedation for endoscopy.73 Although the patient may appear perfectly relaxed and cooperative during the procedure, the fact that the patient can recall the events later may have been a cause of dissatisfaction with the entire procedure. The addition of a small dose
of midazolam to the regimen of continuous propofol and remifentanil infusion may be helpful in overcoming this problem. A retrospective review of sedation for endoscopic submucosal dissection also reported that complete resection rates were significantly higher and that procedure times were significantly shorter with continuous infusion of propofol with opioid by an anesthesiologist than with intermittent propofol/ midazolam injection by an endoscopist. However, aspiration pneumonia was more frequent in patients receiving continuous propofol and opioid infusion than in those receiving the intermittent injection. A combined administration of propofol and opioid may have difficulties for non-anesthesiologists to adequately titrate the dosages of these drugs, because these co-administration enhances their side effects of respiratory depression, hypotension, and bradycardia.

ERCP is more complex than other endoscopic procedures. It often requires precise intervention and complete immobilization without gagging or squirming to ensure the safety and success of the procedure. Moreover, many patients who require ERCP are vulnerable. In a recent clinical study of conscious sedation for ERCP, the combined use of dexmedetomidine (a loading dose of 1 μg/kg over 10 min) resulted in significantly better patient satisfaction scores and lower desaturation rates than did the combined use of midazolam (0.05 mg/kg) during remifentanil infusion (a loading dose of 1 μg/kg and an infusion rate of 0.05–0.2 μg/kg/min). In addition, dexmedetomidine has been reported to be safe and to decrease the total dose of other hypnotics in very old patients undergoing ERCP.

Sedation for MRI or CT
For ensuring patient satisfaction and acquiring good-quality MRI and CT images, immobilization of the patient is important during these imaging procedures. However, staying alone for long periods in a dark, noisy environment is not easy for children and adults with claustrophobia. In a review focused on sedation for pediatric MRI, dexmedetomidine was found to have a greater sedative effect than did chloral hydrate, pentobarbital, and midazolam; in addition, preterm or small children should preferably be given general anesthesia for the safety and success of the diagnostic test. A randomized controlled study compared pharmacodynamic responses to a combination of dexmedetomidine (a loading dose of 1 μg/kg and an infusion rate of 0.5 μg/kg/h) and midazolam (0.1 mg/kg) vs. propofol (250–300 μg/kg/min) in children anesthetized using sevoflurane for MRI, and demonstrated that dexmedetomidine/midazolam provided adequate anesthesia, although it had a more prolonged recovery time than did propofol. Neuromuscular blockers might change the sedative requirements. In an animal study, autistic rats showed increased requirements of propofol and dexmedetomidine than did the control rats.

Neurologic interventions
A recent matched-cohort study comparing conscious sedation and general anesthesia for patients undergoing flow diverter placement for aneurysms demonstrated that conscious sedation could be successfully applied for short and simple neurologic procedures.10 When selecting sedatives for neurologic procedures, ketamine should be avoided because of its characteristics of increasing intracranial pressure and inducing psychomimetic activity, which may affect the validity of the neurologic examination.

Cardiologic procedures
Cardiologic procedures that require sedation include cardiovascular, ablation, transesophageal echocardiography, device implantation, and percutaneous transcatheter valve procedures. Propofol administration by nursing staff might be appropriate for some cardiologic procedures that require moderate sedation. However, proper training is essential for using capnography to detect respiratory depression, and using a target-controlled infusion pump is recommended for propofol administration. A study comparing dexmedetomidine (a loading dose of 1 μg/kg over 10 min and a maintenance infusion rate of 0.2 μg/kg/h) and thiamylal (a bolus of 1.25 mg/kg and the same bolus dose every 15 min) for sedation during ablation of atrial fibrillation showed that both sleep-disordered breathing events and the number of body movements were significantly lower in the dexmedetomidine group than in the thiamylal group. Therefore, they suggested that dexmedetomidine was a safe and proper sedative for cardiologic procedural sedation.

CONCLUSION
The need for sedation and anesthesia outside the OR is increasing because of the increased use of diagnostic tools and procedural treatment methods. It is important to understand the characteristics and side effects of sedatives and analgesics when selecting them, because the degree or depth of sedation required to improve the patient’s stability and to ensure the success of the procedure may vary. Clinicians should remember that as the depth of sedation increases, the risks of respiratory depression and cardiovascular suppression become serious, and hence, precautions should be taken using appropriate surveillance systems.

AUTHOR CONTRIBUTIONS
Wrote the first draft of the manuscript: Youn Yi Jo. Approved the final version: Youn Yi Jo and Hyun Jeong Kwak. Each author has participated sufficiently in the work to take public responsibility for appropriate portions of the content.
REFERENCES

1. Practice Guidelines for Moderate Procedural Sedation and Analgesia 2018: a report by the American Society of Anesthesiologists Task Force on Moderate Procedural Sedation and Analgesia, the American Association of Oral and Maxillofacial Surgeons, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, and Society of Interventional Radiology. Anesthesiology 2018;128:437-79.

2. Pino RM. The nature of anesthesia and procedural sedation outside of the operating room. Curr Opin Anaesthesiol 2005;20:471-7.

3. Cravero JP, Beach ML, Blike GT, Gallagher SM, Hertzog JH; Pediatric Sedation Research Consortium. The incidence and nature of adverse events during pediatric sedation/analgesia with propofol for procedures outside the operating room: a report from the Pediatric Sedation Research Consortium. Anesth Analg 2009;108:795-804.

4. Michel Foehn ER. Adult and pediatric anesthesia/sedation for gastrointestinal procedures outside of the operating room. Curr Opin Anaesthesiol 2015;28:469-77.

5. Youn AM, Ko YK, Kim YH. Anesthesia and sedation outside of the operating room. Korean J Anesthesiol 2015;68:323-31.

6. Gozal D, Gozal Y. Pediatric sedation/analgesia outside the operating room. Curr Opin Anaesthesiol 2008;21:491-4.

7. Bell A, Treston G, McNabb C, Monypenny K, Cardwell R. Profil ing adverse respiratory events and vomiting when using propofol for emergency department procedural sedation. Emerg Med Australas 2007;19:405-10.

8. Agrawal D, Manzi SF, Gupta R, Krauss B. Preprocedural fasting state and adverse events in children undergoing procedural sedation and analgesia in a pediatric emergency department. Ann Emerg Med 2003;42:636-46.

9. Godwin SA, Burton JH, Gerardo CJ, Hatten BW, Mace SE, Silvers SM, et al. Clinical policy: procedural sedation and analgesia in the emergency department. Ann Emerg Med 2014;63:247-58.

10. Van De Velde M, Kuypers M, Teunkens A, Devroe S. Risk and safety of analgesia outside the operating room. Minerva Anestesi ol 2009;75:345-8.

11. Bhananker SM, Posner KL, Cheney FW, Caplan RA, Lee LA, Domino KB. Injury and liability associated with monitored anesthesia care: a closed claims analysis. Anesthesiology 2006;104:228-34.

12. Choi JW, Kim DK, Cho CK, Park SJ, Son YH. Trends in medical disputes involving anesthesia during July 2009-June 2018: an analysis of the Korean Society of Anesthesiologists database. Korean J Anesthe siol 2019;72:156-63.

13. Metzner J, Domino KB. Risks of anesthesia or sedation outside the operating room: the role of the anesthesia care provider. Curr Opin Anaesthesiol 2010;23:523-31.

14. Cacho G, Pérez-Calle JL, Babado A, Lledó JL, Ojea R, Fernández-Rodríguez CM. Capnography is superior to pulse oximetry for the detection of respiratory depression during colonoscopy. Rev Esp Enferm Dig 2010;102:86-9.

15. Qaderer MA, Varghese J, Dumot JA, Lopez R, Trolli PA, Stevens T, et al. Capnographic monitoring of respiratory activity improves safety of sedation for endoscopic cholangiopancreatography and ultrasonography. Gastroenterology 2009;136:1568-76.

16. Waring JP, Baron TH, Hirota WK, Goldstein JL, Jacobson BC, Leighton JA, et al.; American Society for Gastrointestinal Endoscopy, Standards of Practice Committee. Guidelines for conscious sedation and monitoring during gastrointestinal endoscopy. Gastrointest Endosc 2003;58:317-22.

17. ASA Committee on Standards and Practice Parameters. Standards for basic anesthetic monitoring [accessed on 2019 January 31]. Available at: https://www.asahq.org/-/media/Sites/ASAHQ/Files/Public/Resources/standards-guidelines/standards-for-basic-anesthetic-monitoring.pdf.

18. Academy of Medical Royal Colleges. Safe sedation practice for healthcare procedures: standards and guidance [accessed on 2019 January 31]. Available at: https://www.rcpra.co.uk/system/files/PUB-SafeSedPrac2013.pdf.

19. Hinkelbein J, Lamperti M, Akeson J, Santos J, Costa J, De Robertis E, et al. European Society of Anaesthesiology and European Board of Anaesthesiology guidelines for procedural sedation and analgesia in adults. Eur J Anaesthesiol 2018;35:6-74.

20. Australian and New Zealand College of Anaesthetists. Guidelines on sedation and/or analgesia for diagnostic and interventional medical, dental or surgical procedures [accessed on 2019 January 31]. Available at: http://www.anzca.edu.au/documents/ps09-2014-guidelines-on-sedation-and-or-analgesia.

21. American Society of Anesthesiologists. Continuum of depth of sedation: definition of general anesthesia and levels of sedation/analgesia [accessed on 2019 January 31]. Available at: https://www.asahq.org/standards-and-guidelines/continuum-of-depth-of-sedation-definition-of-general-anesthesia-and-levels-of-sedation-analgesia.

22. Weaver CS, Hauer WH, Duncan CE, Brizendine EJ, Cordwell WH, An assessment of the association of bispectral index with 2 clinical sedation scales for monitoring depth of procedural sedation. Anesthe siol 2007;25:918-24.

23. Fruchter O, Tirosh M, Carmi U, Rosengarten D, Kramer MR. Prospective randomized trial of bispectral index monitoring of sedation depth during flexible bronchoscopy. Respiration 2014;87:388-93.

24. Yang KS, Habib AS, Lu M, Branch MS, Muir H, Manberg P, et al. A prospective evaluation of the incidence of adverse events in nurse-administered moderate sedation guided by sedation scores or Bispectral Index. Anesth Analg 2014;119:43-8.

25. Paspatis GA, Chainaki I, Manolaraki MM, Vardas E, Theodoropoulou A, Tribonias G, et al. Efficacy of bispectral index monitoring as an adjunct to propofol deep sedation for ERCP: a randomized controlled trial. Endoscopy 2009;41:1046-51.

26. von Delfus S, Salletmaier H, Meinig A, Wagemple S, Saur D, Bajbouj M, et al. Bispectral index monitoring of midazolam and propofol sedation during endoscopic retrograde cholangiopancreatography: a randomized clinical trial (the EndoBIS study). Endoscopy 2012;44:258-64.

27. Analgesic agents. In: Butterworth JF, Mackey DC, Wasnick JD, editors. Clinical anesthesiology. 6th ed. New York: McGraw-Hill Education; 2018. p. 171-85.

28. Intravenous anesthetics. In: Butterworth JF, Mackey DC, Wasnick JD, editors. Clinical anesthesiology. 6th ed. New York: McGraw-Hill Education; 2018. p. 324-62.

29. Intravenous anesthetics. In: Morgan MJ, Mackey DC, Wasnick JD, editors. Morgan & Mikhail’s clinical anesthesiology, 6th ed. New York: McGraw-Hill Education; 2018. p. 187-97.

30. Intravenous anesthetics. In: Butterworth JF, Mackey DC, Wasnick JD, editors. Clinical anesthesiology. 6th ed. New York: McGraw-Hill Education; 2018. p. 171-85.

31. Intravenous anesthetics. In: Morgan MJ, Mackey DC, Wasnick JD, editors. Morgan & Mikhail’s clinical anesthesiology, 6th ed. New York: McGraw-Hill Education; 2018. p. 324-62.

32. Glaxo Wellcome. Ultiva (remifentanil hydrochloride) product information [accessed on 2019 January 31]. Available at: https://www.gsk.com/media/216414/pi_ultiva.pdf.

33. Cohen LB, Delegehe MH, Aisenberg J, Brill JF, Inadomi JM, Kochman ML, et al.; AGA Institute. AGA Institute review of endoscopic}
sedation. Gastroenterology 2007;133:675-701.
32. Pfizer, Inc. Product monograph - midazolam injection USP (preservative-free) [accessed on 2019 January 31]. Available at: https://www.pfizerca.com/en/midazolam_pres_free.pdf.
33. Hospira, Inc. Etomidate injection, solution [accessed on 2019 January 31]. Available at: https://www.pfizer.com/sites/default/files/products/material_safety_data/Amidate_(Etomidate)_(hospi-ra)060214.pdf.
34. Hospira, Inc. Precedex package insert [accessed on 2019 January 31]. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2013/021038s021lbl.pdf.
35. Ketamine injection [accessed on 2019 January 31]. Available at: https://www.drugs.com/pro/ketamine-injection.html#s-34068-7.
36. Forster A, Gardas JP, Suter PM, Gempterle M. Respiratory depression by midazolam and diazepam. Anesthesiology 1980;53:494-7.
37. Golparvar M, Saghaei M, Sajedi P, Razavi SS. Paradoxical reaction following intravenous midazolam premedication in pediatric patients - a randomized placebo controlled trial of ketamine for rapid tranquilization. Paediatr Anaesth 2004;14:924-30.
38. Mancuso CE, Tanzig MG, Gabay M. Paradoxical reactions to benzodiazepines: literature review and treatment options. Pharmacotherapy 2004;24:1177-85.
39. Khan LC, Lustik SJ. Treatment of a paradoxical reaction to midazolam with haloperidol. Anesth Analg 1997;85:213-5.
40. Jackson BE, Beck LA, Losek JD. Successful fumazenil reversal of paradoxical reaction to midazolam in a child. J Emerg Med 2015;48:e67-72.
41. Bryson HM, Fulton BR, Faulds D. Propofol. An update of its use in anaesthesia and conscious sedation. Drugs 1995;50:513-59.
42. Machata AM, Willshchke H, Kabon B, Kettner SC, Marhofer P. Propofol-based sedation regimen for infants and children undergoing ambulatory magnetic resonance imaging. Br J Anaesth 2008; 101:239-43.
43. Na SH, Song Y, Kim SY, Byon HJ, Jung HH, Han DW. A simulation study of propofol effect-site concentration for appropriate sedation in pediatric patients undergoing brain MRI: pharmacodynamic analysis. Yonsei Med J 2017;58:1216-21.
44. Yan JW, McLeod SL, Lansavitchene A. Ketamine-propofol versus propofol alone for procedural sedation in the emergency department: a systematic review and meta-analysis. Acad Emerg Med 2015;22:1003-13.
45. Brechmann T, Maier C, Kaisler M, Vollert J, Schmiegel W, Pak S, et al. Propofol sedation during gastrointestinal endoscopy arouses euphoria in a large subset of patients. United European Gastroenterol J 2018;6:536-46.
46. Mamiya H, Noma T, Watanabe Y, Yamamura T, Funasaka K, Ohno E, et al. Dexmedetomidine provides less body motion and respiratory depression during sedation in double-balloon enteroscopy than midazolam. SAGE Open Med 2017;5:2050312117729920.
47. Cho JS, Shim JK, Na S, Park I, Kwak YL. Improved sedation with dexmedetomidine-remifentanil compared with midazolam-remifentanil during catheter ablation of atrial fibrillation: a randomized, controlled trial. Europace 2014;16:1000-6.
48. Paris A, Tonner PH. Dexmedetomidine in anaesthesia. Curr Opin Anaesthesiol 2005;18:412-8.
49. Giovannitti JA Jr, Thoms SM, Crawford JJ. Alpha-2 adrenergic receptor agonists: a review of current clinical applications. Anesthesiology 2015;62:31-9.
50. Ahmed SS, Unland T, Slaven JE, Nitu ME, Rigby MR. Successful use of intravenous dexmedetomidine for magnetic resonance imaging sedation in autistic children. South Med J 2014;107:559-64.
51. Singh SA, Prakash K, Sharma S, Dhakate G, Bhatia V. Comparison of propofol alone and in combination with ketamine or fentanyl for sedation in endoscopic ultrasonography. Korean J Anesthesiol 2018;71:43-7.
52. Litman RS. Conscious sedation with remifentanil during painful medical procedures. J Pain Symptom Manage 2000;19:468-71.
53. Hohl CM, Kelly-Smith CH, Yeung TC, Sweet DD, Doyle-Waters MM, Schulzer M. The effect of a bolus dose of etomidate on cortisol levels, mortality, and health services utilization: a systematic review. Ann Emerg Med 2010;56:105-13.
54. Vinson DR, Bradbury DR. Etomidate for procedural sedation in emergency medicine. Ann Emerg Med 2002;39:592-8.
55. Sivilotti ML, Filbin MR, Murray HE, Slavos PW, Walls RM; NEAR Investigators. Does the sedative agent facilitate emergency rapid sequence intubation? Acad Emerg Med 2003;10:612-20.
56. Wagner RL, White PF. Etomidate inhibits adrenergic cortical function in surgical patients. Anesthesiology 1984;61:647-51.
57. Owen H, Spence AA. Etomidate. Br J Anaesth 1984;56:555-7.
58. Craven R. Ketamine. Anaesthesia 2007;62 Suppl 1:48-53.
59. Christ G, Mundigler G, Merhart C, Zehetgruber M, Kratochwill C, Heinz G, et al. Adverse cardiovascular effects of ketamine infusion in patients with catecholamine-dependent heart failure. Anesth Intensive Care 1997;25:255-9.
60. Gorlin AW, Rosenfeld DM, Ramakrishna H. Intravenous sub-anesthetic ketamine for perioperative analgesia. J Anaesthesia Clin Pharmacol 2016;32:160-7.
61. Gworski M, Matthes K. Gastrointestinal endoscopy procedures. In: Urman R, Gross WL, Philip B, editors. Anesthesia outside the operating room. 1st ed. New York: Oxford University Press; 2011. p.151-66.
72. Park CH, Shin S, Lee SK, Lee H, Lee YC, Park JC, et al. Assessing the stability and safety of procedure during endoscopic submucosal dissection according to sedation methods: a randomized trial. PLoS One 2015;10:e0120529.
73. Thomson A, Andrew G, Jones DB. Optimal sedation for gastrointestinal endoscopy: review and recommendations. J Gastroenterol Hepatol 2010;25:469-78.
74. Park CH, Min JH, Yoo YC, Kim H, Joh DH, Jo JH, et al. Sedation methods can determine performance of endoscopic submucosal dissection in patients with gastric neoplasia. Surg Endosc 2013;27:2760-7.
75. Lu Z, Li W, Chen H, Qian Y. Efficacy of a dexmedetomidine-remifentanil combination compared with a midazolam-remifentanil combination for conscious sedation during therapeutic endoscopic retrograde cholangio-pancreatography: a prospective, randomized, single-blinded preliminary trial. Dig Dis Sci 2018;63:1633-40.
76. Inatomi O, Imai T, Fujimoto T, Takahashi K, Yokota Y, Yamashita N, et al. Dexmedetomidine is safe and reduces the additional dose of midazolam for sedation during endoscopic retrograde cholangiopancreatography in very elderly patients. BMC Gastroenterol 2018;18:166.
77. Schulte-Uentrop L, Goepfert MS. Anaesthesia or sedation for MRI in children. Curr Opin Anaesthesiol 2010;23:513-7.
78. Heard C, Burrows F, Johnson K, Joshi P, Houck J, Lerman J. A comparison of dexmedetomidine-midazolam with propofol for maintenance of anesthesia in children undergoing magnetic resonance imaging. Anesth Analg 2008;107:1832-9.
79. Elmersy SA, Soliman GF, Rashed LA, Elgendy H. Dexmedetomidine and propofol sedation requirements in an autistic rat model. Korean J Anesthesiol 2019;72:169-77.
80. Griessenauer CJ, Shallwani H, Adeeb N, Gupta R, Rangel-Castilla L, Siddiqui AH, et al. Conscious sedation versus general anesthesia for the treatment of cerebral aneurysms with flow diversion: a matched cohort study. World Neurosurg 2017;102:1-5.
81. Takeshita H, Okada Y, Sari A. The effects of ketamine on cerebral circulation and metabolism in man. Anesthesiology 1972;36:69-75.
82. Laskowski K, Stirling A, McKay WP, Lim HJ. A systematic review of intravenous ketamine for postoperative analgesia. Can J Anaesth 2011;58:911-23.
83. Furniss SS, Sneyd JR. Safe sedation in modern cardiological practice. Heart 2015;101:1526-30.
84. Sairaku A, Yoshida Y, Hirayama H, Nakano Y, Ando M, Kihara Y. Procedural sedation with dexmedetomidine during ablation of atrial fibrillation: a randomized controlled trial. Europace 2014;16:994-9.