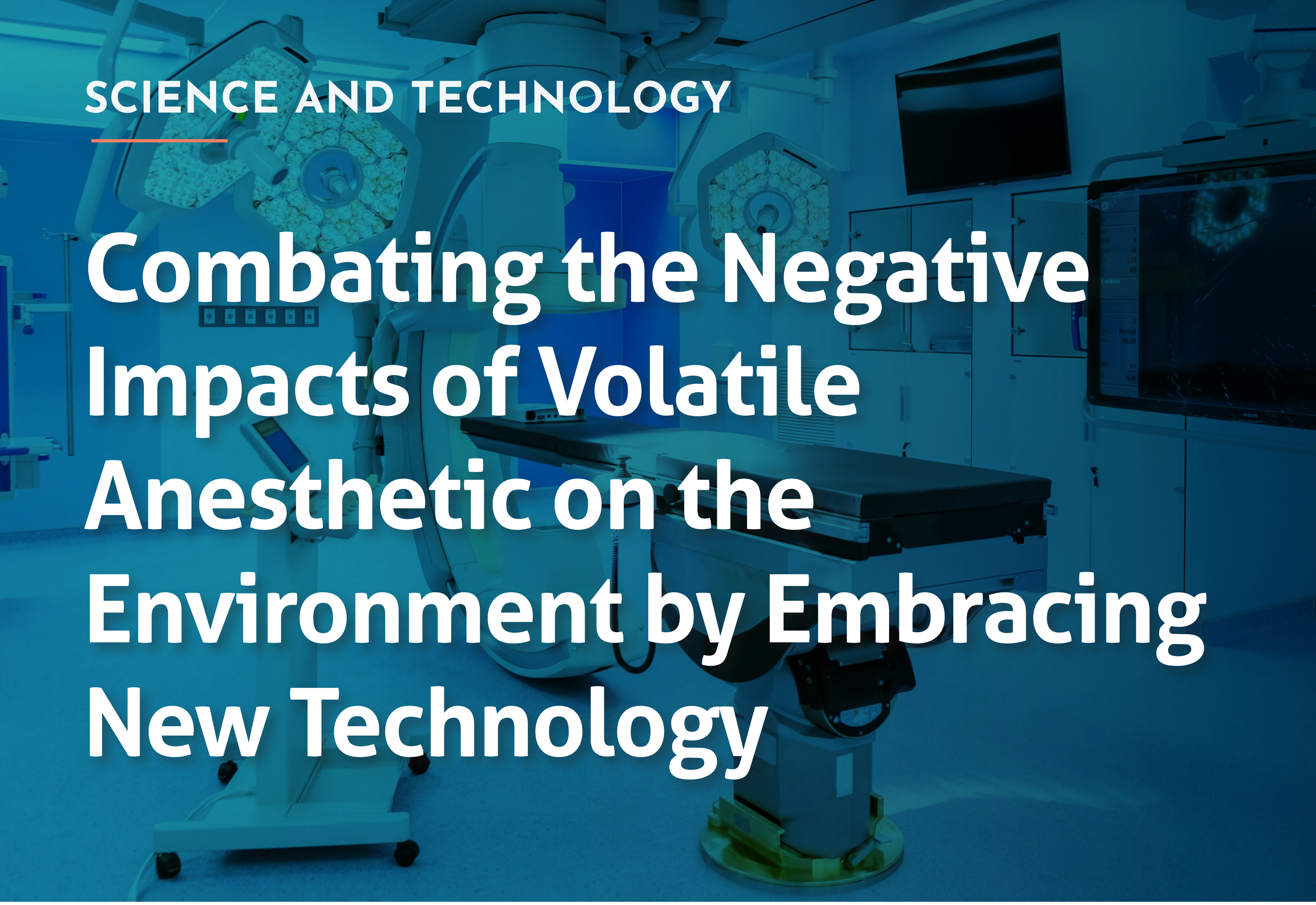
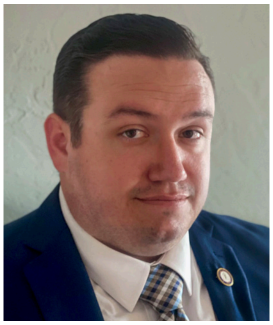


SCIENCE AND TECHNOLOGY

Combating the Negative Impacts of Volatile Anesthetic on the Environment by Embracing New Technology



BRYAN FULTON, M.ED., CER.A.T.T.
PROFESSOR, DIRECTOR OF LABS & SIMULATIONS
OCCC ANESTHESIA TECHNOLOGY

ABOUT THE AUTHOR

Bryan Fulton is a Professor of Anesthesia Technology at Oklahoma City Community College (OCCC) and Director of Labs and Simulations at OCCC. When he is not teaching at college, he volunteers with ASATT and the CoA-ATE, most recently serving as the ASATT's president. Bryan is a doctoral student at Baker University and focuses his research on the impacts of clinical instructors on the persistence and retention of students in allied health professions programs. He is a father to four wonderful children and loves spending time with his wife and family, exploring all Oklahoma offers.

DISCLOSURES

This article contains references to particular companies and specific products. The author wishes to disclose that they have neither financial nor non-financial affiliations with the companies or products mentioned in this article. The primary aim of this article is to inform readers about ongoing efforts in developing technologies to reduce the environmental impact of volatile anesthetics.

OVERVIEW

Over the past several decades, a global cultural shift has focused on addressing climate change. This shift has led to a concerted effort by various industries to modify traditional manufacturing techniques and overall operations to reduce the impact of CO2 emissions on the atmosphere. For instance, the proliferation of electric vehicles and the expansion of solar services are popular examples of industries striving to be more conscious of their impact on the global climate.

However, several industries are also making efforts to enhance their emissions footprint concerning the atmosphere. Notably, healthcare, specifically the perioperative environments, are reshaping how they deliver surgical services to minimize their environmental impact. This article aims to explore the trends in perioperative technology that have been designed to reduce their impact on the climate.

BACKGROUND

According to the National Centers for Environmental Information, global temperatures have risen by two degrees since 1880. More notably, since 1981, the average increase in global temperatures has accelerated to 0.32°F per decade, marking a 128% increase from the average decade increase prior to 1981 (Lindsey & Dahlman, 2023). The primary contributor to this global warming is increased atmospheric carbon dioxide levels. As scientists continue to predict rising temperatures in the coming decades, other concerns related to climate care, such as the impacts of gases other than carbon dioxide on the climate, come into focus.

Within the field of anesthesia, a significant focus has been placed on the environmental impact of volatile anesthetics. For instance, research into the effects of Desflurane on global warming has revealed that one bottle of Desflurane produces the same global warming effect as burning 440 kg of coal (NHS, 2021). This equivalence is also on par with driving a car for 3,200 miles (Heron, 2023). Such an impact means that Desflurane is significantly more harmful than the more commonly known greenhouse gases and is "2,500 times more impactful than carbon dioxide" (Heron, 2023).

This research highlighting the considerable negative impacts of Desflurane has prompted numerous institutions to remove Desflurane from their operating rooms. For example, the National Health Service, the United Kingdom's government-funded healthcare provider, has ceased using Desflurane at 40 health systems (NHS, 2023). Similarly, domestically, we are witnessing comparable trends in the removal of Desflurane from the operating room, with the University of Pittsburgh Medical Center (UPMC) committing to the complete removal of Desflurane from all 40 hospital systems by the end of the year (DeWitt, 2023). Desflurane is one of the most prominent examples of the perioperative environment's shift towards greater awareness of its impact on the climate.

AN OVERVIEW OF DESFLURANE

Volatile anesthetics are inhaled anesthetics used to induce or maintain stage three general anesthesia. All volatile anesthetics used today, except for Nitrous oxide and Xenon, are ether derivatives and are considered halogenated. This means the chemical complexes are formed from halogen elements bound to carbon or oxygen. Examples of halogens used to make contemporary volatile anesthetics include fluorine and chlorine.

Structurally, Desflurane is almost identical to its cousin anesthetic agent, Isoflurane, with the only difference being the number of fluorine atoms—six, with the sixth fluorine replacing the chlorine atom found in Isoflurane. Desflurane has distinctive physical properties, including a pungent smell, which makes it unsuitable for inhalation inductions. Furthermore, its volatility makes it more expensive to use. Desflurane will boil at a standard room temperature of 22 degrees Celsius (Özelsel, Sondekoppam, & Buro, 2019). This means that to use it; the agent has to be superheated well above its partial pressure of 669mmHg to an extreme pressure of over 1300mmHg to ensure accurate administration to patients undergoing surgery. To put this into perspective, the standard boiling pressure on Earth is 760mmHg. This means that Desflurane, left unabated, is 88% of the standard boiling pressure, and within a vaporizer, it is superheated to 71% above the standard boiling pressure to ensure safe delivery to patients. These factors contribute to Desflurane being an energy-intensive anesthetic to maintain, making its stabilization requirements expensive and environmentally impactful.

Despite its complexity of use, Desflurane is a valuable anesthetic for specific situations, justifying its continued use in the operating room. For example, despite the requirement of using a six-percent delivery to reach 1-MAC (the amount of anesthetic required to render 50% of the population under general anesthesia), Desflurane reaches its peak alveolar concentration much faster than its cousin agent, Isoflurane, making it easier to control in the patient (Butterworth et al., 2022). Desflurane's ability to reach peak concentration also results in quicker patient emergence from anesthesia compared to other volatile anesthetics (Butterworth et al., 2022).

Clinically, Desflurane has several considerations, including the onset of tachycardia in higher doses, which is thought to result from a vagolytic effect (Pardo, 2023). A positive aspect of Desflurane is its lack of interaction with the renal system. Unlike other volatile anesthetics, Desflurane does not cause an increase in serum fluoride levels, meaning it is not typically associated with adverse impacts on the renal system. The same is true for Desflurane's impact on the hepatic system, where liver failure from Desflurane is less than 1 in 1,000,000 (Pardo, 2023). Cardiovascular impacts of Desflurane are similar to those of Isoflurane, with noted vasodilation qualities and a lowering of cardiac index. However, as mentioned previously, Desflurane is seen to produce transient tachycardic episodes in higher doses administered rapidly, a characteristic not found in Isoflurane (Butterworth et al., 2022).

WHAT MAKES DESFLURANE SO HARMFUL TO THE ENVIRONMENT?

As previously discussed, Desflurane has legitimate uses in the operating room, primarily due to its ability to be controlled efficiently, thanks to its low blood/gas coefficient, resulting in faster emergence times. However, a significant drawback is its instability at low temperatures, requiring external heating for thermoregulation during anesthesia.

With an increased focus by perioperative teams worldwide on being responsible stewards of our climate, Desflurane has come under scrutiny for its significant negative impact on global warming. In 2014, Vollmer found that Desflurane accounted for a concentration of 0.30 parts per trillion in the atmosphere, as samples were taken from the northern hemisphere (American Geophysical Union, 2015). This concentration may seem small, especially when compared to the atmospheric concentration of carbon dioxide at 400 parts per million. However, it is essential to remember that despite its low atmospheric concentration, Desflurane is 2,500 times more impactful on global warming (Özelsel, Sondekoppam, & Buro, 2019).

Moreover, according to Sherman and Chesebro (2022), Desflurane's greenhouse gas emissions are 40 times greater than those of Isoflurane and Sevoflurane, partially explaining why significant levels of Desflurane were found in the atmosphere during gas sampling in 2014 in the northern hemisphere. Another concerning aspect of the harmful effects of Desflurane is its lifespan in the atmosphere. When Desflurane is evacuated from operating rooms via scavenging systems, the expelled gases do not break down quickly but remain intact in the atmosphere for years. Among the three primary ether-derived anesthetics used in the United States, Desflurane remains in the atmosphere for a minimum of ten (10) years, with some research indicating that it may persist for up to 21 years. This far exceeds the figures for Isoflurane, which has a mean of 3.6 years and a range of 3-6 years. Additionally, Sevoflurane has a mean of 1.2 years and a range of 1-5 years (Varughese & Ahmed, 2021; Yasny & White, 2012). Considering that minimal metabolism occurs when using volatile anesthetics, most of the gases used during surgery exit the patient and enter the atmosphere directly via the scavenging system. Recent advancements aimed at mitigating the impact of volatile anesthetics and reducing waste have given rise to low-flow anesthesia as a technique to minimize the adverse effects of volatile anesthetics while avoiding their complete elimination from use in anesthesia (Varughese & Ahmed, 2021).

WHAT DEFINES LOW-FLOW ANESTHESIA

At its base level, low-flow anesthesia delivers fresh gas flow below a patient's minute volume. This process of running a minimal gas flow allows for the anesthetic agent to be recycled (Honemann & Mierke, n.d.). The end goal is only to deliver the minimum needed oxygen concentration to prevent hypoxia (Upadya & Saneesh, 2018). According to GE HealthCare, to use Low-flow techniques, the fresh gas flow must be "less than half the minute ventilation of the patient, which is most often less than 3.0L/min on average in a normal adult" (GE HealthCare, 2020). This low flow aims to reduce waste and reuse the volatile anesthetic. If you recall, earlier in the article, volatile anesthetics are poorly metabolized in the body, meaning the exhalation contains nearly the same amount of anesthetics in the inspiratory phase. This process involves recycling the anesthetic agent back into the patient instead of flushing it with high-flow oxygen into the scavenger. The low-flow approach leverages the inherent chemical qualities of the agent, allowing for its reuse and minimizing its release into the atmosphere. (Honemann & Mierke, n.d.).

The benefits of low-flow anesthesia are numerous; the reduced flow results in less oxygen and volatile anesthetic waste. In fact, in states of high-flow anesthesia, rates above 5.0L/min result in wasting at least 80% of the administered volatile anesthetic (GE HealthCare, 2020). From a patient care perspective, low-flow anesthesia has several advantages, the primary being the preservation of heat and humidity, which optimizes gas exchange in the lungs and preserves the patient's temperature (Upadya & Saneesh, 2018). Within the perioperative space, low-flow anesthesia has also been found to protect clinicians by avoiding overexposure to the agents through operating room pollution. This directly impacts anesthesia technologists by limiting their exposure during maintenance phases, such as refilling the vaporizers. By utilizing low-flow anesthesia, the vaporizer needs less frequent refilling (Upadya & Saneesh, 2018). From a climate perspective, the benefits of low-flow anesthesia are apparent; recycling the volatile anesthetics sends fewer anesthetics to the atmosphere, ultimately limiting the greenhouse gases that damage the ozone layer (Upadya & Saneesh, 2018).

You may be asking yourself, hasn't low-flow anesthesia been around since the development of the circle system? The answer to this question is complex, but the answer is yes at its core. However, the complex nature of maintaining the minimum delivery of oxygen made proper low-flow anesthesia nonideal because of the constant changes in delivery for specific patients and changing conditions, coupled with complex formulas to ensure appropriate delivery. However, in recent years, anesthesia machine manufacturers have answered this problem with technological advances to make low-flow anesthesia practical and safe.

TECHNOLOGIES BEING USED TO CURB THE EFFECTS OF VOLATILE ANESTHETICS ON THE ENVIRONMENT

GE HealthCare End-tidal Control (Et Control) software

As healthcare technology continues to advance, and with a growing emphasis on reducing our carbon footprint, anesthesia machine manufacturers, anesthesia researchers, and other companies are actively developing new technologies to minimize the environmental impact of wasted anesthetic gases.

GE Healthcare, the maker of various anesthesia machines widely used across the country and holding the largest market share for anesthesia machines in the United States, is one such company dedicated to innovating its technology to mitigate the environmental effects of anesthesia.

This year, GE Healthcare partnered with the University of Michigan to upgrade the entire fleet of Aisys CS2 anesthesia machines, totaling 171 units (GE Healthcare, 2023). The objective was straightforward: integrate End-tidal control software into all machines to align with the University's long-term commitment to reduce its climate impact as part of its Green Anesthesia Initiative. The addition of this new software marks a significant step toward the University of Michigan's goal of reducing "greenhouse emissions from anesthetic gases by 80%" (UM Anesthesiology, 2022). According to GE Healthcare, the University of Michigan is the first hospital system in the United States to implement this software in its operating rooms (GE Healthcare, 2023). However, the Et Control software is not entirely new and has been widely used in Europe for over a decade (GE Healthcare, 2023).

The Et Control software is a multimodal system that enables the provider to set an end-tidal goal. The software then conducts analyses and adjusts delivery to ensure the precise administration of oxygen and volatile anesthetic (GE Healthcare, n.d.). The software relies on five safety mechanisms: Et Control Supervisor, Et Control System Check, Et Control Fresh Gas Sample Check, Et Control Increased Flow, and Et Control Auto Exit (GE Healthcare, n.d.). These five mechanisms collaborate to continuously inspect the machine for leaks and proper calibration during active use on patients (GE Healthcare, n.d.). For example, the Et Control Fresh Gas Sample Check operates in the background every three minutes, lasting approximately 13 seconds (GE Healthcare, n.d.). Additionally, if the software cannot correct any faults detected by the other four safety mechanisms, the system will automatically exit the Et Control mode using the Et Control Auto Exit mechanism (GE Healthcare, n.d.).

It is crucial for anesthesia technicians and technologists to be familiar with the five mechanisms used to ensure the system's proper operation. Additionally, they should understand how to program the system before use. When utilizing the Et Control software, the technician or technologist needs to be aware of the provider's desired End-tidal Oxygen (EtO2) value for the patient and the desired End-tidal Anesthetic Agent (EtAA) for the patient (GE Healthcare, n.d.). This is accomplished through the machine monitor, where the Et Control software is activated by selecting the start icon and then specifying the end-tidal targets on the lower portion of the screen (GE Healthcare, n.d.).

Mindray's A Series Advantage Optimizer for Low-flow Anesthesia

Similar to the GE Et Control system, the Mindray Optimizer seeks to lessen emissions and optimize the utilization of gasses via a low-flow delivery. The Optimizer can be found on the A7 and WATO EX-65 Pro anesthesia machines (Mindray North America, 2019). Unlike the GE system, the Optimizer does not have an automatic system; instead, the Optimizer uses its software to analyze the current oxygen and volatile anesthetic usage and then provides a recommended or target delivery for both anesthetic agent and fresh gas flow.

On a tangential note, the Optimizer system also provides the anesthesia team with a cost per hour, allowing the system to not only provide a reduction in emissions but also a quantifiable way of showing the low-flow systems cost savings for the institution (Mindray North America, 2019).

For the anesthesia technologist, the operations of the Optimizer are different from the GE System. However, there are some essential items to be aware of for its safe operation. In order for the Optimizer to be functional, three conditions on the machine must be met. One, the electronic flow control system (EFcs) must be active and operational. The EFcs is an electronic flowmeter system that relies on solenoids attached to sensors, whose purpose is to control the flow of gas and monitor actual flows against the desired settings. Two, the External AG module must be active and operational (Electronic Flow Control System-EFCS - Mindray WATO EX-55Pro Service Manual [Page 66], 2020). The External AG module is a system that analyzes the gases in the machine and displays the MAC value of the agent in the patient. Third, for the Optimizer to be functional, the machine must be in mechanical ventilation mode.

In most cases, if those three items are addressed, the Optimizer will function and provide recommendations for low-flow delivery. However, the system will be disabled if certain situations occur. For example, the Optimizer will not be enabled if the "circuit leak test is skipped or has failed" (Mindray North America, 2016). Furthermore, if specific alarms engage, the Optimizer will deactivate.

These alarms include:

- Apnea
- Apnea > 2 min
- Apnea CO2
- Flow Sensor Failure
- Check Flow Sensors
- Pinsp Not Achieved
- Vt Not Achieved
- Patient Circuit Leak
- The CO2 Absorber Canister not Locked
- Ventilator Comm Stop
- Drive Gas Pressure Low
- AG Hardware Error
- External AG Self-Test Error
- AG Hardware Malfunction
- AG Init Error
- AG No Water trap
- AG Change Water trap
- AG Comm Stop
- AG Airway Occluded
- AG Zero Failed
- External AG Module Disconnected
- Incompatible AG Software Version

In summary, the Mindray Optimizer allows clinicians to optimize volatile anesthetics without complex calculations to meet the patient's metabolic demands.

EMERGING TECHNOLOGIES FOR CONTROLLING VOLATILE ANESTHETICS

While low-flow anesthesia and the software developed by machine manufacturers have provided the most streamlined approach to prevent the excessive release of greenhouse gases, other emerging technologies may find their way into operating rooms in the coming years. One such technology, similar to low-flow, relies on older concepts to address wasted gases, specifically absorption (Ang et al., 2019). When we think of anesthetic absorption, we often associate it with charcoal filters used for malignant hyperthermia. However, activated charcoal is being explored as a method for absorbing anesthetics in non-emergency situations. Another example of absorption technology being deployed is Deltasorb. Similar to a carbon dioxide absorber, Deltasorb operates through filtration to capture the anesthetic agent. The agent is subsequently re-liquified and stored for recycling later (Wasiwicz, Grewal, 2016; Yasny & White, 2012).

CONCLUSIONS

The past few decades have seen a global shift towards addressing climate change, resulting in various industries adapting their practices to reduce CO2 emissions. Within the perioperative environment and anesthesia, a concerted focus has been on limiting the greenhouse effect of volatile anesthetics. As global temperatures rise from rising carbon dioxide levels and other greenhouse gases, a closer look at limiting the negative impact of volatile anesthetics on the environment is warranted.

Desflurane, despite its clinical benefits, poses significant challenges due to its disproportionate impact on global warming. Fortunately, technological advances identified safe ways to utilize this gas, most notably in low-flow anesthesia.

As the healthcare industry continues to address climate change, these technological advancements and shifting practices reflect a shared commitment to environmental responsibility.

FIGURES

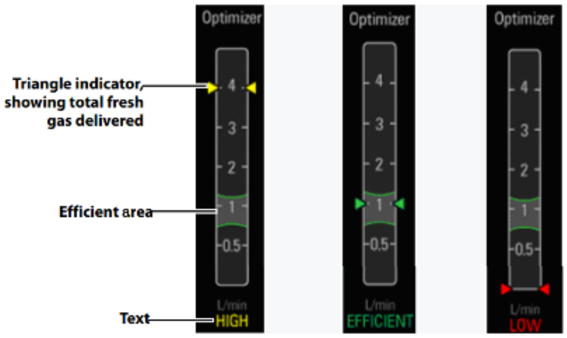


FIGURE 3-19 OPTIMIZER® Indication States

Mindray North America A7 Instruction Manual

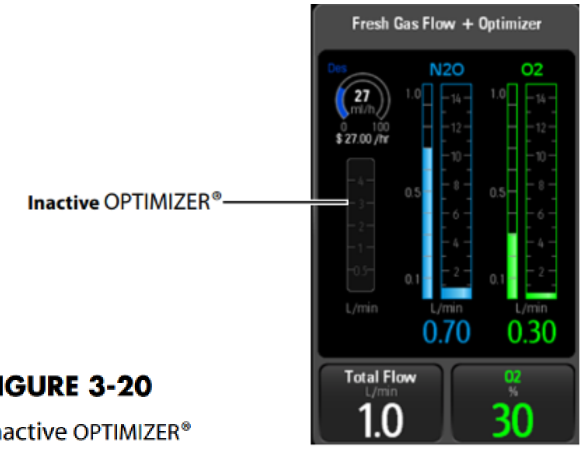
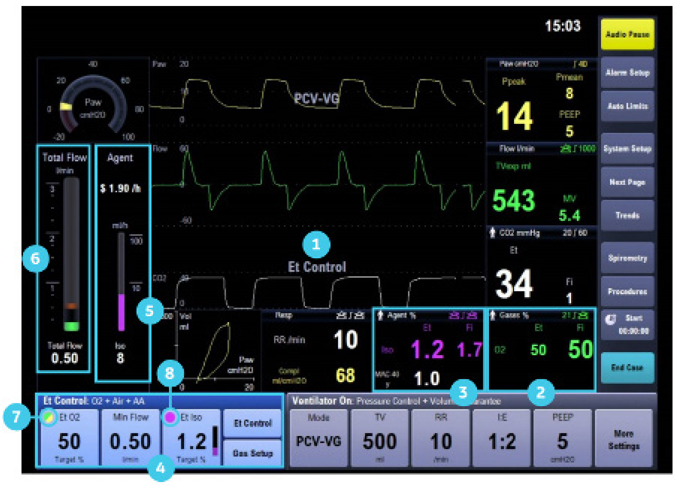


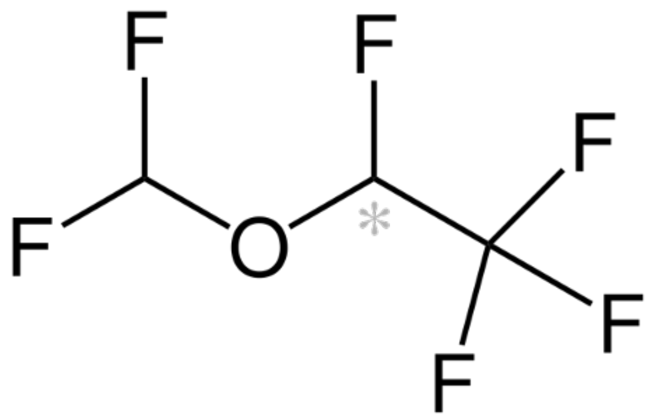
FIGURE 3-20

Inactive OPTIMIZER®

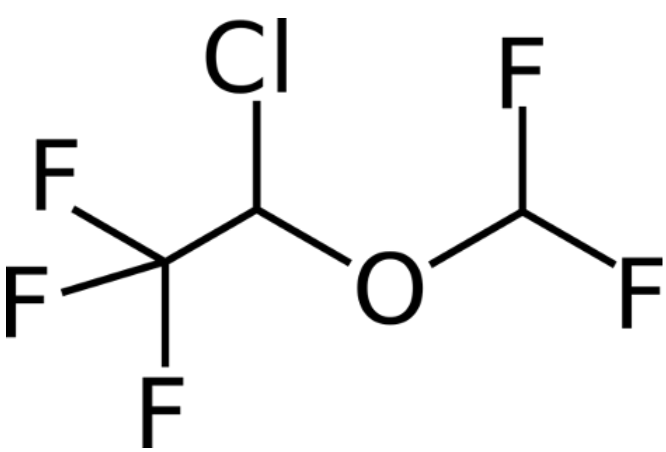
Mindray North America A7 Instruction Manual



GE HealthCare ET Control Module



Desflurane Chemical Structure – public domain



Isoflurane Chemical Structure – Public Domain

Creative Commons

References

Ang, T. N., Baroutian, S., Young, B. R., Hyland, M. M., Taylor, M., & Burrell, R. (2019).

Adsorptive separation of volatile anaesthetics: A review of current developments. Separation and Purification Technology, 211, 491-503. **https://doi.org/10.1016/j.seppur.2018.10.012**

American Geophysical Union. (2015, April 7). *Anesthetic gases raise Earth's temperature (A little) while you sleep.* Phys.org. **https://phys.org/news/2015-04-anesthetic-gases-earth-temperature.html**

Butterworth, J. F., Mackey, D. C., Wasnick, J. D., Morgan, G. E., & Mikhail, M. S. (2022). *Morgan & Mikhail's clinical anesthesiology* (7th ed.). McGraw Hill.

DeWitt, E. (2023, September 25). *UPMC to cease use of environmentally harmful anesthetic by end of 2023.* UPMC & Pitt Health Sciences News Blog. **https://inside.upmc.com/upmc-to-cease-use-of-environmentally-harmful-anesthetic-by-end-of-2023/**

GE HealthCare. (n.d.). *Aisys CS2 end-tidal control software. ge monogram primary white RGB.* **https://www.gehealthcare.com/products/anesthesia-delivery/aisys-cs2/end-tidal-control?utm_medium=cpc&utm_source=google&utm_campaign=USC-PS-REG-AlwaysOn&utm_term=&utm_content=12518725892&npclid=Cj0KCQiAo7KqBhDhARIsAKhZ4uiwF2Kh7qEsGZa76okWt8oF2pgznZSgWDfu--88Tz0hypSHlRNrWW8aAkYYEALw_wcB&gad_source=1&gclid=Cj0KCQiAo7KqBhDhARIsAKhZ4uiwF2Kh7qEsGZa76okWt8oF2pgznZSgWDfu-88Tz0hypSHlRNrWW8aAkYYEALw_wcB**

GE HealthCare. (n.d.-a). *Aisys CS2 anesthesia delivery system - GE healthcare.* **https://www.gehealthcare.com/-/jssmedia/gehc/us/images/products/anesthesia-delivery/aisys-cs2/redesign/aisys_cs2_etc_faqs__global_jb00077xx_v4.pdf?rev=-1**

Heron, R. (2023, January 25). *We're saying goodbye to Desflurane for good!* Care Without Carbon. Working towards a greener, Net Zero Carbon NHS. **https://carewithoutcarbon.org/whats-new/medicines-medical-gases/were-saying-goodbye-to-desflurane-for-good#:~:text=Desflurane%20is%202500%20times%20more,to%20driving%20only%20700%20miles**

Honemann, C., & Mierke, B. (n.d.). *Low-flow, minimal-flow and metabolic-flow anaesthesia clinical* ... Low-flow, minimal-flow and metabolic-flow anaesthesia Clinical techniques for use with rebreathing systems. **https://www.draeger.com/Content/Documents/Products/low-minimal-flow-anaesthesie-bk-9067990-en.pdf**

Pardo, M. C. (2022). Miller's Basics of Anesthesia (8th ed.). Elsevier - OHCE. **https://bookshelf.health.elsevier.com/books/9780323796798**

Yasny, J. S., & White, J. (2012). Environmental implications of anesthetic gases. *Anesthesia progress*, 59(4), 154–158. **https://doi.org/10.2344/0003-3006-59.4.154**

Varughese, S., & Ahmed, R. (2021). Environmental and Occupational Considerations of Anesthesia: A Narrative Review and Update. *Anesthesia and analgesia*, 133(4), 826–835. **https://doi.org/10.1213/ANE.0000000000005504**

Upadya, M., & Saneesh, P. J. (2018). Low-flow anaesthesia - underused mode towards "sustainable anaesthesia". *Indian journal of anaesthesia*, 62(3), 166–172. **https://doi.org/10.4103/ija.IJA_413_17**

Mindray North America. (2019). A Series Advantage Optimizer. **https://www.mindraynorthamerica.com/wp-content/uploads/2019/05/Optimizer-product-sheet_1627revA.pdf**

Mindray North America. (n.d.) Operating Instruction: A7. **https://mindraynorthamerica.com/cmsAdmin/uploads/h-046-004667-00-a7-operating-instructions-12-0.pdf**

NHS England. (n.d.). NHS choices. **https://www.england.nhs.uk/greenernhs/whats-already-happening/nhs-organisations-cut-desflurane-in-drive-for-greener-surgery/#:~:text=At%20least%2040%20NHS%20organisations,Officer%20for%20the%20NHS%2C%20Dr**

Electronic Flow Control System-EFCS - Mindray WATO EX-55Pro Service Manual [Page 66] (2020, August 30). ManualsLib. **https://www.manualslib.com/manual/1867426/Mindray-Wato-Ex-55pro.html?page=66**

Özelsel, T. J. P., Sondekoppam, R. V., & Buro, K. (2019). The future is now—it's time to rethink the application of the Global Warming Potential to anesthesia. Canadian Journal of Anesthesia/Journal canadien d'anesthésie, 66, 1291–1295. **https://doi.org/10.1007/s12630-019-01385-w**

Wong, K., Wasowicz, M., Grewal, D., et al. (2016). Efficacy of a simple scavenging system for long-term critical care sedation using volatile agent-based anesthesia. Canadian Journal of Anesthesia/Journal canadien d'anesthésie, 63, 630–632. **https://doi.org/10.1007/s12630-015-0562-1**

Take the QUIZ on the next page!

Continuing Education Quiz

To test your knowledge on this issue's article, provide correct answers to the following questions on the form below. Follow the instructions carefully.

GE Et Control:

1. **What does GE Healthcare's End-tidal Control (Et Control) software aim to achieve?**
   A) To increase gas flow.
   B) To reduce environmental impact.
   C) To induce hypoxia.
   D) To enhance patient sedation.

2. **What safety mechanisms does the Et Control software rely on?**
   A) Et Control Fresh Gas Sample Check.
   B) Increased Flow Auto Exit.
   C) Et Control Increased Pressure.
   D) Et Control Temperature Adjustment.

3. **Which institution was the first in the United States to implement GE Healthcare's Et Control software?**
   A) National Health Service (NHS).
   B) University of Pittsburgh Medical Center (UPMC).
   C) University of Michigan.
   D) American Geophysical Union.

4. **What is the main function of the Et Control Fresh Gas Sample Check?**
   A) Monitoring patient vital signs.
   B) Analyzing the machine for leaks.
   C) Adjusting gas flow.
   D) Regulating temperature.

5. **Why is the Et Control software considered a significant step in reducing environmental impact?**
   A) It increases gas emissions.
   B) It enhances patient sedation.
   C) It aligns with a commitment to reduce greenhouse emissions.
   D) It operates manually.

Mindray Optimizer:

6. **What is the Mindray Optimizer designed to optimize?**
   A) Gas flow in the atmosphere.
   B) Emissions of Sevoflurane.
   C) Volatile anesthetics and oxygen usage.
   D) End-tidal Carbon Dioxide (EtCO2) levels.

7. **What information does the Mindray Optimizer provide to the anesthesia team?**
   A) Patient heart rate.
   B) Cost per hour of low-flow anesthesia.
   C) Surgical duration.
   D) Atmospheric pressure.

8. **Which conditions must be met for the Mindray Optimizer to be functional?**
   A) Patient must be in a supine position.
   B) Apnea alarms must be activated.
   C) External AG module must be active.
   D) Ventilator must be in standby mode.

9. **How does the Optimizer differ from the GE Et Control system?**
   A) It uses a manual system.
   B) It does not have safety mechanisms.
   C) It provides cost savings calculations.
   D) It requires high-flow anesthesia.

10. **What happens if the circuit leak test is skipped or fails in the Mindray Optimizer system?**
    A) The system operates normally.
    B) The Optimizer provides an error message.
    C) The system switches to high-flow anesthesia.
    D) The Optimizer deactivates.

Continuing Education Quiz

To apply for Continuing Education/ Contact Hours:

1) Provide all the information requested on this form.

2) Provide correct answers to this issue's quiz in the box to the right

3) Mail this form along with $10 Member or $20 Non-Member *(check or money order, payable to ASATT) to:*
ASATT
6737 W Washington St, Ste 4210
Milwaukee, WI 53211

The answers to the Winter 2023 "Combating the Negative Impacts of Volatile Anesthetic" Quiz 2 are: (circle answers)

1.	A	B	C	D	6.	A	B	C	D
2.	A	B	C	D	7.	A	B	C	D
3.	A	B	C	D	8.	A	B	C	D
4.	A	B	C	D	9.	A	B	C	D
5.	A	B	C	D	10.	A	B	C	D

Quiz 2

Name: ______________________________

ASATT Number: ______________________________

Street Address: ______________________________

____

Phone Number: ______________________________

City: ____________________ State: ________ Zip: ____________

Signature: ____________________ Date: ____________

SUBMISSIONS FOR THIS ISSUE'S QUIZ EXPIRE **DECEMBER 31, 2024.**
ACHIEVE 80% IN THIS QUIZ TO EARN ONE (1) CONTINUING EDUCATION CREDIT.