Case Report

ROLE OF NURSES IN INHALATION SEDATION IN THE INTENSIVE CARE UNIT: A CASE REPORT

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ABSTRACT

Background: In contemporary critical care practice sedation is predominantly maintained with intravenous agents, most notably propofol, benzodiazepines, and dexmedetomidine. More recently, inhalational sedation using volatile anesthetics such as sevoflurane and isoflurane has been increasingly utilized. The advantages of this approach include precise control of drug delivery and elimination, better regulation of sedation depth, faster awakening, and a lower risk of drug accumulation.

Methods: Data were collected at the Department of Internal Medicine, University Hospital Centre Split, from the hospital information system and through clinical patient monitoring, with informed consent and approval from the Ethics Committee. A case of a 65-year-old patient admitted due to theophylline intoxication, respiratory failure, and severe metabolic acidosis is presented, requiring intubation and mechanical ventilation. During treatment, vital signs, laboratory parameters, and depth of sedation were monitored.

Results: During treatment, stable hemodynamic, adequate sedation depth, and rapid recovery of consciousness following discontinuation of sedation were achieved. Early extubation was successfully performed, with no signs of neurological or renal complications. These findings are consistent with available literature confirming the safety and efficacy of short-term inhalational sedation.

Conclusions: Inhalational sedation with sevoflurane represents an effective and safe therapeutic option in intensive care units, particularly for patients with complex comorbidities, offering advantages such as rapid titration, minimal accumulation, and favorable clinical outcomes.

Keywords: *AnaConDa, inhalation sedation, nurse, nursing care, Sevoflurane.*

INTRODUCTION

Anesthesia is a medical procedure used to induce insensitivity. It can be classified into general, conduction, regional, and local anesthesia. Anesthesia can achieve unconsciousness, analgesia, amnesia, immobility, and suppression of the autonomic nervous system response to painful stimuli (1). In intensive care units (ICUs), sedation is used to improve patient tolerance and comfort during mechanical ventilation, to prevent patient–ventilator asynchrony, and to facilitate invasive procedures and nursing care. Current sedation practices in ICUs primarily rely on intravenous medications, including sedatives, opioids, and neuromuscular blocking agents. The most commonly used agents are propofol and benzodiazepines, particularly midazolam, as well as dexmedetomidine (1). Benzodiazepines are associated with prolonged duration of mechanical ventilation, increased risk of delirium, and poorer long-term outcomes. Propofol is not associated with prolonged sedation and is easier to titrate than midazolam, although it may cause hypertriglyceridemia. Dexmedetomidine does not cause respiratory depression but may have cardiotoxic effects at higher doses and does not allow for deep sedation (1).

Volatile anesthetics such as sevoflurane and isoflurane are most commonly used in operating rooms for general anesthesia. In recent years, they have also been increasingly used for sedation in ICUs, with their use rising notably during the COVID-19 pandemic (2, 3). The advantage of inhalational sedation lies in the ability to fully control both the delivery and elimination of the anesthetic. Its effect begins with inhalation and absorption through the alveolar–capillary membrane, followed by distribution and redistribution throughout the body. Biotransformation varies among different inhalational anesthetics, while elimination occurs primarily via the lungs (1).

The concentration of inhalational anesthetics in the central nervous system depends on several factors: the oil–gas partition coefficient, blood solubility of the anesthetic, partial pressure, cardiac output, and minute ventilation. Minimum Alveolar Concentration (MAC) is defined as the alveolar concentration of an inhalational anesthetic at 1 atmosphere and a temperature of 37°C that prevents movement in 50% of patients in response to a standardized stimulus. The lower the MAC value, the more potent the anesthetic. MAC values are expressed as percentages and vary with age (1).

The use of volatile anesthetics as an alternative sedation modality has become more common in recent years in ICUs. Volatile anesthetics, particularly sevoflurane and isoflurane, have favorable pharmacokinetic and pharmacodynamic properties that make them suitable for titrating sedation in mechanically ventilated patients. Sevoflurane and isoflurane are lipophilic molecules (with isoflurane being more lipophilic), and they accumulate significantly in adipose tissue, especially during prolonged continuous administration. Obese patients have a larger fat mass, which acts as a reservoir for these anesthetics. During sedation, the anesthetic distributes into adipose tissue and is gradually released back into the bloodstream after discontinuation, resulting in slower reduction of blood concentrations and prolonged awakening (3).

In patients receiving chronic psychopharmacological therapy, tolerance to benzodiazepines and reduced sensitivity are often present, requiring significantly higher doses (e.g., midazolam) to achieve adequate sedation. Volatile anesthetics bypass GABA-related tolerance. Additionally, psychotropic drugs (particularly antipsychotics and mood stabilizers) may induce hepatic enzymes, increase propofol clearance, and reduce its hypnotic effect, necessitating higher doses and increasing the risk of hypotension and hemodynamic instability. Volatile anesthetics do not depend on hepatic metabolism but rather on alveolar concentration (4,5).

Sevoflurane is a halogenated inhalational anesthetic that provides hypnosis, amnesia, analgesia, akinesia, and suppression of autonomic responses during surgical and procedural interventions. It is approved by the U.S. Food and Drug Administration (FDA) for induction and maintenance of general anesthesia in both adult and pediatric patients. In patients sedated with sevoflurane, vital parameters such as electrocardiogram, blood pressure, oxygen saturation, and end-tidal carbon dioxide ($EtCO_2$) are continuously monitored. Although consciousness usually returns within minutes after discontinuation, allowing earlier administration of analgesics, mild mood changes may persist for several days (6).

Contraindications for the use of sevoflurane include known genetic susceptibility to malignant hyperthermia and hypersensitivity to sevoflurane or other halogenated anesthetics (e.g., history of liver dysfunction, fever, leukocytosis, and/or eosinophilia of unknown origin). Like other inhalational anesthetics, sevoflurane may cause short-term side effects of mild to moderate intensity, including dose-dependent cardiovascular depression, laryngospasm, breath-holding, apnea, delirium, agitation, nausea, and vomiting (6).

Sevoflurane may reduce systemic vascular resistance, which at higher doses can lead to hypotension. Increased doses (expressed as MAC values) also cause cerebral vasodilation, increasing cerebral blood flow and intracranial pressure, which may be problematic in patients with hydrocephalus or those in neurocritical conditions; therefore, its use is not recommended in such cases. The most serious complication of improper or susceptible use of anesthetics is malignant hyperthermia, which occurs in individuals with genetic predisposition and certain underlying conditions (6). Objective methods for assessing the depth of sedation have been developed to enable more precise monitoring of patient status, particularly in situations where clinical scales cannot be applied (e.g., during deep sedation or when neuromuscular blockers are used). Electroencephalography (EEG) and electromyography (EMG) provide insight into brain activity, with characteristic changes in brain wave patterns as sedation deepens. Based on EEG, monitoring systems such as the Bispectral Index (BIS) have been developed, which quantify the level of consciousness using a single numerical value, as well as entropy monitors that also incorporate EMG signals. Although useful in anesthesiology, their application in the ICU is limited due to variability in results and the influence of multiple confounding factors (7). Auditory evoked potentials represent an additional method for assessing the nervous system's response to auditory stimuli through analysis of EEG signals. Measurement of plasma drug concentrations may also be useful when a clear correlation exists between concentration and clinical effect; however, in critically ill patients, this relationship is often disrupted due to impaired liver and kidney function, hypoxia, and inflammatory processes. Therefore, this method is not considered reliable for routine use (7).

Subjective methods of assessment are based on clinical scales that evaluate the level of consciousness and patient response to stimuli. Several scales are available, including the Ramsay Sedation Scale (RSS), Sedation-Agitation Scale (SAS), Motor Activity Assessment Scale (MAAS), Automated Target- Controlled Infusion system (ATICE), and Mid- Stream Arterial Pressure (MSAT) (7). The most commonly used scale in clinical practice is the Richmond Agitation-Sedation Scale (RASS), which is simple, quick to apply, and reliable. It can be used in both spontaneously breathing patients and those receiving mechanical ventilation. The scale consists of ten levels, ranging from +4 to –5. In clinical practice, the goal is to maintain a sedation level between –2 and 0, which ensures adequate calmness while preserving the ability to interact (7).

Table 1. Richmond Agitation-Sedation Scale.

LABEL	DESCRIPTION	POINTS
Combative	Violent, immediate danger to staff	+4
Very agitated	Pulls or removes tubes/catheters; aggressive	+3
Agitated	Frequent non-purposeful movement, fights ventilator	+2
Restless	Anxious, not aggressive, but with increased movement	+1
Alert and calm	Spontaneously pays attention to caregiver	0
Drowsy	Not fully alert, sustained awakening to voice (>10 seconds)	-1
Light sedation	Briefly awakens with eye contact to voice (<10 seconds)	-2
Moderate sedation	Movement or eye opening to voice, but no eye contact	-3
Deep sedation	No response to voice, but responds to physical (painful) stimulation	-4
Unarousable	No response to voice or physical stimulation	-5

For Sedation in intensive care units (ICUs), the ideal MAC range for sevoflurane is between 0.4 and 0.5, which corresponds to an end-tidal fraction of 0.72–0.8%. A study that specifically investigated MAC for deep sedation in the ICU showed that deep sedation, corresponding to a RASS greater than –3, is achieved at a MAC of 0.42–0.46. In clinical practice, sevoflurane is usually administered at a median MAC of 0.45 to achieve a target RASS range of –3 to –5 (8).

For isoflurane, the ideal MAC range is between 0.5 and 0.6. A large randomized study showed that isoflurane can be safely used for ICU sedation at a median MAC of 0.58 ± 0.06 (9).

Maintaining a constant MAC does not guarantee a stable depth of sedation over time (9).

The ideal target RASS range during inhalational sedation in the ICU is –2 to +1, representing light to moderate sedation, in accordance with current guidelines recommending light sedation for most critically ill patients. However, in clinical practice with inhalational sedation, a wider range from –1 to –4 is often used depending on the patient's clinical needs (9).

The 2018 Society of Critical Care Medicine (SCCM) guidelines recommend light sedation (RASS –2 to +1) for critically ill, mechanically ventilated adult patients, unless deeper sedation is clinically indicated. Deeper sedation may be indicated in cases of status epilepticus, intracranial hypertension, severe respiratory failure, or the use of neuromuscular blocking agents (9).

The largest randomized trial of inhalational sedation (301 patients) used a target RASS range of –1 to –4 for isoflurane and propofol, which is one to two levels deeper than in other sedation studies, but still clinically relevant. Studies show that more than 50% of patients in the first days of critical illness require sedation at a level of RASS –3 or deeper (10).

AnaConDa is a medical device that enables the administration of volatile anesthetics (sevoflurane and isoflurane) via a ventilator into the patient's airway. The device is used with a conventional ventilator and is positioned between the Y-piece and the endotracheal tube. The liquid volatile anesthetic is delivered via a syringe mounted on a perfusor (syringe infusion pump). From the syringe, the anesthetic is transported to an evaporator connected between the patient's endotracheal tube and the Y-piece. German sedation guidelines recommend inhalational sedation as an alternative to intravenous sedation in patients undergoing mechanical ventilation via an endotracheal tube or tracheostomy (8, 9). The inhalational sedation procedure using the AnaConDa system is performed by combining standard and additional equipment. The required components include: AnaConDa or AnaConDa-S, an anesthetic gas scavenging filter, a ventilator, a gas monitor, and a pump (perfusor). The recommended initial infusion rates are 3 mL/h for isoflurane and 5 mL/h for sevoflurane. Dose titration is possible in increments of 0.5–1 mL/h, depending on hemodynamic stability and clinical assessment. Typical infusion rates for isoflurane range from 2 to 7 mL/h, although up to 15 mL/h may be required. For sevoflurane, the usual range is 4 to 10 mL/h, with possible requirements up to 20 mL/h. A bolus dose of 0.3 to 0.5 mL may be administered, depending on the patient's hemodynamic stability (11, 12).

Although there is evidence that the use of inhalational sedation in ICUs may shorten awakening time, time to extubation, and reduce opioid requirements, it is still not clearly defined whether inhalational sedation should be routinely preferred over intravenous sedation, particularly in specific conditions requiring prolonged sedation such as septic shock and acute respiratory distress syndrome. Likewise, long-term neurocognitive outcomes have not yet been fully clarified (13).

A technical barrier to the implementation of this type of sedation is the limited availability of devices for administration and monitoring, as well as the lack of education and experience among physicians and nurses, and challenges related to the control of environmental pollution (2).

The value of the existing literature on inhalational sedation in intensive care units is moderate for short-term clinical outcomes but limited for long-term outcomes and specific patient populations. Current literature, including meta-analyses and randomized clinical trials, suggests that inhalational sedation with sevoflurane or isoflurane allows for better preservation of respiratory drive and diaphragm function, faster awakening and time to extubation, and reduced opioid requirements compared to intravenous sedation, with a similar safety and tolerability profile.

In this case report, a patient sedated with the inhalational anesthetic sevoflurane in a medical intensive care unit is analyzed in detail. The case demonstrates that inhalational sedation with sevoflurane was the most appropriate choice for a patient with theophylline intoxication who was receiving chronic high-dose psychopharmacological therapy. In this case, inhalational sedation proved to be alternative to intravenous sedation due to rapid awakening and the risk of accumulation of intravenous sedatives, which are metabolized in the liver and excreted via the kidneys.

METHODS

The data required for this study were collected at the Department of Internal Medicine, University Hospital Centre Split. The data were obtained from the hospital information system, as well as through observation, measurement, and analysis of patient-related parameters.

The patient was informed about the purpose, benefits, and risks of the study and voluntarily agreed to participate by signing an informed consent form. The Ethics Committee of the University Hospital Centre Split approved the use of medical data (Class: 520-03/25-01/283, Reg. No.: 2181-147/01-06/LJ.Z. – 25-02).

A 65-year-old patient (D.J.) was admitted to the Intensive Care Unit of the Department of Internal Medicine, University Hospital Centre Split, on September 2, 2025, due to theophylline intoxication, respiratory failure, and acidosis.

According to heteroanamnesis and available medical documentation, the patient has been undergoing long-term psychiatric treatment for residual schizophrenia. He has been hospitalized multiple times at the Clinic for Psychiatry, as well as in Rab and Ugljan.

He was initially admitted to the Emergency Department after ingesting 20 tablets of theophylline 200 mg. He was found unconscious at home and had experienced a seizure. A laryngeal mask airway was placed by emergency medical services. Upon arrival at the Emergency Department, the patient had a normal body habitus and nutritional status, with well-perfused skin and visible mucosa, miotic pupils, and was unconscious with no response to painful stimuli. Electrocardiogram showed narrow QRS complex tachycardia with a heart rate of 170/min and intermediate electrical activity. After Arterial Blood Gas (ABG) analysis, the patient was endotracheally intubated, connected to a ventilator, and ventilated using Synchronized Intermittent Mandatory Ventilation (SIMV) mode. A urinary catheter and a nasogastric tube were inserted, and gastric lavage was performed until clear contents were obtained. It was determined that the patient's chronic therapy included haloperidol tablets 10 mg (½ tablet three times daily), olanzapine tablets 10 mg (½–0–1), promazine hydrochloride dragées 25 mg (1 tablet three times daily), and theophylline 350 mg (1–0–1). The patient has a known allergy to penicillin. For the purposes of this study, the following data were used: laboratory findings, radiological reports, ventilation modes, continuous vital sign monitoring parameters, physician and nursing documentation (anamnesis and clinical course), assessment scales (Glasgow Coma Scale (GCS), Morse Fall Scale (MFS), Braden Scale, Trauma Score (TS)), nursing diagnoses according to the NANDA classification, RASS and MAC.

The case report is structured according to CARE guidelines.

RESULTS

Table 2. Arterial blood gas (ABG) findings upon arrival to the Emergency Department.

PARAMETER	VALUE
Ph	6,99
pCO2	1,5 kPa
pO2	38 kPa
sO2	99%
cHCO3	11,9 mmol/l
Lac	18 mmol/l
BE	-15 mmol/l

Patient status upon admission to the ICU

Table 3. Assessment scales at the time of admission of patient D. J. to the ICU.

SCALE	TOTAL SCORE
Glasgow Coma Scale	3
Morse Fall Scale	50
Braden Scale	8
Trauma Score	7
Categorization	64 (category 4)

Course of treatment

Table 4. Course of treatment of patient D. J.

DAY OF HOSPITALIZATION IN ICU	COURSE OF TREATMENT
Day 1	Upon admission to the ICU, the patient was mechanically ventilated, hypotensive, tachycardic, and afebrile. Surveillance swabs of the nose and rectum, as well as blood and urine cultures, were obtained. Under ultrasound guidance, the physician inserted a central venous catheter into the right internal jugular vein for hemodialysis, and an additional central venous catheter for therapeutic purposes into the right femoral vein. An arterial cannula was placed in the right radial artery, and continuous arterial blood pressure monitoring was initiated. A chest X-ray was performed to verify the position of the central venous catheter. According to protocol, the patient was connected to inhalational sedation with sevoflurane via the Sedaconda ACD device. The pump flow was initially set to 5 mL/h as prescribed, achieving a MAC of 0.2%. Due to patient–ventilator asynchrony, the sevoflurane flow was increased to 9 mL/h, maintaining MAC between 0.4–0.5% and achieving deeper sedation. Arterial blood pressure was continuously monitored. Mean Arterial Pressure (MAP) ranged between 60–65 mmHg, without inotropic support or the need for catecholamines or vasopressors. Due to side effects of theophylline, continuous veno- venous hemodiafiltration (CVVHDF) was initiated according to physician orders.
Day 2	At 06:00 A.M., the sevoflurane pump flow was reduced to 5 mL/h, maintaining MAC between 0.2–0.3%. As per the attending physician's order, CVVHDF was discontinued. At 09:00, the sevoflurane pump was turned off and the Sedaconda ACD filter was removed from the ventilator circuit. At 09:20 A.M., the patient was placed on Continous Positive Airway Pressure (CPAP) ventilation mode. At 10:00 A.M., the patient awoke spontaneously, with preserved airway reflexes and no signs of delirium or neurological deficit (GCS 12). After arterial blood gas control, the patient was extubated at 11:00 and placed on oxygen support via a reservoir mask at 10 L/min. Bronchodilator inhalation therapy and intravenous methylprednisolone were administered. At 16:00, oxygen support was reduced to a simple face mask at 6 L/min. The patient was conscious, with limited contact, normal heart rate, normotensive, eupneic, and with adequate oxygen saturation.
Day 3	The patient was conscious, with normal verbal communication and heart rate, normotensive, eupneic, and maintaining adequate oxygen saturation with nasal oxygen support. Acid–base status findings were satisfactory, and the patient was transferred for further treatment to the post-intensive care unit.

Table 5. ABG findings prior to extubation (second day of hospitalization).

PARAMETER	VALUE
pH	7,358
pCO2	4,24 kPa
pO2	9,65 kPa
sO2	98%
cHCO3	21,5 mmol/l
Lac	0,6 mmol/l
BE	-2 mmol/l

Table 6. ABG findings prior to transfer to the post-intensive care unit.

PARAMETER	VALUE
pH	7,365
pCO2	4,12 kPa
pO2	12,7 kPa
sO2	99%
cHCO3	23,2 mmol/l
Lac	0,6 mmol/l
BE	-1,2mmol/l

Table 7. Vital signs and clinical features during the patient's stay in the ICU.

DAY/ TIME	VITAL SIGNS	VALUES
DAY 1, 10:00 A.M.	Body temperature (axillary measurement)	36,2°C
	Pulse	170 bpm
	Blood pressure	100/50 mmHg
	Respiration	18 /min (mechanical ventilation, SIMV mode), SpO_2 99%
DAY 1, 10:00 P.M.	Body temperature (axillary measurement)	36,4°C
	Pulse	110 bpm
	Blood pressure	98/43 mmHg
	Respiration	18 /min (mechanical ventilation, SIMV mode), SpO_2 99%
DAY 2, 10:00 A. M.	Body temperature (axillary measurement)	36,5°C
	Pulse	75 bpm
	Blood pressure	130/80 mmHg
	Respiration	20 /min (mechanical ventilation, CPAP mode), SpO_2 98%
DAY 2, 10:00 P. M.	Body temperature (axillary measurement)	36,4°C
	Pulse	65 bpm
	Blood pressure	122/78 mmHg
	Respiration	19/ min, SpO_2 98% (oxygen mask, 6l/min)
DAY 3, 10:00 A. M.	Body temperature (axillary measurement)	36,5°C
	Pulse	70 bpm
	Blood pressure	120/75 mmHg
	Respiration	16 /min, SpO_2 98% (nasal cannula, 2l/min)

Table 8. Monitoring of sedation depth.

CRITERIA	DAY 1	DAY 2	DAY 3
PUMP FLOW	9 ml/h	5 ml/h	/
MAC	0,4- 0,5 %	0,2- 0,3%	/
RASS	-4 (deep sedation)	-3 (moderate sedation)	/

Therapeutic procedures

During hospitalization, the patient was supported with mechanical ventilation and treated with sevoflurane, pantoprazole, amiodarone, thiamine, 0.9% NaCl, 7.45% KCl, and continuous veno- venous hemodiafiltration (CVVHDF) with the following parameters:

Filter: ST 150

Heparin: 750 IU/h

UF (ultrafiltration): 100 mL/h

Qi (infusion flow): 1000 mL/h

PBP (pre-blood pump): 500 mL/h

Qd (dialysate flow): 1500 mL/h

Patient perspective

Due to the patient's initial condition (coma), a direct patient perspective was not available during the acute phase. After recovery, the patient had no recollection of the ICU stay and did not report any subjective complaints related to sedation.

Nursing diagnoses during the patient's stay in the Intensive Care Unit

Risk for infection related to (r/t) indwelling medical devices, secondary to central venous catheter, urinary catheter, arterial cannula, and endotracheal tube.

Self-care deficit: feeding (4) related to sedation, as evidenced by inability to feed independently.

Self-care deficit: elimination (4) related to sedation, as evidenced by inability to independently eliminate urine and stool.

Self-care deficit: personal hygiene (4) related to sedation, as evidenced by inability to perform personal hygiene independently.

DISCUSSION

In the presented case of a patient with theophylline intoxication, respiratory insufficiency, and metabolic acidosis, the use of inhalational sedation with sevoflurane via the Sedaconda ACD device proved to be a safe and effective method of sedation. The MAC values ranged between 0.4 and 0.5, while RASS was in the range of –4 to –3, which is consistent with clinical guidelines. This MAC range also corresponds with findings from studies showing that deep sedation is achieved at a MAC of 0.42–0.46, where RASS is greater than –3. It was particularly justified given the need for Continuous Renal Replacement Therapy (CRRT) and the increased risk of accumulation of intravenous sedatives in a patient already receiving chronic psychopharmacotherapy.

The observed clinical outcome is consistent with the results of the study by Kerstin and Röhm, which demonstrated that short-term inhalational sedation with sevoflurane, despite an increase in inorganic fluorides, does not negatively affect renal function. In our case, despite the need for CVVHDF, no additional deterioration in renal function associated with sevoflurane administration was observed, further supporting the safety profile of this method in acute conditions (14).

Furthermore, the rapid recovery of consciousness and successful early extubation within 24 hours after discontinuation of sedation are consistent with the known pharmacokinetic properties of sevoflurane, as well as with the results of studies analyzing prolonged use of inhalational sedation. For example, Bellgardt et al. demonstrated that inhalational sedation with volatile anesthetics is associated with lower in-hospital and one-year mortality compared to intravenous sedation, with good tolerability even in long-term ventilated patients. Although in our case sedation was short-term, the favorable clinical course without complications supports these findings (14). An additional advantage of inhalational sedation in this patient was the ability to precisely titrate the depth of sedation without drug accumulation, which is particularly important in patients with compromised organ function. This reduced the risk of prolonged sedation, delirium, and adverse effects associated with intravenous anesthetics.

This case report confirms findings from the literature that inhalational sedation with sevoflurane is a safe, effective, and clinically justified alternative to intravenous sedation, especially in complex patients with multiple comorbidities and an increased risk of drug accumulation, with the added benefit of faster recovery and a stable hemodynamic profile.

The role of the nurse in the administration of inhalational sedation in the ICU

A high-quality multidisciplinary approach results in better treatment outcomes for patients in whom adverse reactions, side effects, or deterioration of health status may occur. The role of the nurse, as an indispensable member of the healthcare team, in the administration of inhalational anesthesia is described as promoting effective collaboration and professional relationships among different branches of healthcare, with the aim of improving and preserving patient health. Communication regarding the patient's status should be maintained at all times among all members of the professional medical team (5, 15).

A nurse trained in the administration of inhalational anesthesia possesses a set of competencies that include both technical and general skills, enabling the provision of high-quality and advanced care for the benefit of patients. The American Society of Anesthesiologists (ASA) recommends that all patients receiving general anesthesia with inhalational and/or intravenous agents should be monitored according to standard ASA guidelines, which include the continuous presence of qualified personnel and monitoring of ventilation, oxygen saturation, temperature, and circulation (5, 15).

Ventilation is monitored by measuring end-tidal CO_2 ($EtCO_2$) and the concentration of inhalational anesthetics, while oxygen saturation is monitored using pulse oximetry and inspired oxygen levels with mandatory alarms. Patient temperature may be monitored via the skin, esophagus, rectum, or urinary bladder. Circulation is monitored through continuous cardiac activity display, noninvasive blood pressure measurements at five-minute intervals, and electrocardiography (5,15).

In collaboration with the intensivist/anesthesiologist, the nurse prepares, administers, and implements the prescribed sedation. It is necessary to prepare equipment for inhalational sedation (AnaConDa filter, AnaConDa syringe, perfusor, prescribed anesthetic, gas monitor, anesthetic gas scavenging filter with a flexible exhaust tube for the ventilator, monitoring line, ventilator). The nurse connects the AnaConDa system and continuously monitors the patient's condition, observing changes in vital parameters and overall appearance, and promptly informs the physician of any changes. They monitor the gas analyzer to control the depth of sedation and perform endotracheal suctioning according to protocol. After completion of treatment, all waste is disposed of in accordance with institutional protocols (11, 12, 15).

Environmental aspects and education costs in the use of inhalational sedation in ICU

Inhalational anesthetics have a significant negative impact on the environment. Their ecological relevance stems from the fact that they act as greenhouse gases contributing to global warming. Most inhalational anesthetics are chemically very stable and are minimally metabolized in the human body, which results in more than 95% of the administered dose being exhaled unchanged and released into the atmosphere. Consequently, hospitals become a source of waste anesthetic gas emissions (16).

Sevoflurane has a relatively short atmospheric lifetime, estimated at approximately one to five years. For this reason, it is considered more environmentally acceptable compared to other inhalational anesthetics. Its global warming potential is lower, meaning it contributes less to climate change, although this impact is still not negligible. On the other hand, isoflurane has a longer atmospheric lifetime, estimated at around three to six years. Due to its longer persistence in the atmosphere and higher global warming potential, its environmental impact is more pronounced than that of sevoflurane. Like sevoflurane, isoflurane is minimally metabolized and largely eliminated via the lungs, further contributing to greenhouse gas emissions (16).

It is important to emphasize that the environmental impact of inhalational anesthetics depends not only on their chemical properties but also on the method of administration. The use of high fresh gas flows increases the amount of anesthetic released into the environment, whereas low-flow techniques can significantly reduce emissions (16).

In intensive care units, inhalational sedation utilizes a system that includes a bacterial filter as well as a heat and moisture exchanger. Approximately 90% of the administered anesthetic can be reused due to an activated charcoal filter that absorbs anesthetic vapor during exhalation and releases it back to the patient during inhalation, a phenomenon known as sevoflurane reflection. The concentration of sevoflurane on both sides of the reflector remains constant, with levels on the patient side being approximately ten times higher than on the ventilator side (16).

Despite the high degree of recycling, it is necessary to use a gas scavenging system to reduce environmental pollution and occupational exposure of healthcare personnel. For optimal device performance, single-day use is recommended (16).

A national survey in France showed that the main reasons for not using inhalational sedation in ICUs were: "device not available" (40–76%), "lack of knowledge or familiarity with the technique" (35–60%), and "lack of staff training" (58%). These findings indicate that education represents a key barrier to implementation (17).

CONCLUSIONS

Inhalational sedation with volatile anesthetics, particularly sevoflurane and isoflurane, represents an effective and increasingly used modality of sedation in intensive care units. Compared to intravenous sedatives, volatile anesthetics offer numerous advantages, including rapid onset and offset of action, easier titration of sedation depth, minimal accumulation, and favorable pharmacodynamic effects such as bronchodilation and neuroprotection. They are especially valuable in patients tolerant to benzodiazepines, those on long-term psychopharmacotherapy, and in situations where stable and predictable sedation is required. The development and introduction of devices such as the AnaConDa system have enabled the safe and practical administration of inhalational anesthetics via standard mechanical ventilators. This expands sedation options in the ICU while simultaneously reducing the risk of healthcare personnel exposure to anesthetic gases. Despite numerous advantages, it is essential to be aware of potential complications, including hemodynamic changes, respiratory side effects, and rare but potentially fatal reactions such as malignant hyperthermia. The nurse plays a key role in the safe administration of inhalational sedation. Their expertise in system preparation, continuous patient monitoring, timely recognition of changes in vital parameters, and collaboration with physicians is essential for optimal treatment outcomes. The application of high monitoring standards, in accordance with ASA recommendations, ensures patient safety and quality of care. In the described case of a patient admitted due to theophylline intoxication, (continuous renal replacement therapy) CRRT was required during treatment, and inhalational sedation with sevoflurane was introduced. This method proved to be safe and more effective. Due to the complex clinical condition and the use of high doses of psychopharmacological agents, there was a significant risk of accumulation of intravenous sedatives metabolized in the liver and eliminated via the kidneys. Sevoflurane, as an inhalational anesthetic with minimal systemic metabolism and rapid elimination through the lungs, enabled more precise control of sedation depth, faster recovery after discontinuation, and reduced the risk of hepatotoxicity and nephrotoxicity compared to standard intravenous agents.

In the presented case, inhalational sedation with sevoflurane was a feasible, safe, effective, and justified therapeutic option in a patient with severe intoxication and limited possibilities for intravenous sedation, resulting in rapid recovery and no complications.

Overall, inhalational sedation represents a valuable complement to standard sedation methods in intensive care medicine. Proper application, staff education, and a multidisciplinary approach allow the full potential of this method to be utilized for the benefit of patients requiring prolonged, stable, and easily controllable sedation.

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