

This file has been downloaded from Lovisenberg Diaconal University College's institutional archive [LDH Brage](#).

# Intensive care nurses' experiences using volatile anaesthetics in the intensive care unit: An exploratory study

**Jim Harald Olsby**

Lovisenberg Diaconal University College  
Oslo University Hospital

**Alfhild Dihle**

OsloMet – Oslo Metropolitan University

**Kristin Hofsø**

Lovisenberg Diaconal University College  
Oslo University Hospital

**Simen A. Steindal**

Lovisenberg Diaconal University College  
VID Specialized University

## When referring to the publication, use the full reference:

Olsby, J. H., Dihle, A., Hofsø, K. & Steindal, S. A. (2022). Intensive care nurses' experiences using volatile anaesthetics in the intensive care unit: An exploratory study. *Intensive and Critical Care Nursing*, 70, 103220. <https://doi.org/https://doi.org/10.1016/j.iccn.2022.103220>

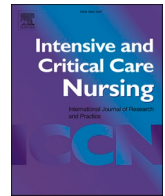
## Rights and disclaimer:

This is the accepted version of article in **Intensive and Critical Care Nursing**.  
Publisher's version: DOI: <https://doi.org/10.1016/j.iccn.2022.103220>



Contents lists available at ScienceDirect

## Intensive &amp; Critical Care Nursing

journal homepage: [www.sciencedirect.com/journal/intensive-and-critical-care-nursing](http://www.sciencedirect.com/journal/intensive-and-critical-care-nursing)

## Research Article

## Intensive care nurses' experiences using volatile anaesthetics in the intensive care unit: An exploratory study

Jim Harald Olsby<sup>a,b,\*</sup>, Alfild Dihle<sup>c</sup>, Kristin Hofso<sup>a,d</sup>, Simen A. Steindal<sup>a,e</sup><sup>a</sup> Lovisenberg Diaconal University College, Lovisenberggata 15B, 0456 Oslo, Norway<sup>b</sup> Department of Postoperative and Intensive Care, Division of Emergencies and Critical Care, Oslo University Hospital, Ullevål sykehus, Postboks 4956 Nydalen, 0424 Oslo, Norway<sup>c</sup> Faculty of Health Science, OsloMet – Oslo Metropolitan University, Oslo, Norway<sup>d</sup> Department of Research and Development, Division of Emergencies and Critical Care, Oslo University Hospital, Oslo, Norway<sup>e</sup> Faculty of Health Studies, VID Specialized University, Oslo, Norway

## ARTICLE INFO

## Keywords:

AnaConDa  
ICU nurses  
Volatile anaesthetics  
Sedation alternative  
Qualitative study

## ABSTRACT

**Objective:** To explore the experiences intensive care nurses have with volatile anaesthetics in the intensive care unit.**Research methodology and design:** A qualitative exploratory and descriptive design was used. Data were collected in 2019 from individual interviews with nine intensive care nurses, who were recruited using purposive sampling. Data were analysed using systematic text condensation.**Setting:** The study was undertaken in two general intensive care units from different university hospitals in Norway where volatile anaesthetics were utilised.**Findings:** Three categories emerged from the data analysis: experiencing the benefits of volatile anaesthetics; coping with unfamiliarity in handling volatile anaesthetics; and meeting challenges related to volatile anaesthetics in practice.**Conclusion:** The intensive care nurses had positive experiences related to administering volatile anaesthetics in the intensive care unit and responded positively to the prospect of using it more often. Because volatile anaesthetics were rarely used in their units, the participants felt uncertain regarding its use due to unfamiliarity. Collegial support and guidelines were perceived as pivotal in helping them cope with this uncertainty. The participants also experienced several challenges in using volatile anaesthetics in the intensive care unit, with ambient pollution being regarded as the main challenge.

## Implications for clinical practice

- Leaders of the intensive care unit and nurse educators should be aware that guidelines and collegial support are pivotal when introducing volatile anaesthetics.
- Intensive care unit leaders should be aware of and address the potential for increased resource demand when implementing volatile anaesthetics treatment in the units.
- Intensive care units should facilitate patient rooms when using volatile anaesthetics to ensure a healthy working environment for healthcare professionals.

## Introduction

In the intensive care unit (ICU), critically ill patients on mechanical ventilation (MV) often experience distress for various reasons, such as pain, anxiety, delirium, dyspnoea and inability to communicate (Page and McAuley, 2015; Tietze and Fuchs, 2019). Distress can lead to physical and psychological reactions, such as increased sympathetic stress response, which may affect short-term and long-term outcomes (Fuchs and Bellamy, 2020; Hughes et al., 2012a). Therefore, alleviating distress is regarded as one of the ICU nurses' main tasks (Douglas et al., 2013; Guttormson et al., 2019; Hetland et al., 2018).

\* Corresponding author at: Lovisenberg Diaconal University College, Lovisenberggata 15B, 0456 Oslo, Norway.

E-mail addresses: [Olsby.j.h@gmail.com](mailto:Olsby.j.h@gmail.com) (J.H. Olsby), [alfild@oslomet.no](mailto:alfild@oslomet.no) (A. Dihle), [kristin.hofso@ldh.no](mailto:kristin.hofso@ldh.no) (K. Hofso), [simen.alexander.steindal@ldh.no](mailto:simen.alexander.steindal@ldh.no) (S.A. Steindal).<https://doi.org/10.1016/j.iccn.2022.103220>

Received 12 March 2021; Received in revised form 16 January 2022; Accepted 9 February 2022

0964-3397/© 2022 Elsevier Ltd. All rights reserved.

To reduce patient distress and to increase comfort, continuous intravenous medication with sedative-hypnotic medications, such as Benzodiazepines and Propofol, is commonly practised (Devabhakthuni et al., 2012); however, both medications are associated with significant adverse effects and a risk that may prolong MV and ICU length of stay (Devabhakthuni et al., 2012; Wiatrowski et al., 2016). Since the beginning of the millennium, there has been a trend toward lighter sedation involving strategies such as daily sedation interruption (Kress et al., 2000) and analgo-sedation (Devlin et al., 2013; Wiatrowski et al., 2016). The goal of analgo-sedation is to address pain and discomfort first using analgesics and then to add a hypnotic agent if necessary (Devlin et al., 2013; Sessler et al., 2008).

An alternative to intravenous sedatives for the ICU population is volatile anaesthetics (Tietze and Fuchs, 2019). Volatile anaesthetics, such as sevoflurane and isoflurane, have a long history of use in anaesthesiology and have some qualities that seem desirable compared to intravenous sedatives (Jerath et al., 2017). Volatile anaesthetics affect the entire nervous system and provide pain relief, sedation and muscle relaxation at lower concentrations and lead to diminished motor and autonomic responses at higher concentrations (Campagna et al., 2003; Jerath et al., 2016; Ryu et al., 2018). This sedation method is still rarely used in the ICU, which could be attributed to fear of environmental pollution, lack of knowledge and familiarity, ICU culture, economy (Rehder, 2017) and the absence of large studies ensuring its safety in the long-term (Hughes et al., 2012b; Jerath et al., 2017; Rizoug Zeghlache et al., 2017). Previous research regarding volatile anaesthetics is limited and has primarily focused on outcomes, such as feasibility, length of stay and organ-specific effects (Kim et al., 2017; Rizoug Zeghlache et al., 2017).

When volatile anaesthetics is used in an ICU setting, the indications are usually severe acute asthma or refractory status epilepticus (Jerath et al., 2017; Landoni et al., 2016). Other indications include therapeutic hypothermia after cardiac arrest (Hellstrom et al., 2014; Staudacher et al., 2018), acute respiratory distress syndrome (ARDS) (Chanques et al., 2020; Jabaudon et al., 2017; Koutsogiannaki et al., 2019) and other cases in which conventional intravenous sedation is inadequate (Landoni et al., 2016; Mencia et al., 2018; Rizoug Zeghlache et al., 2017). Volatile anaesthetics has been made available to the ICU through products such as the anaesthetic conserving device (AnaConDa, Sedana Medical, Sweden) (Farrell et al., 2018; Romagnoli et al., 2017). The AnaConDa device is shown in Fig. 1.

The benefits of volatile anaesthetics include rapid onset and offset (Tietze and Fuchs, 2019), less deprivation of intestinal motility and a strong bronchodilatory effect (Heider et al., 2019; Jerath et al., 2016); however, volatile anaesthetics also have adverse effects, including cardiovascular alterations (hypotension and arrhythmias), risk of accumulating fluorides with prolonged use and malignant hyperthermia (Misra and Koshy, 2012; Roberts et al., 2012; Tietze and Fuchs, 2019), and caution should be exercised in patients with cerebral injuries (Bösel et al., 2012; Laferriere-Langlois et al., 2017; Purruker et al., 2015). When administrating a different and potent treatment in the ICU, there will naturally be raised concerns regarding both administration, adequate training as well as the effect of the treatment among nurses. We could not identify any studies on nurses' experiences caring for patients receiving volatile anaesthetics as sedation method in the ICU setting. Consequently, the aim of this study was to explore the experiences ICU nurses have with volatile anaesthetics in the ICU.

## Method

This qualitative study used an exploratory and descriptive design with semi-structured individual interviews. This design has the potential to explore and to describe clinical nursing practice from the nursing perspective and is suitable to describe and to understand nurses' experiences when no previous studies on a topic are identified (Hunter et al., 2019). Semi-structured interviews allow the participants to reflect on and share experiences that are perceived as important to them while providing structure in the interview to generate data relevant to the study's aim (Malterud, 2017; Polit and Beck, 2017).

## Setting and participants

The participants were recruited from two level 3 general ICUs from two different university hospitals located in different parts of Norway to enhance diversity and different experiences regarding volatile anaesthetics. The ICUs have a nurse-to-patient ratio of approximately 1.5 nurses to 1 patient, and the units had eight and 10 beds. The ICUs treated approximately 800 patients yearly combined with approximately 320 patients receiving invasive ventilation. Both university hospitals treat approximately 70 000 somatic inpatient patients per year (Buanes et al., 2020; Marshall et al., 2017). The units had experience in using volatile anaesthetics administered with the AnaConDa. Device numbers have

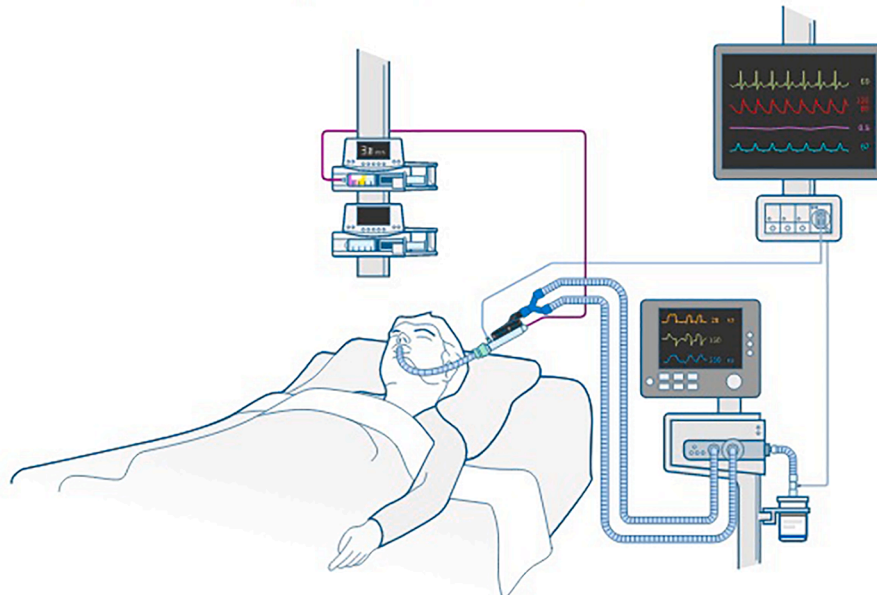


Fig. 1. Anaesthetic Conserving Device (AnaConDa).

changed over time, but the current device numbers are 26,100 and 26,050, depending on which model used by the units. Both units implemented the use of volatile anaesthetics in the ICUs approximately 10 years ago, and staff completed theoretical and practical training prior to the implementation and approximately yearly thereafter. Only ICU nurses trained in the administration of volatile anaesthetics had the responsibility for patients receiving this sedation, which was nearly all the ICU nurses. The units had approximately one to two patients receiving treatment with volatile anaesthetics per month.

The unit manager carried out the recruitment process in one hospital, and the nurse in charge of professional development carried it out at the unit at the other hospital. Purposive sampling was chosen to recruit participants who could provide information-rich and relevant data (Malterud, 2017; Polit and Beck, 2017). To be included in the study, the participants had to have a post-graduate specialty in intensive care nursing without an anaesthesiology background and had to have been responsible for the primary care of at least one patient who received volatile anaesthetics as the sedation method. Nine ICU nurses agreed to participate (Table 1).

### Ethical approval

The study was approved by the Norwegian Centre for Research Data (reference number 885970), by the data protection officer at the two hospitals and by the leaders of the units. The participants were given written and oral information about the study prior to the interviews. The first author underlined that participation was voluntary, that they could withdraw at any time until the data analysis phase began and that anonymity and confidentiality would be safeguarded before the interviews. After the information was given, the participants signed written informed consent forms.

### Data collection

The interviews were conducted between April and September 2019 at the participants' workplaces and were conducted in separate rooms from the ward with only the participant and the first author present to ensure privacy. The interviews lasted from 24 to 46 minutes (mean 34.6 minutes) and were conducted by the first author, who has no affiliation with the actual hospitals and no personal relationship with the participants. A semi-structured interview guide was developed to facilitate reflection, open conversation and rich descriptions of hands-on experiences. The guide contained open-ended questions to enable the participant to talk freely and covered topics such as participants' experiences caring for patients sedated with volatile anaesthetics, practical and theoretical challenges, sedation depth and titrating, combination

**Table 1**  
Demographics of the sample N = 9.

	Mean (SD)	Range
Age	42.1 (8,06)	33–55
Years as ICU specialty nurse	9.4 (6,77)	0,6–25
Years in current unit	8.6 (6,68)	0,6–21
Primary care to number of patients receiving volatile anaesthetics	5.4 (2,06)	3–10
Months since participants last cared for patient receiving volatile anaesthetics	7.9 (7,94)	1–24
	n	
Sex		
Female	5	
Male	4	
Hospitals		
Hospital A	5	
Hospital B	4	

therapy, fears and coping. The interview guide was pilot-tested, after which no changes were made. The pilot interview was conducted with a former ICU nurse who had vast experience using volatile anaesthetics in the ICU setting; however, this interview was not included because this participant no longer worked in an ICU. To create a relaxed atmosphere and mutual trust, the first author and the participant had a short informal conversation before the interview, and then audio recording began. The interviews were audio-recorded and transcribed verbatim by the first author.

### Data analysis

The data were analysed inductively using systematic text condensation (STC), an iterative, thematic cross-case analysis method well-suited for the novice researcher (Malterud, 2017). MAXQDA by VERBI software was used to facilitate the storage and organisation of the data. STC consists of four steps. In the first step, the first author read the data material several times to gain an overall impression and overview. Guided by the aim of this study, seven preliminary themes emerged. In the second step, meaning units containing information relevant to the preliminary themes were identified, coded and sorted into code groups. The seven preliminary themes were transformed into three code groups. In the third step, the meaning units were sorted into two to three subgroups within each code group. The content in each subgroup was abstracted and condensed into condensates. In the fourth step, the code groups were transformed into categories by summarising and creating an analytical text abstracted from the central content of each condensate from the subgroups within each code group. These categories constitute the findings of the study. The illustration of the analysis process in Table 2 is an example with one category illustrating the analytical process of the category "Experiencing the benefits of volatile anaesthetics".

### Trustworthiness

The first author works as an ICU nurse at a general ICU but has no prior experience or in-depth practical knowledge with volatile anaesthetics. After the pilot interview was conducted, the first author became more conscious about his own preconceptions. Preconceptions, the interview guide and the analysis process were discussed among the first author, and the second and last authors, who are nurses with different clinical and research backgrounds (one with expertise in palliative care and the other in anaesthesiology). This enhanced transparency, reflexivity and facilitated alternative interpretations during the analysis process. All authors agreed upon the final categories and the interpretation of the findings.

Transcriptions and the analysis process were managed with computer software created for qualitative research to help follow the data trail throughout the process and document the data analysis steps (Graneheim and Lundman, 2004). The relevance and usefulness of the findings depends on whether the readers are able to utilise the findings in this article and adapt and apply them to their own settings (Graneheim and Lundman, 2004; Polit and Beck, 2017).

### Findings

Three categories emerged from the data analysis: experiencing the benefits of volatile anaesthetics, coping with unfamiliarity handling volatile anaesthetics and meeting challenges related to volatile anaesthetics in practice.

#### *Experiencing the benefits of volatile anaesthetics*

The participants experienced that sedation with volatile anaesthetics is an alternative treatment for the patient when intravenous sedation alone becomes inadequate. The participants described that intravenous

Table 2

An example illustrating the analytical process of the category “Experiencing the benefits of volatile anaesthetics”.

Preliminary theme	Code group	Meaning units	Condensate	Subgroups	Category
Quality of sedation	Alternative when intravenous sedation is inadequate	But maybe that episode in particular, when I saw how quickly the spasms stopped. The patient relaxed, (he/she) was sedated before, but we were unable to properly ventilate the patient. So, yes, this was kind of a sunshine story, and the patient fared well afterwards. (Participant 2)	Was unable to ventilate a patient due to bronchospasms. We started the AnaConDa, and the spasm stopped.	Beneficial for patients with respiratory and/or sedation challenges	Experiencing the benefits of volatile anaesthetics
		My experience is that they are deeply sedated for several reasons, primarily to stabilise the ventilation and get them more stable and maybe lower the effort from the ventilator. (Participant 4)	Experience that the patients are deeply sedated to stabilise ventilation and reduce ventilator effort.	Operating and using the AnaConDa to find the right level of sedation throughout the ICU stay	

sedation was their first choice to treat the patients and that initiating treatment with volatile anaesthetics was used as a ‘last resort’; however, they all had positive experiences treating patients with volatile anaesthetics, and especially for patients with challenges related to respiration or sedation, the treatment worked well. The indications for starting the treatment were usually status asthmaticus with bronchospasms or chronic obstructive pulmonary disease (COPD) or high tolerance for sedatives or opioids, such that intravenous sedation alone was inadequate. One participant had treated a patient with volatile anaesthetics for whom it was otherwise not possible to reach the prescribed sedation level:

*‘We did not reach our target... That status (epilepticus) demanded such large amounts that we simply did not reach the sedation level we wanted with what we had. So, it was sort of a last resort to try to reach the sedation level that we wanted’.* (Participant 6)

Several participants had patients receiving volatile anaesthetics treatment because they had become tolerant to opioids during their pain treatment for an underlying diagnosis, such as cancer or Crohn’s disease. Participants described a successful treatment in which they intubated and sedated the patients with volatile anaesthetics, let them be sedated for a day or more and removed all their opioids. When they withdrew the sedation, pain treatment could restart at a much lower, sometimes minimal, dosage. The participants used the terms ‘resetting’ and ‘detoxification’.

Participants had positive attitudes and experiences with patients using volatile anaesthetics due to experiences with patients who had significantly benefited from using them in the past. The participants’ experience was that the sedation of patients with volatile anaesthetics gave a more stable and deeper sedation level than intravenous sedation. This was vital because it was usually the most critically ill patients who received this treatment. Moreover, the participants said that it caused relief and satisfaction to see the patient they had struggled to either sedate or ventilate finally be able to relax, receive treatment and ventilate properly after starting treatment with volatile anaesthetics. As participant 5 expressed:

*‘It gives you a good feeling, as a nurse, especially in these patients who struggle and are fighting against the ventilator. It is tough to look at and care for... I feel that one can see a big difference quickly after starting the treatment. The patient relaxes and ventilates better’.*

The volatile anaesthetics equipment was perceived as easy to use, intuitive and safe. The therapy was sometimes used alone, while other times, it was used as a supplement to intravenous medication. Several participants said that they often administered an intravenous analgesic supplement to patients if bolus doses were needed. Participants felt more comfortable using a patient treatment that they were more familiar with. If sedating with volatile anaesthetics did not have the desired effect, it would usually be discontinued. It was common to return to

intravenous sedation when weaning the patient off the ventilator or sedation, primarily because participants felt more in control and because the patient woke up more slowly and in a more controllable manner.

#### *Coping with unfamiliarity handling volatile anaesthetics*

To a varying degree, the participants described feelings of uncertainty and unfamiliarity using volatile anaesthetics for patients. Because such treatment is rare in the ICU, they rarely had responsibility for patients receiving volatile anaesthetics. Therefore, the participants felt that they never reached an expert level in contrast to their experience with intravenous sedation. The participants explained that they had an inherent knowledge and feeling of control and certainty giving intravenous sedation to patients that they lacked with volatile anaesthetics. However, after familiarizing themselves with them, several experienced feeling at ease and believed that caring for these patients repeatedly aided them in coping with the responsibility. Notably, some of the most experienced participants did not problematise treating patients with volatile anaesthetics and regarded this treatment as another strategy to reach the desired sedation level. Furthermore, the participants found that anaesthesiologists could be unsure about the treatment and that competence and knowledge among colleagues varied, which could lead to increased uncertainty:

*‘...And the challenge was that you rarely had AnaConDa for so long that you are able to become skilled at it because three or four or several months might pass until the next time. What you learned during those shifts will eventually disappear unless you use it regularly’.* (Participant 4)

The participants described a work environment where there was a shared understanding and acceptance of feeling uncertain when administering volatile anaesthetics, and the understanding that colleagues should assist, support and learn from each other. The units needed to have someone who had increased knowledge about the treatment to troubleshoot, usually an ICU nurse with ample experience with the treatment or a nurse with theoretical and training responsibility. Furthermore, it was pivotal for the units to have guidelines and algorithms that were informative and easy to understand, which the participants would follow systematically. The guidelines gave them a framework to work within and simplified the treatment, as one participant described:

*‘I think everyone feels unsure, most importantly, because we rarely use it. I think that goes for everything that you rarely use or do... But, I think it is nice to have guidelines and procedures you can look at. And it’s always nice to have a colleague you can ask’.* (Participant 4)

Collaboration with the anaesthesiologist or ICU physician was essential to the participants. It was vital that a physician was nearby or reachable if a situation related to sedation treatment should occur. The



physicians were usually present at the start-up phase and remained until the patient was at the right sedation level and stable. Afterwards, the participants titrated the dosage independently but usually in dialogue with the physician.

#### Meeting challenges related to volatile anaesthetics in practice

One of the main challenges the participants experienced when operating the AnaConDa was the problem of leakage and the fear of the leakage of volatile anaesthetics into the room. The participants experienced leakage in different ways. Most had noticed the foul smell of gas first, and for some, it was the only reason they noticed the leakage; however, others had felt physical symptoms, such as headaches, dizziness, nausea and the general feeling of ill-being. One participant characterised the headache as a unique kind of headache: not very painful but a distinct feeling of increased head pressure. Nevertheless, the participants did not perceive the leakage as a significant problem because they usually fixed the leakage quickly and could ventilate the room or withdraw from the area where the leakage had occurred. Still, some were afraid of exposure and its potential consequences:

*'Well, it was unpleasant to feel this headache because it was a different kind of headache. But, I'm not afraid of using it [volatile anaesthetics]. And we managed to resolve it quite quickly.'* (Participant 3)

The participants' experience was that leakage usually occurred when changing the filter or during procedures that required closeness to the patient's airways, such as tracheal suction or oral hygiene. Some had experienced leakage due to malfunctions in the equipment and human errors, such as the improper fastening of connections or the discarding of the syringe in a regular garbage bin after use. Several participants said that they regarded exposure to volatile anaesthetics as unavoidable because ICU nurses are bedside most of the time.

Due to the leakage problem, the participants' experience was that colleagues were concerned about having patients on volatile anaesthetics, and some even asked to be removed from the care of these patients. Participants in one of the units stated that colleagues and patients' visitors were advised to avoid entering the room if they were or could be pregnant. However, none of the participants in the other unit mentioned this. The participants also said that the introduction to the treatment was initially met with considerable scepticism and resistance, but now they rarely encountered these reactions. On the contrary, many wanted to support these patients and were curious about the treatment. As participant 2 said:

*'We were met with a lot of scepticism in the beginning when we launched it because it was new, and it was gas. It could leak gas into the room. There were many sceptics. Today, we don't hear a single word.'*

Because the participants experienced unfamiliarity and uncertainty regarding the treatment, they needed an extra nurse to double-check and problem solve with, which increased the resource demand compared to intravenous sedation. The participants' experience was that having patients on volatile anaesthetics required them to take more factors into consideration, both mentally and practically. For example, they had to closely observe the patients' breathing patterns and the angle of the AnaConDa device to maintain the prescribed level of sedation. The need for extra personnel was important in the start-up phase with equipment setup and treatment initiation; however, some participants said that once they were familiarised with it and the treatment began, they did not see it as more resource-demanding than other sedation methods.

When reflecting on limitations, participants said that the computer systems were not compatible with the treatment, making it necessary for them to manually insert values in the electronic patient record system regularly. All the rooms were not suited for volatile anaesthetics as they lacked ventilation options, sometimes requiring logistical work before the treatment could begin. If the patient needed to be transported, the

participants switched sedation to intravenous, which could have several unwanted consequences regarding haemodynamics, sedation level and treatment delays. Because this sedation method was rarely used in the units, theoretical and practical training was needed regularly. Several participants also mentioned that this sedation method was more expensive than the intravenous method, which would also affect the unit's resources:

*'Well, it is maybe that we rarely use it, that... It's resource-demanding when we're doing the setup or changing the filter – we do it so rarely that you want it to be two [nurses]'*. (Participant 8)

#### Discussion

The aim of this study was to explore the experiences intensive care nurses have with volatile anaesthetics in the intensive care unit. The findings show that ICU nurses experienced sedation with volatile anaesthetics in the ICU as being able to provide a good sedation alternative when intravenous sedation was inadequate. The findings provide insight into how ICU nurses cope with unfamiliarity related to the use of volatile anaesthetics and the challenges and limitations ICU nurses face while using it in their units.

In line with previous research (Blondonnet et al., 2020; Landoni et al., 2016; Mencía et al., 2018), the experience of participants in this study was that volatile anaesthetics were often used in cases where intravenous sedation was inadequate or in cases where physicians wanted a bronchodilatory effect, such as for severe asthma or COPD. Volatile anaesthetics seem to be a potential option to enhance bronchodilatation in patients with refractory status asthmaticus, which might save the patient from extremely invasive treatments, such as extracorporeal membrane oxygenation (Rehder, 2017).

The participants in this study did not mention having experience with ARDS patients receiving volatile anaesthetics; however, with the current coronavirus disease (COVID-19) pandemic, for which clinical experience shows that these patients need to be deeply sedated (Payen et al., 2020; Sorbello et al., 2020), conventional intravenous sedatives are at risk of becoming short in supply (Ferrière et al., 2020; Jerath et al., 2020), requiring sedation alternatives. Studies have shown the potential for volatile anaesthetics as an alternative in the treatment of COVID-19 (Flinspach et al., 2020) and ARDS patients (Heider et al., 2019; Jabaudon et al., 2017; Rand et al., 2018).

However, it was surprising to find that the participants considered volatile anaesthetics an effective strategy for mitigating opioid tolerance. In contrast, a Cochrane review does not recommend such use because there is a significantly increased risk of serious adverse events and resource demand (Gowing et al., 2012). A study examining opioid tolerance in patients with critical illnesses presented numerous mitigating strategies, such as opioid rotation, adjunctive treatment with non-opioids, such as ketamine, dexmedetomidine, methadone, gabapentinoids, and even cannabinoids; however, volatile anaesthetics were not mentioned (Martyn et al., 2019).

The participants in this study generally had positive attitudes towards using volatile anaesthetics in the ICU and seemed to feel satisfaction when they were finally able to alleviate the patients' distress using volatile anaesthetics. ICU nurses work in a stressful environment with high stakes, and observing patients suffering or in distress, inappropriate care and feelings of frustration or helplessness may contribute to both moral and emotional distress (McAndrew et al., 2018; Van Mol et al., 2015). Furthermore, ICU nurses may have a personal and professional moral dilemma as recent guidelines for sedation recommend a light level of sedation and the avoidance of sedatives (Devlin et al., 2018), while at the same time, they feel compassion for the patient in distress that they would like to alleviate (Berntzen et al., 2019; Gutormson et al., 2019; Van Mol et al., 2015).

The participants expressed the feeling of uncertainty regarding

volatile anaesthetics because it is a treatment they rarely used and for which they felt they never reached an expert level; however, in light of Benner's (1982) descriptions of acquisition and the development of a skill, all the participants may have been at least on level four of proficiency (Benner, 1982). At this level, the nurses are able to see the patient situation as a whole, rather than in parts, to recognise what is similar and dissimilar to previous experiences and to modify plans according to the situation (Benner, 2004). In this context, the participants seemed to be able to view the sedation method as a means of obtaining the prescribed level of sedation to enable patient treatment or to understand cases in which the sedation or bronchial dilatation was the treatment itself. Their feeling of uncertainty and not having reached an expert level could be due to a lack of exposure to clinical situations with volatile anaesthetics over time. Moreover, the findings suggest that some of the participants could be on level five: experts. These participants seemed to be able to detach themselves from the guidelines or algorithms that were crucial to the nurses on level four (Benner, 1982). Benner (2004) uses Aristotle's term *phronesis*, which means practical wisdom. Expert nurses in this context use their vast practical experience with similar or dissimilar situations combined with formal knowledge (*techné*) to respond to situations and to take immediate action when needed without further assessment or reassurances. Expert nurses are response-based and are able to adapt their skillset and experience to attain a maximum grasp of the situation, and to an expert nurse, the correct response is considered obvious (Benner, 2004). One of the most experienced nurses in the current study regarded sedation with volatile anaesthetics as just another method to sedate a patient and did not problematise it further, possibly showing the situational understanding of an expert nurse.

The participants highlighted collegial support and guidelines as pivotal to them in coping with uncertainty regarding unfamiliarity with volatile anaesthetics. This is in line with a study that showed that collaboration with other nurses and physicians for reassurance or to validate one's thinking is vital in coping with uncertainty (Cranley et al., 2012). Furthermore, the participants sought reassurance and guidance from guidelines and algorithms, which is in line with studies in which clinical guidelines were perceived as crucial in guiding nurses in decision-making regarding the sedation of mechanically ventilated patients (Ääri et al., 2008; Slomka et al., 2000).

The participants expressed concerns regarding the ambient pollution of volatile anaesthetics in the room and the potential consequences of exposure. The problem is not unknown, and studies point to the fear of pollution as one of the main causes of the ICU community's hesitance to utilise volatile anaesthetics (Herzog-Niescery et al., 2018; Hughes et al., 2012a; Pickworth et al., 2013). Long-term occupational exposure to high concentrations of volatile anaesthetics has been shown to increase the risk of spontaneous abortions as well as central nervous system alterations, such as those affecting memory and concentration (Tankó et al., 2014); however, studies have not shown evidence of adverse effects in professionals exposed to low concentrations of volatile anaesthetics below the safety limits (Molina Aragonés et al., 2016). Several studies have examined ambient pollution and exposure to volatile anaesthetics using the AnaConDa in the ICU, and all showed that long-term exposure is below the safety limit as long as gas scavenging and room air exchanges are functioning properly (Landoni et al., 2016; Pickworth et al., 2013; Sackey et al., 2005); however, the current study illuminates what exposure to volatile anaesthetics really entails for the bedside caregiver and how it may negatively affect the healthy working environment. Quantitative studies measuring low levels of ambient pollution within what is regarded as the safety limits proves its safety (Herzog-Niescery et al., 2018; Pickworth et al., 2013), but are not able to provide any insight into how working with volatile anaesthetics in the ICU and being exposed to it are experienced by the professionals responsible for the treatment. The researchers of this study have not been able to identify any studies researching options for venting and other safety measurements that can improve the healthy working environment when treating patients with volatile anaesthetics in the ICU. This could be explored in

futures studies.

### Limitations

A limitation of this study is the participants' limited experience with volatile anaesthetics. The participants had varying degrees of experience with volatile anaesthetics and ICU nursing in general. ICU nurses with more experience with volatile anaesthetics from several units may have enriched the data with more experiences than this study has identified. Another limitation may be that the unit manager carried out the recruitment process in one hospital. We provided the unit manager with inclusion criteria for the recruitment, but the unit manager may potentially have recruited participants representing the unit manager's own attitudes and experiences with volatile anaesthetics; however, the participants spoke openly and displayed both positive and negative experiences.

### Conclusion

The findings of this study provide a novel insight into the experiences ICU nurses have with volatile anaesthetics in the ICU. The ICU nurses who participated in this study had positive experiences when administering volatile anaesthetics to patients where they had struggled to either sedate or ventilate patients. Therefore, they responded positively to the prospect of using it more. Since they rarely used volatile anaesthetics in their units, the participants felt uncertainty due to unfamiliarity when responsible for the care of these patients. Collegial support and guidelines were perceived as pivotal in coping with this uncertainty. The participants experienced several challenges in using volatile anaesthetics in the ICU, such as leakage or ambient pollution of volatile anaesthetics and the fear of consequences of exposure.

Future research should address the overall benefits and challenges using volatile anaesthetics in the ICU.

### Ethical statement

The study was approved by the Norwegian Centre for Research Data (reference number 885970), by the data protection officer at the two hospitals, and by the leaders of the units. The participants were given written and oral information about the study prior to the interviews. They were informed that participation was voluntary, that they could withdraw at any time until the data analysis phase began, and that anonymity and confidentiality were safeguarded. After information was given, the participants signed written informed consent forms.

### Acknowledgments

We would like to acknowledge the participants contributing with their experiences in this study.

### Conflict of interest

The authors declare no conflict of interest.

### Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### Author contribution

JHO: The conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and final approval of the version to be submitted.

AD: Analysis and interpretation of data, revising article critically for

important intellectual content and final approval of the version to be submitted.

KH: Interpretation of data, revising article critically for important intellectual content and final approval of the version to be submitted.

SAS: The conception and design of the study, analysis and interpretation of data, revising article critically for important intellectual content and final approval of the version to be submitted.

## References

- Ääri, R.L., Tarja, S., Helena, L.K., 2008. Competence in intensive and critical care nursing: a literature review. *Intensive Crit. Care Nurs.* 24, 78–89. <https://doi.org/10.1016/j.iccn.2007.11.006>.
- Benner, P., 2004. Using the Dreyfus model of skill acquisition to describe and interpret skill acquisition and clinical judgment in nursing practice and education. *Bull. Sci. Technol. Soc.* 24, 188–199. <https://doi.org/10.1177/0270467604265061>.
- Benner, P., 1982. From novice to expert. *Am. J. Nurs.* 82, 402–407.
- Berntzen, H., Bjørk, I.T., Wøien, H., 2019. "Having the compass—drawing the map": Exploring nurses' management of pain and other discomforts during use of analgesedation in intensive care. *Nurs. Open* 6, 453–462. <https://doi.org/10.1002/nop.2227>.
- Blondonnet, R., Quinson, A., Lambert, C., Futier, E., Bazin, J.-E., Pereira, B., Bastarache, J., Ware, L.B., Constantin, J., Jabaudon, M., 2020. Use of volatile agents for sedation in the intensive care unit a national survey in France. *Am. J. Respir. Crit. Care Med.* <https://doi.org/10.1164/ajrccm-conference.2020.201.1.MeetingAbstracts.A3570>.
- Bösel, J., Purrucker, J.C., Nowak, F., Renzland, J., Schiller, P., Pérez, E.B., Poli, S., Brunn, B., Hacke, W., Steiner, T., 2012. Volatile isoflurane sedation in cerebrovascular intensive care patients using AnaConDa®: Effects on cerebral oxygenation, circulation, and pressure. *Intensive Care Med.* 38, 1955–1964. <https://doi.org/10.1007/s00134-012-2708-8>.
- Buanes, E.A., Kvåle, R., Barratt-Due, A., 2020. Norsk intensivregister Årsrapport for 2019 med plan for forbedringstiltak.
- Campagna, J.A., Miller, K.W., Forman, S.A., 2003. Mechanisms of actions of inhaled anesthetics. *N. Engl. J. Med.* 348, 2110–2124. <https://doi.org/10.1056/NEJMra021261>.
- Chanques, G., Constantin, J.-M., Devlin, J.W., Ely, E.W., Fraser, G.L., Gélinas, C., Girard, T.D., Guérin, C., Jabaudon, M., Jaber, S., Mehta, S., Langer, T., Murray, M.J., Pandharipande, P., Patel, B., Payen, J.-F., Puntillo, K., Rochweg, B., Shehabi, Y., Ström, T., Olsen, H.T., Kress, J.P., 2020. Analgesia and sedation in patients with ARDS. *Intensive Care Med.* 46, 2342–2356. <https://doi.org/10.1007/s00134-020-06307-9>.
- Cranley, L.A., Doran, D.M., Tourangeau, A.E., Kushniruk, A., Nagle, L., 2012. Recognizing and responding to uncertainty: a grounded theory of nurses' uncertainty. *Worldviews Evid-Based Nurs.* 9, 149–158. <https://doi.org/10.1111/j.1741-6787.2011.00237.x>.
- Devabhakthuni, S., Armahizer, M.J., Dasta, J.F., Kane-Gill, S.L., 2012. Analgesedation: a paradigm shift in intensive care unit sedation practice. *Ann. Pharmacother.* 46, 530–540.
- Devlin, J., Fraser, G., Ely, E., Kress, J., Skrobik, Y., Dasta, J., 2013. Pharmacological management of sedation and delirium in mechanically ventilated ICU patients: remaining evidence gaps and controversies. *Seminars Resp. Crit. Care Med.* 34, 201–215. <https://doi.org/10.1055/s-0033-1342983>.
- Devlin, J.W., Skrobik, Y., Gélinas, C., Needham, D.M., Slooter, A.J.C., Pandharipande, P. P., Watson, P.L., Weinhouse, G.L., Nunnally, M.E., Rochweg, B., Balas, M.C., van den Boogaard, M., Bosma, K.J., Brummel, N.E., Chanques, G., Denehy, L., Drouot, X., Fraser, G.L., Harris, J.E., Joffe, A.M., Kho, M.E., Kress, J.P., Lanphere, J.A., McKinley, S., Neufeld, K.J., Pisani, M.A., Payen, J.-F., Pun, B.T., Puntillo, K.A., Riker, R.R., Robinson, B.R.H., Shehabi, Y., Szumita, P.M., Winkelman, C., Centofanti, J.E., Price, C., Nikayin, S., Misak, C.J., Flood, P.D., Kiedrowski, K., Alhazzani, W., 2018. Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Crit. Care Med.* 46, e825–e873.
- Douglas, S., Cartmill, R., Brown, R., Hoonakker, P., Slagle, J., Schultz Van Roy, K., Walker, J.M., Weinger, M., Wetterneck, T., Carayon, P., 2013. The work of adult and pediatric intensive care unit nurses. *Nurs. Res.* 62, 50–58. <https://doi.org/10.1097/NNR.0b013e318270714b>.
- Farrell, R., Oomen, G., Carey, P., 2018. A technical review of the history, development and performance of the anaesthetic conserving device "AnaConDa" for delivering volatile anaesthetic in intensive and post-operative critical care. *J. Clin. Monit. Comput.* 32, 595–604. <https://doi.org/10.1007/s10877-017-0097-9>.
- Ferrière, N., Bodenès, L., Bailly, P., L'Her, E., 2020. Shortage of anesthetics: Think of inhaled sedation! *J. Crit. Care* 63, 104–105. <https://doi.org/10.1016/j.jccr.2020.09.009>.
- Flinspach, A.N., Zacharowski, K., Ioanna, D., Adam, E.H., 2020. Volatile isoflurane in critically ill Coronavirus Disease 2019 patients—A case series and systematic review. *Crit. Care Explor.* 2, e0256 <https://doi.org/10.1097/ccc.0000000000000256>.
- Fuchs, B., Bellamy, C., 2020. Sedative-analgesic medications in critically ill adults: Selection, initiation, maintenance, and withdrawal [WWW Document]. UpToDate. URL <https://www.uptodate.com/contents/sedative-analgesic-medications-in-critically-ill-adults-selection-initiation-maintenance-and-withdrawal>.
- Gowing, L., Ali, R., White, J., 2012. Opioid antagonists under heavy sedation or anaesthesia for opioid withdrawal (Review). *Cochrane Database Syst. Rev.* 1–47. <https://doi.org/10.1002/14651858.CD002022.pub3>.
- Graneheim, U.H., Lundman, B., 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ. Today* 24, 105–112. <https://doi.org/10.1016/j.nedt.2003.10.001>.
- Guttormson, J.L., Chlan, L., Tracy, M.F., Hetland, B., Mandrekar, J., 2019. Nurses' attitudes and practices related to sedation: a national survey. *Am. J. Crit. Care* 28, 255–263. <https://doi.org/10.4037/ajcc2019526>.
- Heider, J., Bansbach, J., Kaufmann, K., Heinrich, S., Loop, T., Kalbhenn, J., 2019. Does volatile sedation with sevoflurane allow spontaneous breathing during prolonged prone positioning in intubated ARDS patients? A retrospective observational feasibility trial. *Ann. Intensive Care* 9, 41. <https://doi.org/10.1186/s13613-019-0517-8>.
- Hellstrom, J., Öwall, A., Martling, C.-R., Sackey, P.V., 2014. Inhaled isoflurane sedation during therapeutic hypothermia after cardiac arrest: a case series. *Crit. Care Med.* 42, 161–166. <https://doi.org/10.1097/CCM.0b013e3182a643d7>.
- Herzog-Niescery, J., Vogelsang, H., Gude, P., Seipp, H.M., Bartz, H., Uhl, W., Weber, T.P., Bellgardt, M., 2018. The impact of the anaesthetic conserving device on occupational exposure to isoflurane among intensive care healthcare professionals. *Minerva Anestesiol.* 84, 25–32. <https://doi.org/10.23736/S0375-9393.17.11770-0>.
- Hetland, B., Guttormson, J., Tracy, M.F., Chlan, L., 2018. Sedation is tricky: a qualitative content analysis of nurses' perceptions of sedation administration in mechanically ventilated intensive care unit patients. *Aust. Crit. Care* 31, 153–158. <https://doi.org/10.1016/j.aucc.2018.02.001>.
- Hughes, C.G., McGrane, S., Pandharipande, P.P., 2012a. Sedation in the intensive care setting. *Clin. Pharmacol.* 4, 53–63. <https://doi.org/10.2147/CPAA.S26582>.
- Hughes, C.G., McGrane, S., Pandharipande, P.P., 2012b. Sedation in the intensive care setting. *Clin. Pharmacol.* 53–63.
- Hunter, D.J., McCallum, J., Howes, D., 2019. Defining Exploratory-Descriptive Qualitative (EDQ) research and considering its application to healthcare. *J. Nurs. Health Care* 4.
- Jabaudon, M., Boucher, P., Imhoff, E., Chabanne, R., Faure, J.-S., Roszyk, L., Thibault, S., Blondonnet, R., Clairefond, G., Guérin, R., Perbet, S., Cayot, S., Godet, T., Pereira, B., Sapin, V., Bazin, J.-E., Futier, E., Constantin, J.-M., 2017. Sevoflurane for sedation in acute respiratory distress syndrome: a randomized controlled pilot study. *Am. J. Respir. Crit. Care Med.* 195, 792–800. <https://doi.org/10.1164/rccm.201604-0686OC>.
- Jerath, A., Ferguson, N.D., Cuthbertson, B., 2020. Inhalational volatile-based sedation for COVID-19 pneumonia and ARDS. *Intensive Care Med.* 46, 1563–1566. <https://doi.org/10.1007/s00134-020-06154-8>.
- Jerath, A., Panckhurst, J., Parotto, M., Lightfoot, N., Wasowicz, M., Ferguson, N.D., Steel, A., Beattie, W.S., 2017. Safety and efficacy of volatile anaesthetic agents compared with standard intravenous midazolam/propofol sedation in ventilated critical care patients: a meta-analysis and systematic review of prospective trials. *Anesth. Analg.* 124, 1190–1199.
- Jerath, A., Parotto, M., Wasowicz, M., Ferguson, N.D., 2016. Volatile anesthetics is a new player emerging in critical care sedation? *Am. J. Respir. Crit. Care Med.* 193, 1202–1212. <https://doi.org/10.1164/rccm.201512-2435CP>.
- Kim, H.Y., Lee, J.E., Kim, H.Y., Kim, J., 2017. Volatile sedation in the intensive care unit: a systematic review and meta-analysis. *Medicine* 96, e8976. <https://doi.org/10.1097/MD.00000000000008976>.
- Koutsogiannaki, S., Shimaoka, M., Yuki, K., 2019. The use of volatile anesthetics as sedatives for acute respiratory distress syndrome. *Transl. Perioperative Pain Med.* 6, 27–38. <https://doi.org/10.31480/2330-4871/084>.
- Kress, J.P., Pohlman, A.S., O'Connor, M.F., Hall, J.B., 2000. Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *New Engl. J. Med.* 342, 1471–1477.
- Laferrière-Langlois, P., D'aragon, F., Manzanares, W., 2017. Halogenated volatile anesthetics in the intensive care unit: current knowledge on an upcoming practice. *Minerva Anestesiol.* 83, 737–748. <https://doi.org/10.23736/S0375-9393.17.11735-9>.
- Landoni, G., Pasin, L., Cabrini, L., Scandroglio, A.M., Baiardo Redaelli, M., Votta, C.D., Bellandi, M., Borghi, G., Zangrillo, A., 2016. Volatile agents in medical and surgical intensive care units: a meta-analysis of randomized clinical trials. *J. Cardiothorac. Vasc. Anesth.* 30, 1005–1014. <https://doi.org/10.1053/j.jvca.2016.02.021>.
- Malterud, K., 2017. Kvalitative forskningsmetoder for medisin og helsefag, 4th editio. Universitetsforlaget, Oslo.
- Marshall, J.C., Bosco, L., Adhikari, N.K., Connolly, B., Diaz, J.V., Dorman, T., Fowler, R. A., Meyfroidt, G., Nakagawa, S., Pelosi, P., Vincent, J.-L., Vollman, K., Zimmerman, J., 2017. What is an intensive care unit? A report of the task force of the World Federation of Societies of Intensive and Critical Care Medicine. *J. Crit. Care* 37, 270–276. <https://doi.org/10.1016/j.jccr.2016.07.015>.
- Martyn, J.A.J., Mao, J., Bittner, E.A., 2019. Opioid tolerance in critical illness. *N. Engl. J. Med.* 380, 365–378. <https://doi.org/10.1056/NEJMra1800222>.
- McAndrew, N.S., Leske, J., Schroeter, K., 2018. Moral distress in critical care nursing: the state of the science. *Nurs. Ethics* 25, 552–570. <https://doi.org/10.1177/0969733016664975>.
- Mencía, S., Palacios, A., García, M., Llorente, A.M., Ordóñez, O., Toledo, B., López-Herce, J., 2018. An exploratory study of sevoflurane as an alternative for difficult sedation in critically ill children. *Pediatric Crit. Care Med.* 19, e335–e341. <https://doi.org/10.1097/PCC.0000000000001538>.
- Misra, S., Koshy, T., 2012. A review of the practice of sedation with inhalational anaesthetics in the intensive care unit with the AnaConDa® device. *Indian J. Anaesthesia* 518. <https://doi.org/10.4103/0019-5049.104565>.



- Molina Aragonés, J.M., Ayora, A.A., Ribalta, A.B., Aparici, A.G., Lavela, J.A.M., Vidiella, J.S., López, M.H., 2016. Occupational exposure to volatile anaesthetics: a systematic review. *Occup. Med.* 66, 202–207. <https://doi.org/10.1093/occmed/kqv193>.
- Page, V.J., McAuley, D.F., 2015. Sedation/drugs used in intensive care sedation. *Curr. Opin. Anaesthesiol.* 28, 139–144.
- Payen, J.-F., Chanques, G., Futier, E., Velly, L., Jaber, S., Constantin, J.-M., 2020. Sedation for critically ill patients with COVID-19: Which specificities? One size does not fit all. *Anaesthesia Crit. Care Pain Med.* 39, 341–343. <https://doi.org/10.1016/j.accpm.2020.04.010>.
- Pickworth, T., Jerath, A., DeVine, R., Kherani, N., Wasowicz, M., 2013. The scavenging of volatile anesthetic agents in the cardiovascular intensive care unit environment: A technical report. La récupération des agents anesthésiques volatils dans l'environnement de l'unité des soins intensifs cardiovasculaires: un rapport technique. *Canadian J. Anesthesia* 60, 38–43. <https://doi.org/10.1007/s12630-012-9814-5>.
- Politi, D.F., Beck, C.T., 2017. *Nursing Research: Generating and Assessing Evidence for Nursing Practice*, 10th edition. Wolters Kluwer.
- Purrucker, J.C., Renzland, J., Uhlmann, L., Bruckner, T., Hacke, W., Steiner, T., Bösel, J., 2015. Volatile sedation with sevoflurane in intensive care patients with acute stroke or subarachnoid haemorrhage using AnaConDa®: an observational study † †Parts of this work have been presented and awarded at the annual meeting of the German Interdisciplina. *Br. J. Anaesth.* 114, 934–943. <https://doi.org/10.1093/bja/aev070>.
- Rand, A., Zahn, P.K., Schildhauer, T.A., Waydhas, C., Hamsen, U., 2018. Inhalative sedation with small tidal volumes under venovenous ECMO. *J. Artif. Organs* 21, 201–205. <https://doi.org/10.1007/s10047-018-1030-9>.
- Rehder, K.J., 2017. Adjunct therapies for refractory status asthmaticus in children. *Respiratory Care* 62, 849–865. <https://doi.org/10.4187/respcare.05174>.
- Rizoug Zeghlache, N., Simonet, O., de kock, M., Vallot, F., 2017. Why aren't the halogenated agents used in the intensive care unit? Contributions of the AnaConDa device. *Acta Anaesthesiologica Belgica*.
- Roberts, D.J., Haroon, B., Hall, R.I., 2012. Sedation for critically ill or injured adults in the intensive care unit: a shifting paradigm. *Drugs* 72, 1881–1916. <https://doi.org/10.2165/11636220-000000000-00000>.
- Romagnoli, S., Chelazzi, C., Zagli, G., Benvenuti, F., Mancinelli, P., Boninsegni, P., Paparella, L., 2017. Critical care sedation with sevoflurane: a single center experience with the new mirus system. *Crit. Care*.
- Ryu, K.-H., Song, K., Lim, T.-Y., Choi, W.-J., Kim, Y.-H., Kim, H.-S., 2018. Does Equi-minimum alveolar concentration value ensure equivalent analgesic or hypnotic potency? *Anesthesiology* 128, 1092–1098. <https://doi.org/10.1097/aln.0000000000002158>.
- Sackey, P.V., Martling, C.-R., Nise, G., Radell, P.J., 2005. Ambient isoflurane pollution and isoflurane consumption during intensive care unit sedation with the Anesthetic Conserving Device. *Crit. Care Med.* 33, 585–590. <https://doi.org/10.1097/01.CCM.0000156294.92415.E2>.
- Sessler, C.N., Grap, M.J., Ramsay, M.A.E., 2008. Evaluating and monitoring analgesia and sedation in the intensive care unit. *Crit. Care* 12, S2. <https://doi.org/10.1186/cc6148>.
- Slomka, J., Hoffman-Hogg, L., Mion, L.C., Bair, N., Bobek, M.B., Arroliga, A.C., 2000. Influence of clinicians' values and perceptions on use of clinical practice guidelines for sedation and neuromuscular blockade in patients receiving mechanical ventilation. *Am. J. Crit. Care* 9, 412–418.
- Sorbello, M., El-Boghdadly, K., Di Giacinto, I., Cataldo, R., Esposito, C., Falcetta, S., Merli, G., Cortese, G., Corso, R.M., Bressan, F., Pintaudi, S., Greif, R., Donati, A., Petrini, F., 2020. The Italian coronavirus disease 2019 outbreak: recommendations from clinical practice. *Anaesthesia* 75, 724–732. <https://doi.org/10.1111/anae.15049>.
- Staudacher, D.L., Hamilton, S.K., Duerschmied, D., Biever, P.M., Zehender, M., Bode, C., Wengenmayer, T., 2018. Isoflurane or propofol sedation in patients with targeted temperature management after cardiopulmonary resuscitation: a single center study. *J. Crit. Care* 45, 40–44. <https://doi.org/10.1016/j.jcrr.2018.01.014>.
- Tankó, B., Molnár, L., Fülesdi, B., Molnár, C., 2014. Occupational hazards of halogenated volatile anesthetics and their prevention: Review of the literature. *J. Anesthesia Clin. Res.* 5 <https://doi.org/10.4172/2155-6148.1000426>.
- Tietze, K.J., Fuchs, B., 2019. Sedative-analgesic medications in critically ill adults: Properties, dosage regimens, and adverse effects [WWW Document]. UpToDate. URL [https://www.uptodate.com/contents/sedative-analgesic-medications-in-critically-ill-adults-properties-dosage-regimens-and-adverse-effects?search=sedation-icu&source=search\\_result&selectedTitle=2~150&usage\\_type=default&display\\_rank=2#H1](https://www.uptodate.com/contents/sedative-analgesic-medications-in-critically-ill-adults-properties-dosage-regimens-and-adverse-effects?search=sedation-icu&source=search_result&selectedTitle=2~150&usage_type=default&display_rank=2#H1) (accessed 5.4.19).
- van Mol, M.M.C., Kompanje, E.J.O., Benoit, D.D., Bakker, J., Nijkamp, M.D., Seedat, S., 2015. The prevalence of compassion fatigue and burnout among healthcare professionals in intensive care units: a systematic review. *PLoS ONE* 10, e0136955. <https://doi.org/10.1371/journal.pone.0136955>.
- Wiatrowski, R., Norton, C., Giffen, D., 2016. Analgo-sedation: improving patient outcomes in ICU sedation and pain management. *Pain Manage. Nurs.* 17, 204–217. <https://doi.org/10.1016/j.pmn.2016.02.052>.