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An Update on the Perioperative Considerations for COVID-19 Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2)

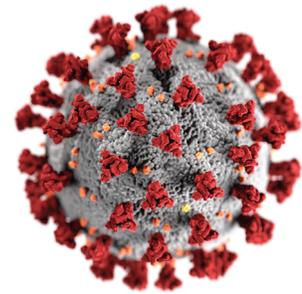
by Liana Zucco, MD; Nadav Levy, MD; Desire Ketchandji, MD; Michael Aziz, MD; and Satya Krishna Ramachandran, MD

INTRODUCTION

The COVID-19 pandemic caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) continues to have a profound impact on life across the globe and has placed an enormous strain on health care systems and economies, including with likely untold psychological and social implications. The outbreak of SARS-CoV-2, which originated in Wuhan, China, rapidly progressed to become a pandemic and has now spread to over 150 countries, infecting

over 3.1 million people, as of April 29, 2020, with over 1 million cases in the United States alone.^{1,2}

Current estimates suggest a fatality rate ranging from 2 to 20% for hospitalized patients, and up to 88% for those requiring mechanical ventilation.^{3–5} SARS-CoV-2 has an estimated basic reproductive number (R0) of 2.2–2.7,⁶ which means a single infected person has the potential to spread infection to more than 2 susceptible individuals. This can lead to rapid, exponential spread, which we have now seen within communities across the US.⁷



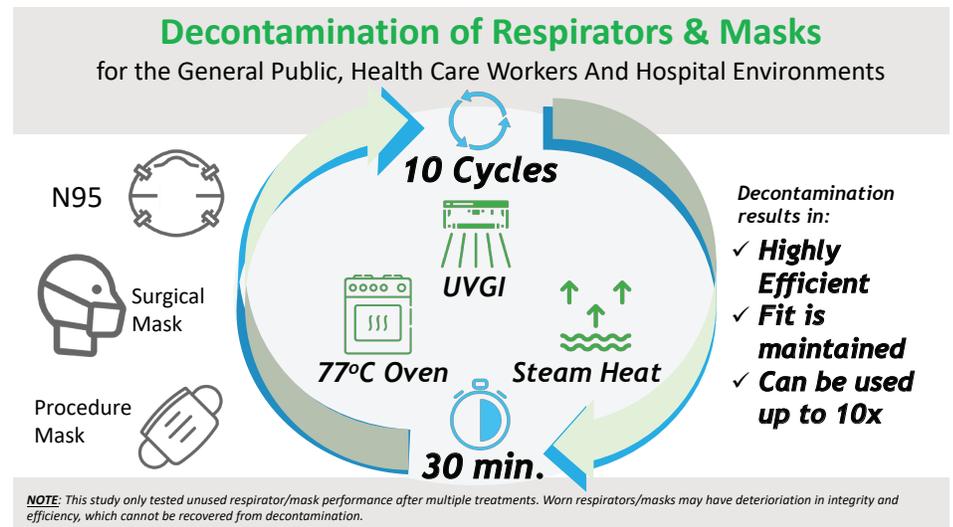
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ORIGINAL WORK

COVID-19 Pandemic—Decontamination of Respirators and Masks for the General Public, Health Care Workers, and Hospital Environments

by Qisheng Ou, PhD; Chenxing Pei; Seong Chan Kim, PhD; Kumar Belani, MD; Rumi Faizer, MD; John Bischof, PhD; and David Y. H. Pui, PhD

There is a serious shortage of respirators and masks that are essential for the protection of frontline health care workers and for the mitigation of community transmission during this COVID-19 pandemic.¹ Reuse of disposable filtering facepiece respirators and surgical masks after decontamination has become a necessary strategy.^{2,3} We provide here scientific data to support the use of three decontamination methods.



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NEW

Guide for Authors

The *APSF Newsletter* is the official journal of the Anesthesia Patient Safety Foundation. It is widely distributed to a variety of anesthesia professionals, perioperative providers, key industry representatives, and risk managers. Therefore, we strongly encourage publication of those articles that emphasize and include the multidisciplinary, multiprofessional approach to patient safety. It is published three times a year (February, June, and October). **Deadlines for each issue are as follows: 1) February Issue: November 15th, 2) June Issue: March 15th, 3) October Issue: July 15th.** The content of the newsletter typically focuses on anesthesia-related perioperative patient safety. Decisions regarding content and acceptance of submissions for publication are the responsibility of the editors. Some submissions may go in future issues, even if the deadline is met. At the discretion of the editors, submissions may be considered for publication on our APSF website and social media pages. Articles submitted that are not in accordance with the following instructions may be returned to the author prior to being reviewed for publication.

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2. Q&A articles are submitted by readers regarding anesthesia patient safety questions to knowledgeable experts or designated consultants to provide a response. The articles should be limited to 750 words.
3. Letters to the editor are welcome and should be limited to 500 words. Please include references when appropriate.
4. Rapid Response (to questions from readers), formerly known as, "Dear SIRS," which was the "Safety Information Response System," is a column that allows for expeditious communication of technology-related safety concerns raised by our readers, with input and response from manufacturers and industry representatives. Dr. Jeffrey Feldman, current chair of the Committee on Technology, oversees the column and coordinates the readers’ inquiries and the response from industry.
5. Invited conference reports summarize clinically relevant anesthesia patient safety topics based on the respective conference discussion. Please limit the word count to less than 1000.

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2. Please define all abbreviations.
3. Please use generic drug names.
4. Please be aware of HIPAA and avoid using patient names or personal identifiers.
5. Plagiarism is strictly prohibited.

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Lessons Learned from Current and Past Viral Outbreaks

From “COVID-19 Perioperative Considerations,” Cover Page

Given the capacity for human-to-human transmission,^{8–10} SARS-CoV-2 continues to pose a high risk to all health care professionals in the perioperative setting. **We implore perioperative and hospital leaders to develop strategic steps for interventions on patients who have suspected or confirmed COVID-19 infection.** The purpose of this communication is to present prudent safety measures in the perioperative setting, recognizing that these measures are based on learning from the current outbreak as well as from previous viral outbreaks.¹¹ Specifically, we address those measures which resulted in the success or failure of curtailing transmission of viral pathogens (SARS-CoV-2, SARS-CoV, and Middle Eastern Respiratory Syndrome Coronavirus [MERS-CoV]) in health care settings. While nonpharmacological interventions remain the mainstay in curtailing the spread of disease, global experiences highlight the prominent role of prompt public health measures in combating a pandemic of this magnitude.

SARS-COV-2 PATHOGEN TRANSMISSION

Pathogen transmission can occur between humans via inhalation of infected respiratory droplets, in particular if the exposure of droplets is within close proximity (6 feet) or if you are in a relatively closed-off environment with continuous exposure to high aerosol counts.^{12,13} Transmission can also occur through close contact, either directly or indirectly, with mucous membranes (i.e., eyes, nose, mouth) and through the digestive tract.^{12,14} There is now evidence to suggest that transmission may occur from direct or indirect contact with contaminated surfaces (fomites) and this may predispose to subsequent self-inoculation and/or transmission. Similar to other coronaviruses, SARS-CoV-2 is able to survive outside the body for approximately 12 hours (fabrics, cardboard surfaces) and up to 72 hours (plastic or metal surfaces).^{11,15,16}

Preventing transmission of the SARS-CoV-2 remains the most effective public health effort to lessen its impact. This effort involves rapid identification of cases, tracing of contacts, isolation/quarantine of infected/exposed individuals, and supportive care. **We recognize the perioperative setting as a site for possible unrecognized exposure to SARS-CoV-2; therefore, hospital-wide guidelines should be available for health care professionals to manage exposure and implement measures to mitigate transmission.**



Recommendations for Airway Management in a Patient with Confirmed or Suspected COVID-19 Infection

YOUR personal protection is **THE** priority. Personal protective equipment (PPE) should be available for all providers to ensure droplet/contact isolation precautions can be achieved. Review protocols for donning and doffing PPE. Careful attention is required to avoid self-contamination.

Patients with confirmed or suspected COVID-19 infection:

- Should **NOT** be brought to holding or PACU areas
- Should be managed in a **designated OR**, with signs posted on the doors to minimize staff exposure.
- Should be **recovered in the OR** or **transferred to ICU** into a negative pressure room.
- Should have a high-quality HME (heat and moisture exchanging) filter, rated to remove at least 99.97% of airborne particles 0.3 microns or greater, placed between the ETT and circuit/reservoir bag at all times.

Plan ahead:

- For time to allow all staff to apply PPE and barrier precautions
- Consider intubation early to avoid the risk of a crash intubation when PPE cannot be applied safely.

During Airway Manipulation



Apply:

- PPE: N95 mask (or equivalent), eye protection or a face shield, an impermeable fluid resistant gown, disposable head cover, protective footwear, and **2 sets of gloves**.
- Standard ASA monitoring should be applied before induction of anesthesia.

Assign:

- The most **experienced** anesthesia professional available to perform intubation, if possible. Avoid trainee intubation for sick patients.

Discuss:

- The plan for an unanticipated difficult intubation and ensure that desired **rescue equipment** is immediately available, including a supraglottic airway and a surgical airway kit.

Avoid:

- Awake fiberoptic intubation, unless specifically indicated. Atomized local anesthetic will aerosolize the virus. Consider alternate topicalization methods if indicated.

Prepare to:

- Preoxygenate for 5 minutes with 100% FiO₂, or until a desired target EtO₂ is achieved.
- Use equipment most familiar to the intubator; a **video-laryngoscope** is recommended as the primary intubating device to improve intubation success.

Perform a Rapid Sequence Intubation (RSI):

- Perform a RSI to avoid manual ventilation of patient's lungs and potential aerosolization of virus from airways.
- Depending on the clinical condition, the RSI may need to be modified.
- If manual ventilation is required, apply small tidal volumes, ensure an HME filter is in place.
- Immediately post intubation, inflate the ETT cuff **before** applying positive pressure ventilation

Ensure:

- A high quality HME filter is in place between the ETT/facemask and breathing circuit/reservoir bag at all times

Dispose:

- Resheath the laryngoscope immediately post intubation (**double glove technique**) or place within sealed bag. Seal all used airway equipment in a double zip-locked plastic bag. It must then be removed for decontamination and disinfection.

Extubation:

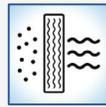
- Should occur under strict adherence to PPE. Consider the use of a protective cloth barrier to cover the mouth during extubation. Carefully dispose of contaminated equipment.

Remember:

- After removing protective equipment, avoid touching hair or face before washing hands.

Track:

- Symptoms of health care providers involved in airway manipulation, consider using an online registry such as IntubateCOVID at <https://intubatecovid.knack.com/registry#add-intubation/>



Updated May 12, 2020

Recommendations for COVID-19 Patient Airway Management

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Lessons Learned from Previous Coronavirus Outbreaks (SARS-CoV, MERS)

We learned from the Toronto SARS-CoV outbreak in 2002 and the MERS-CoV outbreak in 2012 that the majority of cases were associated with nosocomial transmission, in particular amongst health care workers (HCWs) exposed to aerosol-generating procedures.¹⁷ Despite existing safety protocols, confirmed SARS-CoV infection of HCWs was associated with the intubation of a confirmed SARS-CoV infected patient in the ICU, if more than one attempt at intubation was required or when more than three people were in the room.¹⁸ Additional risk factors included patient contact during aerosolizing procedures including via nebulizers, CPAP, BiPAP, or high flow nasal oxygen therapy.¹¹ However, improved measures and adherence to PPE reduced nosocomial transmission during the second wave of the SARS-CoV outbreak in Toronto. More recent data suggest high flow nasal oxygen may not augment aerosol spread during spontaneous coughing in healthy volunteers.¹⁹

Lessons Learned from the Current Outbreak (SARS-CoV-2):

Experience from China, Italy, the United Kingdom, and the United States makes it abundantly clear that community transmission is responsible for the majority of infected patients.¹ Disease prevalence remains high in various parts of the country, with a lack of widely available and reliable testing posing a risk of nosocomial transmission in the perioperative setting. The period immediately prior to symptom onset is associated with SARS-CoV-2 viral shedding and represents a considerable transmission potential, further implicating all (asymptomatic) patients as an additional risk.^{20,21} **To protect and ensure the safety of HCWs, and by extension, patients, preventing nosocomial transmission of SARS-CoV-2 requires a coordinated effort and complete organizational support.**²²

Due to the rapid spread of COVID-19, the ability of health care organizations to prepare for increasing admissions and implement risk mitigation strategies has been time-pressured. Anxiety and fear placed additional pressure on providers, in particular due to concerns of inadequate supplies of personal protective equipment (PPE) and a lack of clarity of information or unified thinking amongst leaders. We've learned that discordant messages cause confusion, create tension, and slow protocol implementation. Furthermore, keeping up with rapidly changing guidelines and communicating them clearly to an entire organization is challenging. **We recom-**

mend a unified approach to supporting and communicating with members of staff within your organization.

Pathogen Transmission in the OR and Around the Anesthesia Work Environment

Within the operating room (OR), the anesthesia work environment allows for numerous surfaces that can harbor droplets, thus serving as reservoirs for the virus if proper droplet precautions or proper decontamination processes are not followed. As noted previously, processes that favor aerosolization of sputum an infected individual in the perioperative setting represents a potential source of exposure to HCWs. For the anesthesia professional and intensivist, attention should be given to the time periods during intubation and extubation, as these represent the highest risk of exposure and involve direct contact with respiratory droplets during airway management.^{23,24}

Areas immediately outside the OR and around the operating department complex represent low-risk areas with regards to aerosol generation, but may still be potential sources for transmission. Irrespective of location, inadequate PPE, improper use of PPE, and poor hand hygiene are potential factors that can lead to transmission to the bedside HCW.^{25,26}

RECOMMENDATIONS FOR THE PERIOPERATIVE PRACTICE OF ANESTHESIA IN PATIENTS WITH COVID-19

Due to the potential for transmission of SARS-CoV-2 in asymptomatic patients and HCWs, we recommend an escalation of standard practice during the perioperative management of all patients to reduce exposure to secretions.

Hand Hygiene:

Frequent hand washing is one of the most important hygiene measures to protect against cross infection and must be actively enforced. Alcohol-based hand wash gels should be located on or near every anesthesia workstation. Hand hygiene (HH) should be meticulously performed according to standard guidelines, specifically after removing gloves; after contact with soiled or contaminated areas; before touching the anesthesia machine, the anesthesia cart or its contents; and after every contact with the patient (e.g., placement of thermometer, nasogastric tube).

Personal Protective Equipment:^{22,27,28}

Personal protective equipment should be available for all providers and should include an N95 respirator (or equivalent) or a powered air-purifying respirator (PAPR), eye protection such as goggles or a face shield, a disposable head

cover, an impermeable fluid-resistant gown, shoe covers, and two sets of gloves. Disposable OR caps reduce the risk of contaminating hands by touching hair which may have been exposed to droplets. **Hand washing is essential before donning and after doffing of PPE.**

N95 masks fulfill the filtering efficiency criteria of the National Institute for Occupational Safety and Health (NIOSH) and are approved for protection against droplet and airborne transmission of 95% of particles greater than 0.3 microns in size. N95 masks, which must be fit tested, offer protection against the contact and droplet spread of the coronavirus. Alternatively, a PAPR may be used instead of an N95 respirator. This provides equivalent protection to an N95, but may offer greater versatility for use across various face sizes, in the presence of facial hair, or in multiple-use scenarios. Bear in mind that a PAPR may be more cumbersome to don and doff without self-contamination, and therefore, careful observation by a colleague may mitigate this risk. **At a minimum, N95 respirators or their equivalent should be used for all known or suspected cases of COVID-19.**

Providers and their organizations should review protocols for correct donning and doffing of PPE. Consider conducting mock intubation/extubation drills using PPE in a real environment (*in situ*). This is an opportunity to promote correct use of PPE among providers and to identify barriers to adherence. Consideration at the organization level should be taken to avoid “rescue like” crash intubations where PPE cannot be fully adhered to.

Airway Manipulation (Intubation and Extubation):

Prior to exposure to an aerosolizing procedure or airway management, HCWs should protect themselves by donning the appropriate PPE, described above. During intubation and extubation, limit the number of staff members present inside the room to reduce the risk of unnecessary exposure, unless staff members are donned in the appropriate PPE. Ensure that a plan for an unanticipated difficult airway has been discussed and the desired rescue equipment is immediately available, including a supraglottic airway and a surgical airway kit.

Prepare intubating equipment in close proximity to the patient, and plan for its disposal in a manner that limits the distance of travel of contaminated equipment. Consider using the double gloving technique during intubation, sheathing the laryngoscope blade with your outer gloves immediately following intubation.

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Recommendations for COVID-19 Patient Airway Management

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Alternatively, place the used laryngoscope directly into a sealed bag and then remove your outer layer of gloves.²⁵

Extubation often results in greater aerosol generation compared to intubation and should be performed with strict adherence to PPE, as described above. Ensure that other HCWs in the room (e.g., respiratory therapist and nurse) also wear PPE. Consider the use of gauze or a protective cloth barrier to cover the mouth and nose during extubation. Carefully dispose of contaminated equipment. Strongly consider prophylactic antiemetics to reduce the risk of vomiting and possible viral spread.

Perioperative Workflow Planning and Simulation Training:

Review the need for specific perioperative workflows for the management of COVID-19 patients within your organization.²⁹ This may require workflow redesign, checklist implementation, and testing in real time to reveal hazards or gaps in care. Designate specific ORs for COVID-19 patients and minimize contamination by removing unneeded contents and applying plastic coverings to nonmobile equipment. We recommend team training through *in-situ* simulation drills to promote awareness of perioperative changes for COVID-19 patients and encourage the development of a shared mental model amongst health care teams.³⁰ Simulation training in donning and doffing PPE, intubating, extubating, and managing an adverse event in a COVID-19 patient is also recommended. Some of the authors' institutional online resources are available at: https://www.anesthesiaeducation.net/qs_i_covid19/.

RECOMMENDATIONS FOR AIRWAY MANAGEMENT IN A PATIENT WITH SUSPECTED OR CONFIRMED CORONAVIRUS (SARS COV-2) INFECTION

General Precautions:

1. Your personal protection is the priority. Personal protective equipment (PPE) should be available to all providers to ensure airborne/droplet/contact isolation precautions can be achieved. Review protocols for donning and doffing PPE. Plan ahead in order to allow sufficient time for staff to apply PPE and barrier precautions. Careful attention is required to avoid self-contamination.
2. Confirmed or suspected SARS CoV-2 infected cases should NOT be brought to holding or PACU areas. A designated OR should be allocated for such cases and signs posted on the doors to minimize staff exposure.



Infected cases should be recovered in the operating room or transferred to ICU into a negative pressure room. Have a clamp ready for circuit disconnections.

3. Ensure that sufficient equipment for airway manipulation and contingencies are available. In addition, make sure that a high quality HME (Heat and Moisture Exchanging) filter, rated to remove at least 99.97% of airborne particles 0.3 microns or greater, and an endotracheal tube-clamp are available before proceeding with intubation.

During Airway Manipulation:

4. Apply a fit-tested disposable N95 respirator, PAPR, or an equivalent mask, eye protection, gown, 2 sets of gloves, and protective footwear. Apply standard monitoring to the patient, as you would for any induction of anesthesia.
5. Designate the most experienced anesthesia professional available to perform intubation, if possible. Avoid trainee intubations of suspected or confirmed SARS CoV-2 infected cases during this time.
6. Discuss the plan for an unanticipated difficult airway and ensure that desired rescue equipment is immediately available, including a supraglottic airway and a surgical airway kit.
7. Avoid awake fiberoptic intubations unless specifically indicated. Atomized local anesthetic will aerosolize the virus, so alternate topicalization techniques should be used if this procedure is indicated. Use equipment most familiar to the intubator; a video-laryngoscope is recommended as the primary intubating device to improve intubation success.³¹

8. Preoxygenate for a minimum of 5 minutes with 100% oxygen, or until a desired target end tidal O₂ is achieved.
9. Perform a rapid sequence induction (RSI) in order to avoid manual ventilation of patient's lungs. Ensure a skilled assistant is available to perform cricoid pressure. If manual ventilation is required during a modified RSI, apply small tidal volumes, ensuring an HME filter is in place.
10. Immediately following intubation, inflate the ETT cuff, before applying positive pressure ventilation.
11. Ensure the placement of a high quality HME filter between the facemask/endotracheal tube and breathing circuit or reservoir bag at all times.
12. Resheath the laryngoscope immediately post intubation or place within a sealed specimen bag. Seal all used airway equipment in a double zip-locked plastic bag. The used airway equipment must then be removed for decontamination and disinfection.
13. Extubation should occur under strict adherence to PPE. Consider the use of a protective cloth barrier to cover the mouth and nose during extubation. Carefully dispose of contaminated equipment.
14. After removing protective equipment, remember to avoid touching your hair or face before washing hands.
15. Consider tracking symptoms in health care workers involved in airway manipulation of a

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Recommendations for Resuming Elective Perioperative Services

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COVID-19 patient, at a local level or using an online platform such as the <https://intubate-covid.org> registry.

Recommendations for Resuming Nonurgent or Elective Perioperative Services

As health systems begin planning to resume nonurgent operative cases, and subsequently, elective cases with ongoing flattening of the SARS-CoV2 infection curve, it remains critical to continue to adhere to the highest evidence-based standards, from local, national, and international guidelines, in order to protect patients and HCWs. Resurgence of COVID-19 remains a strong possibility and concern for a multitude of reasons, including variations in testing availability, lack of clarity on immunity conferred by prior exposure, prevalence of disease, etc.³² Therefore, the need for ongoing surveillance, with emphasis on continuous public efforts, should be encouraged.

In anticipation of reopening nonurgent/elective perioperative services, we recommend careful institutional planning with a slow, phased resumption of nonurgent cases, as suggested in the Joint Statement from the American College of Surgeons (ACS), American Society of Anesthesiologists (ASA), American Hospital Association (AHA), and Association of Perioperative Registered Nurses (AORN) ([Roadmap for Resuming Elective Surgery after COVID-19 Pandemic](#)).³³ Institutional policies and workflows for resuming nonurgent/elective cases should take into consideration testing availability, local disease prevalence, surgical procedure and indication, hospital and ICU capacity, and staffing requirements. Physical workspaces should be mapped out to optimize patient and provider distancing. Provisions should continue to be made for ongoing staff training and support for the overall hospital response to COVID-19.³⁴ In accordance with the joint statement above, we advocate for a phased approach to resuming medically indicated, time-sensitive surgeries.^{34–36} We favor policies and protocols that prioritize patients’ clinical needs and organizational capacity as a way to mitigate the competition for limited operating capacity.

The cornerstone of risk management during pandemic recovery will remain symptom-based preoperative screening. Most hospitals have a dedicated service to ensure that symptom-positive patients have a clear pathway for delaying surgery and follow-up in 14 days where possible.



Recommendations for Preoperative Testing

Preoperative testing is being implemented across the world with three main goals. They are

- Delay elective surgery in patients who are either symptomatic or test positive.
- Trigger perioperative protocols for the appropriate care of suspected or confirmed COVID-19.
- Guide appropriate use of PPE and perioperative care protocols.

We support the recommendations issued in a joint statement by the ASA and APSF ([ASA and APSF Joint Statement on Perioperative Testing for the COVID-19 Virus](#)).³⁷ A population risk assessment identifying the prevalence of SARS-CoV-2 should be reviewed.

When There is Local or Regional Presence of SARS-CoV-2:³⁸

1. All patients should be screened for symptoms prior to presenting to the hospital. Patients reporting symptoms should be referred for additional evaluation. All other patients should undergo nucleic acid amplification testing (including PCR tests) prior to undergoing non-emergent surgery. Health care systems may consider encouraging patients to self-isolate pending testing results.
2. Because false negatives may occur with testing, droplet precautions (surgical mask and eye covering) should be used by OR staff for operative cases. Before performing an aerosol-generating procedure, health care providers within the room should wear an N95 mask, eye protection, gloves, and a gown.
3. If a patient tests positive for SARS-CoV-2, elective surgical procedures should be delayed until the patient is no longer infectious and has demonstrated recovery from COVID-19. A patient may be infectious until either:

a. CDC-recommended test-based strategy

- i. Resolution of fever without the use of fever-reducing medications
- ii. Improvement in respiratory symptoms
- iii. Negative results from two SARS-CoV-2 tests ≥ 24 hours apart

b. CDC non-test-based strategy

- i. At least 72 hours since resolution of fever, without the use of fever-reducing medications, and improvement in respiratory symptoms
 - ii. At least 7 days since symptoms first appeared.
4. Recommendations regarding the definition of sufficient recovery from the physiologic changes from SARS-CoV-2 cannot be made at this time; however, evaluation should include an assessment of the patient’s exercise capacity (metabolic equivalents or METS).

When There is Little or No Regional Presence of SARS-CoV-2:

1. All patients should be screened for symptoms before presenting to the hospital.
2. Patients reporting symptoms should be referred for further evaluation.

COMMENT

Without any current vaccinations or proven pharmacological interventions, we recommend continuous emphasis on public health efforts and nonpharmacological interventions endorsed by the Center for Disease Control (CDC), World Health Organization (WHO), and local state governments. We also advocate for the continuous leveraging of technology (telemedicine) in the perioperative setting to facilitate adequate social distancing and mitigate nosocomial transmissions.³⁹

See “COVID-19 Perioperative Considerations,” Next Page

COVID-19 Perioperative Considerations References (Cont)

From "COVID-19 Perioperative Considerations," Previous Page

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Drs. Zucco, Levy, Ketchandji and Aziz have no conflicts of interest. Dr. Ramachandran receives personal fees from Fresenius Kabi USA (scientific advisor).

REFERENCES

- World Health Organization (WHO). Coronavirus disease situation reports. 2020. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/>. Accessed April 29, 2020.
- John Hopkins University. COVID-19 Dashboard by the Centre for Systems Science and Engineering. Coronavirus Resource Center. <https://coronavirus.jhu.edu/map.html>. Published 2020. Accessed April 29, 2020.
- Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA*. 2020;10022:1-8.
- Arentz M, Yim E, Klaff L, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington State. *JAMA*. 2020;4720:2019-2021.
- Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020;323:1061-1069.
- Sanche S, Lin Y, Xu C, et al. High contagiousness and rapid spread of severe acute respiratory syndrome coronavirus 2. *Emerg Infect Dis*. 2020. <https://doi.org/10.1101/2020.02.07.20021154>
- Holshue ML, DeBolt C, Lindquist S, et al. First case of 2019 novel coronavirus in the United States. *N Engl J Med*. 2020;382:929-936.
- Fuk-Woo Chan J, Yuan S, Kok K-H, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. 2020;6736:1-10.
- Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;6736:1-10.
- Phan LT, Nguyen TV, Luong QC, et al. Importation and human-to-human transmission of a novel coronavirus in Vietnam. *N Engl J Med*. 2020;(Panel D). doi:10.1056/NEJMc2001272
- Kamming D, Gardam M, Chung F. Editorial I. Anaesthesia and SARS. *Br J Anaesth*. 2003;90:715-718.
- Li H, Liu S-M, Yu X-H, et al. Coronavirus disease 2019 (COVID-19): current status and future perspective. *Int J Antimicrob Agents*. 2020;2019(xxxx):105951. doi:10.1016/j.ijantimicag.2020.105951
- Centers for Disease Control and Prevention. Cleaning and disinfection for households. Coronavirus Disease 2019 (COVID-19). <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cleaning-disinfection.html>. Accessed May 8, 2020.
- Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *J Autoimmun*. 2020;109(February):102433. doi:10.1016/j.jaut.2020.102433
- van Doremalen N, Bushmaker T, Morris D, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. 2010;382:1564-1567.
- Chen YC, Huang LM, Chan CC, et al. SARS in hospital emergency room. *Emerg Infect Dis*. 2004;10:782-788.
- Booth CM, Matukas LM, Tomlinson GA, et al. Clinical features and short-term outcomes of 144 patients with SARS in the greater Toronto area. *J Am Med Assoc*. 2003;289:2801-2809.
- Caputo KM, Byrck R, Chapman MG, et al. Intubation of SARS patients: infection and perspectives of healthcare workers. *Can J Anesth*. 2006;53:122-129.
- Iwashyna TJ, Boehman A, Capelcelatro J, et al. Variation in aerosol production across oxygen delivery devices in spontaneously breathing human subjects. *medRxiv*. 2020:2020.04.15.20066688. doi:10.1101/2020.04.15.20066688
- He X, Lau EH, Wu P, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. *medRxiv*. 2020:2020.03.15.20036707. doi:10.1101/2020.03.15.20036707
- Spicer K, Bardossy AC, Oakley LP, et al. Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *NEJM*: April 24, 2020:1-10. DOI: 10.1056/NEJMoa2008457
- Feroli M, Cisternino C, Leo V, et al. Protecting healthcare workers from SARS-CoV-2 infection: practical indications. *Eur Respir Rev*. 2020;29:200068.
- Rowlands J, Yeager MP, Beach M, et al. Video observation to map hand contact and bacterial transmission in operating rooms. *Am J Infect Control*. 2014;42:698-701.
- Loftus RW, Koff MD, Birnbach DJ. The dynamics and implications of bacterial transmission events arising from the anesthesia work area. *Anesth Analg*. 2015;120:853-860.
- Munoz-Price LS, Bowdle A, Johnston BL, et al. Infection prevention in the operating room anesthesia work area. *Infect Control Hosp Epidemiol*. 2019;40:1-17.
- Birnbach DJ, Rosen LF, Fitzpatrick M, et al. A new approach to pathogen containment in the operating room: sheathing the laryngoscope after intubation. *Anesth Analg*. 2015;121:1209-1214.
- Seto WH, Tsang D, Yung RWH, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet*. 2003;361:1519-1520.
- ASA, APSF, AAAA, AANA. The use of personal protective equipment by anesthesia professionals during the COVID-19 pandemic. *Anesthesia Patient Safety Foundation*. <https://www.apsf.org/news-updates/the-use-of-personal-protective-equipment-by-anesthesia-professionals-during-the-covid-19-pandemic/>. Accessed on April, 20, 2020.
- Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Can J Anesth*. 2020. doi:10.1007/s12630-020-01591-x
- Dieckmann P, Torgeisen K, Qvinesland SA, et al. The use of simulation to prepare and improve responses to infectious disease outbreaks like COVID-19: practical tips and resources from Norway, Denmark, and the UK. *Adv Simul (London, England)*. 2020;5:3.
- Cook TM, El-Boghdady K, McGuire B, et al. Consensus guidelines for managing the airway in patients with COVID-19. *Anaesthesia*. 2020:1-15.
- Kissler SM, Tedijanto C, Goldstein E, et al. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science (80-)*. April 2020:eabb5793. doi:10.1126/science.abb5793
- ACS, ASA, AORN, AHA. Joint statement: roadmap for resuming elective surgery after COVID-19 pandemic. <https://www.asahq.org/about-asa/newsroom/news-releases/2020/04/joint-statement-on-elective-surgery-after-covid-19-pandemic>. Published 2020. Accessed April 25, 2020.
- COVIDSurg Collaborative. Global guidance for surgical care during the COVID-19 pandemic. *Br J Surg*. 2020;(March). doi:10.1002/bjs.11646
- Prachand VN, Milner R, Angelos P, et al. Medically necessary, time-sensitive procedures: scoring system to ethically and efficiently manage resource scarcity and provider risk during the COVID-19 pandemic. *J Am Coll Surg*. 2020. doi:10.1016/j.jamcollsurg.2020.04.011
- Dexter F, Parra MC, Brown JR, et al. Perioperative COVID-19 defense. *Anesth Analg*. 2020;XXX(Xxx):1. doi:10.1213/ane.00000000000004829
- ASA, APSF. Joint statement on non-urgent care during the COVID-19 outbreak. <https://www.asahq.org/about-asa/newsroom/news-releases/2020/03/asa-apsf-joint-statement-on-non-urgent-care-during-the-covid-19-outbreak>. Published 2020. Accessed April 29, 2020.
- Centers for Disease Control and Prevention. Overview of influenza surveillance in the United States. *CDC webpage*. 2010:1-5. <http://www.cdc.gov/flu/weekly/pdf/overview.pdf>
- Ohannessian R, Duong TA, Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. *JMIR Public Heal Surveill*. 2020;6:e18810. doi:10.2196/18810



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Decontamination Strategies for Masks

From “Mask Decontamination,” Cover Page

The ultraviolet germicidal irradiation (UVGI) method⁴ was implemented with two UV systems (Clorox Optimum-UV Enlight® System, 216 mJ/cm²) located 1 meter (3.3 feet) away from the front and back of the respirators/masks hanging in the middle of a small decontamination room. It generated UV-C light and irradiated the masks for 5 minutes. For the oven heating method, 77°C (170°F) was chosen because it is the lowest temperature setting for most household ovens, and COVID-19 virus is deactivated at 70°C.⁵ At the target temperature, the respirators/masks were placed on a stack of coffee filters inside the oven without touching any metal surfaces to prevent thermal damage and heated for 30 minutes. For the steam heat treatment method, the respirators/masks were placed on the rack of a steamer with boiling water for 30 minutes. This treatment should not be done in a microwave oven because the metal nose clip may damage both the respirators/masks and the microwave oven.

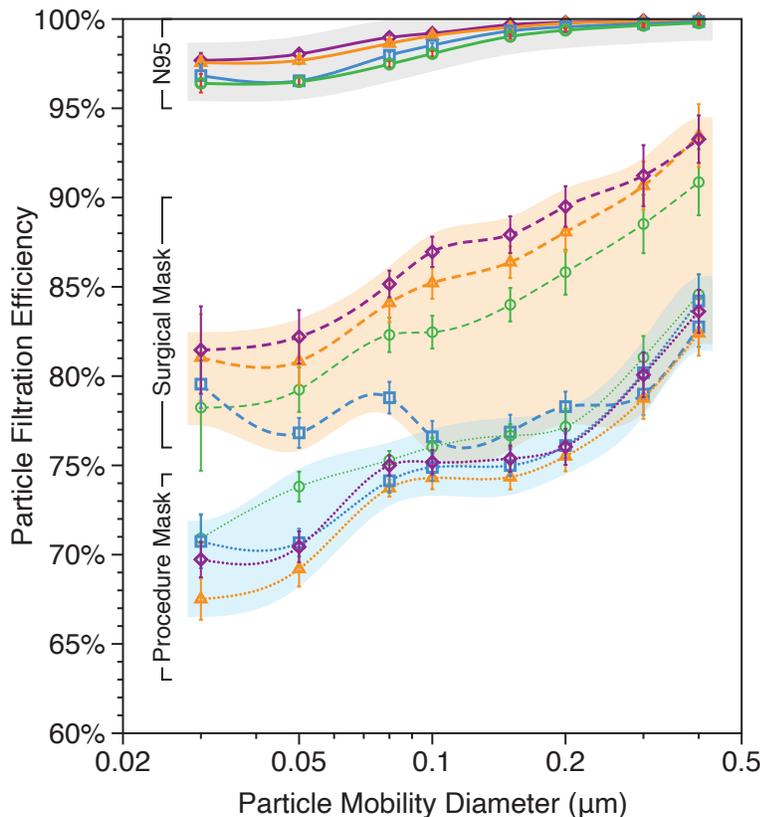
Filtration efficiency and breathing resistance of 3M 8210 N95 respirator (St. Paul, MN.), 3M 1820 procedure mask, and Halyard 48207 surgical mask (Alpharetta, GA) were measured

before and after the decontamination treatment. Although COVID-19 virus is ~0.1 µm in size,⁶ the exhalation droplets can be several micrometers or larger but shrink while traveling in air due to water evaporation. Efficiency of filter media is a strong function of contaminant size. We report here fractional efficiency for different sizes from 0.03 to 0.4 µm, which represents the most penetrating particle size range, so that it can be compared to the size of COVID-19 virus or other pathogens of interest. As shown in Figure 1, N95 respirator has >95% efficiency over the entire size range, with the least efficiency of 96% at 0.05-0.08 µm, and is >98% efficient at COVID-19 virus size of ~0.1 µm. Surgical mask and procedure mask have lower efficiency with ~85% and ~80% at 0.1 µm, respectively. All three decontamination treatments did not cause visible deformation or degradation of the material nor did they degrade filtration efficiency or breathability after as many as 10 treatments. The only exception is that the steam heat treatment caused a slight efficiency drop (<5% on the average) in surgical masks after 10 treatment cycles, suggesting that oven heating is a better option for repetitive reuse. The three decontamination methods were tested safe in retaining filtration

of most household fabric materials (data not shown) that could also be used for home-made masks. Our data indicate there is no systematic change of efficiency or resistance on N95s caused by the treatment. The slight increase in resistance of treated N95s is from sample variation, rather than the treatment itself. The test method is destructive, so we limited our sample counts to save precious N95s and masks.

The quantitative fit tests were performed using a TSI PortaCount® Pro+ 8038 by a specific researcher in this study. The fit factor, defined as the ratio of ambient particle concentration to the particle concentration inside the respirator, should be equal to or above 100 to pass the test. The quantitative fit testing was first performed with a new 3M 8210 N95 respirator and then performed after 1, 3, 5, and 10 cycles of 77°C oven treatment with the same respirator. A second 3M 8210 N95 respirator was fit tested after 1, 3, 5, and 10 cycles of steam heat treatment. As shown in Table 1, oven treatment was deemed safe for the integrity and the fit of the respirator, while the steam heat treatment may affect the respirator fit. All the fit tests were performed with the same person.

See “Mask Decontamination,” Next Page



Treatments

○ New	(Untreated)
△ Oven	77°C 30 min–10 treatments
□ Steam Heat	30 min–10 treatments
◇ UVGI	5 min

Solid Line: N95–3M 8210

Dashed Line: Surgical Mask–Halyard 48207

Dotted Line: Procedure Mask–3M 1820

Breathing Resistance

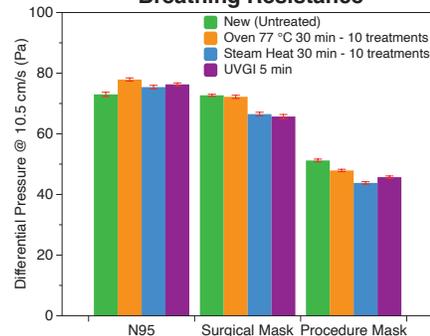


Figure 1: Fractional Particle Filtration Efficiency and Breathing Resistance (Differential Pressure) of the decontamination treated samples of 3M 8210 N95, Halyard 48207 surgical mask, and 3M 1820 procedure mask, compared with the new untreated samples.

Decontamination of Respirators and Masks

From “Mask Decontamination,” Previous Page

Different fit factors should be expected if the tests were performed on a different wearer, even with the same respirator. During the fit testing, the person who conducted the tests did not feel any difference in terms of breathability between untreated and treated N95s.

CONCLUSION:

We tested three methods (UVGI, Oven, and Steam Heat) for decontamination and found that they did not degrade the filtration efficiency and fit factor. Based on our present findings, the reuse respirators and masks are not only highly efficient but can be used repeatedly for up to 10 times. Moreover, the methods are readily available not only in the hospital setting but also in most home environments. This study only tested unused respirator/mask performance after multiple decontamination treatments. Worn respirator/mask may have deterioration in integrity and efficiency, which cannot be recovered from decontamination. We do not recommend reusing N95s or masks that are visibly contaminated or have visible deterioration on any part of the materials.

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The authors have no conflicts of interest. Dr. Qisheng Ou, Mr. Chenxing Pei, Dr. Seong Chan Kim, and Dr. David Y.H. Pui contributed equally to this letter.

Table 1. Quantitative Fit Testing Results of the New N95 Respirator and After Oven and Steam Heat Treatment Cycles

Oven Treatment					
Exercise	New	Cycles			
		1	3	5	10
Normal Breathing	200+	200+	200+	200+	200+
Deep Breathing	200+	200+	200+	200+	200+
Head Side to Side	200+	200+	200+	200+	200+
Head Up and Down	200+	200+	200+	200+	200+
Talking	135	134	124	170	125
Grimace	Excl.	Excl.	Excl.	Excl.	Excl.
Bending Over	200+	200+	151	197	200+
Normal Breathing	200+	200+	200+	200+	200+
Overall Fit Factor	188	188	177	195	185

Steam Heat Treatment					
Exercise	New	Cycles			
		1	3	5	10
Normal Breathing	200+	200+	191	109	141
Deep Breathing	200+	200+	200+	184	179
Head Side to Side	200+	200+	92	43	51
Head Up and Down	200+	165	101	72	99
Talking	135	86	80	56	58
Grimace	Excl.	Excl.	Excl.	Excl.	Excl.
Bending Over	200+	144	136	47	37
Normal Breathing	200+	157	180	112	50
Overall Fit Factor	188	152	124	70	66

The numbers in the table represent the Fit Factor. A fit factor above 100 represents an appropriate fit (and is represented in green). A fit factor below 100 represents a poor fit (and is represented in red).

REFERENCES

- Livingston E, Desai A, Berkwitz M. Sourcing personal protective equipment during the COVID-19 pandemic. *JAMA*. Published online March 28, 2020. <https://jamanetwork.com/journals/jama/fullarticle/2764031>
- Decontamination and reuse of filtering facepiece respirators. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/decontamination-reuse-respirators.html>.
- Coronavirus (COVID-19) Update: reusing face masks and N95 respirators: *JAMA*. Published online April 8, 2020. URL: <https://edhub.ama-assn.org/jn-learning/audio-player/18433414>
- Mills D, Harnish DA, Lawrence C, et al. Ultraviolet germicidal irradiation of influenza-contaminated N95 filtering facepiece respirators. *American Journal of Infection Control*. 2018;46:e49–e55.
- Chin AWH, Chu JTS, Perera MRA, et al. Stability of SARS-CoV-2 in different environmental conditions. *The Lancet Microbe*. Published online April 2, 2020. doi:10.1016/S2666-5247(20)30003-3
- Zhu N, Zhang D, Wang W, et al. A Novel Coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*. 2020;382:727–733.

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Postoperative Recurarization After Sugammadex Administration Due to the Lack of Appropriate Neuromuscular Monitoring: The Japanese Experience

by Tomoki Sasakawa, MD, PhD; Katsuyuki Miyasaka, MD, PhD; Tomohiro Sawa, MD, PhD; and Hiroki Iida, MD, PhD

INTRODUCTION

Sugammadex rapidly reverses neuromuscular blockade via selective encapsulation of rocuronium and other nondepolarizing aminosteroid muscle relaxants. Since its 2010 launch in Japan, sugammadex has been administered to an estimated 12.32 million patients over 8 years. Sugammadex has contributed to safe and effective management of muscle function by reducing the risk of postoperative residual neuromuscular blockade (sugammadex 1–4% vs neostigmine 25–60%).¹ However, the Safety Committee of the Japanese Society of Anesthesiologists (JSA) released a warning in 2019 highlighting the need for correct sugammadex dosing.² This warning was based on 36 cases of recurrence of neuromuscular blockade (recurarization) reported by the end of 2018 in Japan. The appropriate dose of sugammadex should be determined based on the patient's body weight and depth of neuromuscular blockade (Table 1). Moreover, the anesthesia professional should check for signs of anaphylactic reactions and recurarization after sugammadex injection while monitoring for full neuromuscular recovery.

Many incidents reported in Japan involved inappropriate dose determination (lack of neuromuscular monitoring) and insufficient postdose management. Perioperative neuromuscular monitoring with a quantitative device, which measures and displays a train-of-four (TOF) ratio, is the gold standard for avoiding postoperative residual neuromuscular blockade.³ Quantitative

muscle relaxation monitoring is a method for evaluating the degree of muscle relaxation objectively using accelerometer, electromyograms, etc., in conjunction with electric nerve stimulation. Quantitative monitoring enables evaluation of whether the TOF ratio, which is an index of recovery from muscle relaxation, is greater than 0.9. Evaluation of a deeper degree of muscle relaxation, using the Post-Tetanic Count (PTC) is also possible. Qualitative monitoring is based on an anesthesia professional's subjective judgment with palpating or observing muscle contractions using a device with only a nerve stimulation function. While it may be possible to obtain an approximate TOF count, it is not possible to obtain the precision crucial for distinguishing exact TOF ratios, for example, between 0.8 and 0.93.

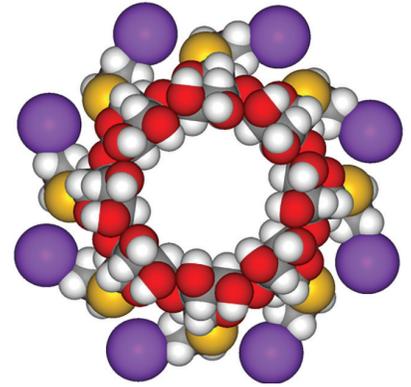
However, a survey showed that quantitative monitors were available to only 22.7% of anesthesia practitioners in the United States.⁴ In addition, the use of qualitative or quantitative monitors is not common in Japan. In most cases, anesthesia professionals subjectively judge recovery of muscle relaxation based on clinical signs. Since the availability of neuromuscular monitors is likely to be similar in Japan and the United States, the lack of appropriate perioperative monitoring may be a major cause of inappropriate dosing of neuromuscular blockade.

RECURARIZATION

Recurarization, or a rapid increase in neuromuscular blockade after a period of recovery, was reported in the past with the use of acetylcholinesterase inhibitors, but is increasingly being reported with sugammadex, where muscle strength appears to recover more reliably. Elveld et al. reported recurrence of neuromuscular blockade during reversal with a small dose of sugammadex at a PTC of 1 (i.e., deep muscle relaxation).⁵ In a subsequent clinical case report, an obese patient experienced recurarization due to an insufficient dose of sugammadex that necessitated tracheal re-intubation after a TOF ratio of 0.9 was observed prior to extubation for the first time.⁶

MECHANISM OF RECURARIZATION

Even when muscle relaxant molecules occupy 75% of the nicotinic acetylcholine receptors at the neuromuscular junction, normal neuromuscular transmission is achieved because the remaining 25% of receptors allow for normal muscle strength.⁷ Thus, the neuro-



By Fvasconcellos (Own work) [Public domain], via Wikimedia Commons
Space-filling model of sugammadex sodium.

muscular junction has a large safety factor under various physiological conditions. In the case mentioned above, muscle strength was apparently normal. However, in the presence of low concentrations of muscle relaxants, recurarization may occur with the onset of respiratory acidosis, administration of magnesium or aminoglycoside antibiotics, or other factors that decrease the safety factor. Some rocuronium molecules remain unbound in the central compartment in some patients who receive an insufficient dose of sugammadex. These free molecules may redistribute to the peripheral compartment, migrate to the neuromuscular junction, and cause further muscle relaxation.

TWO CASES OF RECURARIZATION

Case No. 1. A 70-year-old, 71-kg male patient underwent ureterectomy. The patient had chronic renal insufficiency. In total, 240 mg of rocuronium was administered during anesthesia, which lasted for 7 hours and 33 minutes. Sugammadex 200 mg was administered 87 minutes after the last 20-mg dose of rocuronium. The patient resumed spontaneous respiration. The patient was responsive to verbal communication and extubated. No neuromuscular monitoring was performed. Fifteen minutes after the patient was moved to the post-anesthesia care unit (PACU), he stopped breathing and reintubation was performed. The neuromuscular monitor displayed a TOF count of 3. Upon administration of another 200-mg dose of sugammadex, body movements reappeared, spontaneous respirations resumed, and no signs of recurarization were observed thereafter.

Table 1. Recommended Doses of Sugammadex for Reversal of Neuromuscular Blockade Based on Neuromuscular Monitoring¹²

Level of Neuromuscular Blockade	Sugammadex Dose ¹² (mg/kg)
Moderate (Reappearance of T2 in response to TOF stimulation)	2
Deep (At reappearance of 1 or 2 PTCs)	4
Immediate reversal of neuromuscular blockade (3 minutes after an intubating dose of rocuronium bromide)	16

T2, second twitch. TOF, train-of-four. PTC, post-tetanic count.

Neuromuscular Monitoring Should be Coupled with Use of Sugammadex

From “Recurarization,” Preceding Page

Case No. 2. An 80-year-old, 61-kg male patient underwent surgical abdominal aortic aneurysm repair. Rocuronium (50 mg) was administered for endotracheal intubation and 25-mg doses were injected at 30-minute intervals starting at 1 hour after intubation. No neuromuscular monitoring was performed. Fifty minutes after the last 25-mg dose of rocuronium was administered, 200 mg of sugammadex was injected in the absence of consciousness and spontaneous respirations. Following the administration of sugammadex, weak spontaneous breathing was noted. The patient was responsive to verbal communication, extubated, and transferred to the PACU. Fifteen minutes after extubation, breathing stopped. Spontaneous respiration was restored immediately after an additional 200-mg dose of sugammadex was injected.

NEUROMUSCULAR MONITORING AND CORRECT USE OF SUGAMMADEX

Neuromuscular monitoring was not performed intraoperatively or before administration of sugammadex in either case. These cases show the occurrence of recurarization in elderly patients with presumably high rocuronium sensitivity due to pharmacokinetic and pharmacodynamic factors. Recently, there is a trend to administer relatively large doses of rocuronium to maintain deep relaxation because deep neuromuscular blockade may result in improved operative conditions for laparoscopic surgery compared with moderate blockade.⁸ Given the risk of rocuronium overdosing, deep neuromuscular blockade should be assessed using intraoperative neuromuscular monitoring. If rocuronium overdose results in profound muscle relaxation and disappearance of the twitch response, it is important to wait for spontaneous recovery (initially assessed based on PTC). In the two cases described earlier, one vial of sugammadex (200 mg) was administered on a routine basis in the absence of neuromuscular monitoring, which led to under dosing and eventual recurarization.

REVISED JSA GUIDELINES FOR MONITORING DURING ANESTHESIA

As compared with earlier editions, the 2019 revision of the *JSA Guidelines for Monitoring During Anesthesia* included a more definitive recommendation on the use of neuromuscular monitoring: “Neuromuscular monitoring should be performed in patients receiving muscle relaxants and their antagonists.”⁹ This recommendation replaced the previous version: “Neuromuscular monitoring should be per-

formed where appropriate.” Although no specific monitoring methods were mentioned in the latest edition, the use of a quantitative neuromuscular monitor is desirable in all cases. Qualitative and semi-qualitative neuromuscular monitoring methods, such as clinical muscle function tests (e.g., 5-second head lift and sustained hand grip), can only detect TOF ratios of 0.4 or less and do not correlate with a TOF ratio of 0.9, a threshold indicating the absence of residual paralysis.¹⁰ Perioperative evaluation and management of deep muscle relaxation during anesthesia requires neuromuscular monitoring based on PTC or other reliable parameters.³

INCREASING THE USE OF NEUROMUSCULAR MONITORING

Japan’s national medical insurance system does not promote the use of neuromuscular monitoring in clinical settings because it does not reimburse for the medical expenses incurred by neuromuscular monitoring. In addition, the sale of the stand-alone portable acceleromyography (AMG)-based devices has been discontinued. This has significantly narrowed the range of options, discouraging the purchase of new monitors. However, several new quantitative neuromuscular monitors have been launched in the market and are attracting the interest of anesthesia professionals. New device types include electromyography-based monitors, AMG-based monitors that employ new measurement algorithms (3-dimensional accelerometer), and monitors that comprise a modified blood pressure cuff with neuromuscular electrodes on the inside.¹¹ The advantages of these new models include ease of calibration, ease of use, and presence of adaptive mechanisms to compensate for postural changes. However, given their short post-launch duration and high cost, the medical community is waiting for quality products with time-tested reputations and competitive prices.

CONCLUSIONS

The frequent absence of perioperative neuromuscular monitoring has increased the risk of recurarization due to inappropriate sugammadex dosing in Japan. In light of the increasing use of sugammadex worldwide, we acknowledge the need to warn the medical community that the risk of recurarization is high in many parts of the world. In conclusion, we invite medical device manufacturers to produce price-competitive and easy-to-operate neuromuscular monitors that can be used throughout perioperative care. We also encourage anesthesia professionals to administer sugammadex based on neuro-

muscular monitoring data. Moreover, we call for clinical attention to prevent recurarization, anaphylactic reactions, and other postoperative complications associated with the use of muscle relaxants and their antagonists.

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The authors have no conflicts of interest. All authors are members of the Safety Committee of the Japanese Society of Anesthesiologists.

REFERENCES

- Kotake Y, Ochiai R, Suzuki T, et al. Reversal with sugammadex in the absence of monitoring did not preclude residual neuromuscular block. *Anesth Analg.* 2013;117:345–51.
- Japanese Society of Anesthesiologists. Medical alert: appropriate use of sugammadex (in Japanese) 2019. <https://anesth.or.jp/users/news/detail/5c6e37f8-2d98-4ec8-b342-197fa50cc6ad>
- Murphy GS. Neuromuscular monitoring in the perioperative period. *Anesth Analg.* 2018;126:464–8.
- Naguib M, Kopman AF, Lien CA, et al. A survey of current management of neuromuscular block in the United States and Europe. *Anesth Analg.* 2010; 111:110–9.
- Elefeld DJ, Kuizenga K, Proost JH, et al. A temporary decrease in twitch response during reversal of rocuronium-induced muscle relaxation with a small dose of sugammadex. *Anesth Analg.* 2007; 04:582–4.
- Le Corre F, Nejmeddine S, Fatahine C, et al. Recurarization after sugammadex reversal in an obese patient. *Can J Anaesth.* 2011;58:944–7.
- Waud DR, Waud BE. *In vitro* measurement of margin of safety of neuromuscular transmission. *Am J Physiol.* 1975; 229:1632–4.
- Martini CH, Boon M, Bevers RF, et al. Evaluation of surgical conditions during laparoscopic surgery in patients with moderate vs deep neuromuscular block. *Br J Anaesth.* 2014;112:498–505.
- Japanese Society of Anesthesiologists. Standards and guidelines: monitoring during anesthesia (in Japanese) 2019. https://anesth.or.jp/files/pdf/monitor3_20190509.pdf
- Plaud B, Debaene B, Donati F, Marty J. Residual paralysis after emergence from anesthesia. *Anesthesiology.* 2010; 112:1013–22.
- Markle A, Graf N, Horn K, et al. Neuromuscular monitoring using TOF-Cuff® versus TOF-Scan®: an observational study under clinical anesthesia conditions. *Minerva Anestesiol.* 2020 Feb 17 [Online ahead of print] DOI:10.23736/S0375-9393.20.14272-X.
- MERCK & Co., Inc. Bridion (sugammadex) : Prescribing drug information. https://www.merck.com/product/usa/pi_circulars/bridion/bridion_pi.pdf. Accessed May 11, 2020.

Effective Leadership and Patient Safety Culture

by Brooke Albright-Trainer, MD; Rakhi Dayal, MD; Aalok Agarwala, MD, MBA; and Erin Pukenas, MD

Effective leadership is necessary in medicine to foster an organizational climate that promotes patient safety. Leadership is the cornerstone of success to any project or business. Effective leaders lead by example, value a strong work ethic, and demonstrate a commitment to the mission of an institution or department beyond that of self-preservation.¹ Capable leaders use a clear vision to instill a larger sense of purpose, setting the tone for the direction of an organization. Leaders who promote a positive and cohesive work environment engender trust among providers and staff and establish psychological safety for employees. Leadership determines organizational priorities and can funnel resources toward important safety initiatives. Fostering an environment that encourages others to speak up with concerns allows leaders to act decisively and in a timely manner to protect patients and employees. Ultimately, leaders who promote a positive organizational climate contribute to higher job satisfaction among employees, decreased burnout, fewer medical errors, and an overall improved culture of safety.²

SAFETY CULTURE

Improving safety culture within health care systems is an essential component of preventing and reducing errors. The Joint Commission defines safety culture as the collection of “beliefs, values, attitudes, perceptions, competencies, and patterns of behavior that determine the organization’s commitment to quality and patient safety.”³ A core measure of a strong safety culture is the willingness of employees, whether clinical or in support roles, whether newly hired or experienced, to feel comfortable speaking up when they see something amiss. It is imperative that leaders support and foster an environment in which speaking up is encouraged so that care teams can learn from adverse events, close calls, and unsafe conditions. This can be accomplished by encouraging a transparent and nonpunitive approach to reporting. Moving to a “just culture” where individual blame is minimized or removed, and a focus is placed on system faults that contribute to adverse events, can improve a safety culture.

Leaders must also adopt and champion efforts to eradicate intimidating behaviors. When unprofessional behavior is tolerated within an organization, it undermines patient safety. Failing to address unprofessional behavior in a fair and transparent manner allows such behavior to persist and signals to new employees that such behavior may be tolerated, potentially promoting more of it. Addressing unprofessional behavior in disruptive employees can yield improved staff satisfaction and



Figure 1: Work-life imbalance can contribute to employee burnout.

retention, enhanced reputation, improved patient safety and risk-management experience, and better work environments.⁴

Team members who identify unsafe conditions or who have good suggestions for safety improvements should be recognized and rewarded. Leaders can use a number of techniques to improve safety culture, including use of surveys to identify culture gaps, encouraging teamwork training, performing executive walk-rounds, and establishing unit-based quality and safety teams.⁵ By proactively assessing system strengths and vulnerabilities, health care teams can track progress and prioritize areas to improve safety culture.

PSYCHOLOGICAL SAFETY

Psychological safety is defined as the belief one will not be punished for making an error or speaking up. It is a core component of a safe culture, and intertwines with both patient safety and burnout. Psychological safety allows for creativity, speaking one’s mind, and lack of fear for having new, different, or dissonant ideas.⁶ A psychologically safe environment also permits providers to discuss issues related to their own work-life balance. In creating psychological safety, leaders must foster an environment where providers feel safe communicating issues with patient care. Effective leaders maintain open lines of communication and remain open to feedback. Though this may subject one to increased vulnerability, the ability to accept feedback and react constructively allows leaders to recognize problems earlier and deal with them proactively.¹ Otherwise, team members may not speak up about a problem for fear of retaliation or humiliation.

ORGANIZATIONAL CULTURE AND EMPLOYEE BURNOUT

An organization’s culture can enhance patient safety and drive quality. It can also contribute to burnout (Figure 1). Burnout is a syndrome conceptualized as resulting from chronic workplace stress that has not been successfully managed.⁷ Traditionally, organizational culture in health care has not allowed room for a discussion of work-life balance. Providers have feared voicing concerns regarding their personal needs that may not align with departmental or institutional goals. Some institutions may only start to pay attention to burnout when it begins to contribute to loss of productivity, patient access, lower patient safety scores, and increased costs. Frequent management changeover or uncertainty, lack of a strategic plan, or goal incongruence can lead to physicians feeling devalued or ineffective. High rates of turnover can be a sign that ineffective leadership is contributing to high burnout rates in departments or institutions. Turnover leads to increased costs, recruitment expenses, agency/locum bridging, higher rates of paid time off, and need for additional support services, to name a few.

Today, as data continue to mount relating burnout among health care workers to increases in incidence of medical errors and malpractice, it is in every institution’s best interest to address employee stress and work to successfully manage it. Following the Institute of Medicine (IOM) landmark report asserting that deaths from medical errors had become the third leading cause of death in the US behind cancer and heart disease, quality improvement initiatives to reduce patient harm have spawned nationwide.⁸ Recent studies have suggested a two-fold increase in medical errors when associated with clinician burnout as compared to those not associated with burnout, with an overwhelming 55% of respondents reporting burnout symptoms.⁹ If these issues go unaddressed, the health care professional’s well-being, or potentially even the his or her safety, can become compromised. To prevent burnout and increase wellness amongst providers, leaders should reflect on an organization’s climate and implement change when needed. By implementing monitoring tools, including workplace wellness initiatives and workplace response teams, leaders can foster an organizational culture that prevents burnout.

KEY ATTRIBUTES OF EFFECTIVE LEADERS

Acquisition of certain attributes in leadership is so important that a multitude of workshops, courses, and degrees have been established to help hone and refine these skills. The following list, though not comprehensive, reviews a few of the most important attributes that distinguish an effective leader from an ineffective one (Table 1).

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Leaders Can Foster Culture that Prevents Clinician Burnout

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Effective Communication

Effective communication is necessary to allow an organization’s people to know what is expected, valued, and appreciated. Clearly articulated goals help people remain focused, track progress, and discuss challenges openly. As new ideas are developed, it is critical to clearly define mission objectives and review them at regular intervals along the way with all involved stakeholders, including frontline providers, thought leaders, or senior faculty. This monitoring of progress with regular checks and balances avoids potential miscommunication and assures compliance with intended goals. At all times, leaders must remain open to constructive criticism and feedback. If this is hindered, team members may begin to fear retaliation or humiliation for speaking up.

Collaborative Teamwork

Fostering a culture of teamwork and camaraderie is essential to building a culture of safety. Leaders should take pride in what their providers have already accomplished while nurturing their skills for further development. The positive attitude from the leader is instrumental and contagious at the same time. When leaders work together with their frontline providers, it empowers them to partner with the vision and the growth at the highest level. One example of collaborative teamwork is the sharing of important data metrics. Providers are more likely to comply with the recurrent demands of workplace objectives when given a better understanding of why they need to do it. Effective communication and collaborative teamwork are essential in aligning with a common goal.

Experience

While experience alone does not make a great leader, experienced leaders may be more comfortable taking chances and more confi-

dent making decisions. When leaders hesitate or become indecisive, as inexperienced leaders sometimes do, it can lead to confusion and exhaustion among employees. However, every future leader needs a place to start. Professional development and leadership training for high-potential individuals can be of great benefit to organizations. While some may have the skills to be successful as leaders more innately than others, not everyone is a natural born leader. Even those with significant experience or professional leadership training may fail. A study by the Center for Creative Leadership showed that roughly 38% to more than half of new leaders fail within their first 18 months.⁷ Leaders can avoid becoming part of this staggering statistic by incorporating good leadership strategies that motivate their team members to accomplish their goals. Openness to feedback, checking in regularly with one’s own goals, and recognizing signs of failure are all keys to success and continuous improvement.

Adaptability

It is imperative that leaders work with frontline providers to develop and implement creative work strategies to maximize efficiency while limiting workplace stressors and reducing burnout. Increasing pressure continues to mount from organizational and third-party stakeholders to meet metrics. Some institutions are seeing only a slight increase in volume, yet the work hours are longer, translating to an increased risk to the employee’s health with diminishing returns in productivity. Longer employee work hours are associated with increased fatigue, poor mood, poor recovery from work, and a nearly 40% increase in risk for coronary artery disease.¹⁰⁻¹² Men and women working long hours showed higher prevalence of depression and anxiety disorders.¹³ For decades, the National Institute for Occupational Safety and Health (NIOSH) has recognized shift

work and work-related sleep loss to be a hazard in the workplace and has carried out an active research program to address this hazard. A goal of NIOSH’s National Occupational Research Agenda (NORA) for Healthcare and Social Assistance is that health care organizations adopt best practices for scheduling and staffing that minimize excessive workload and other factors associated with fatigue.¹⁴ As the cost of health care continues to increase, so do the demands on productivity. With continual improvements in information technology, electronic medical records, and machine learning, there is a growing list of tools available to help improve processes and streamline care so that increased productivity demands do not always translate into increased workload.

CONCLUSION

Effective leadership in medicine is necessary to promote patient safety. Leaders must continually strive to be role models, stewards of resources, and improve processes. Effective leaders support safety initiatives and create systems that address concerns brought forth by frontline providers and patients. Constraints of any kind in an organization can lead to increased frustration, communication breakdown, and potential errors. In order to remain efficient and effective, leaders must overcome these obstacles and maintain forward thinking, regularly checking in with their employees, ensuring their state of wellbeing, and taking corrective action when elements become out of balance. By creatively adapting and effectively communicating, leaders can help their organizations accomplish goals, even in difficult times. Employees with higher job satisfaction at work have lower rates of burnout, allowing for increased focus, productivity, and fewer overall medical errors.

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Table 1: Key Attributes of Effective Leaders

EFFECTIVE COMMUNICATION	<ul style="list-style-type: none"> Clearly articulates goals and objectives Open to constructive criticism and feedback
COLLABORATION	<ul style="list-style-type: none"> Fosters a culture of teamwork and camaraderie Inclusive and nurturing
EXPERIENCE	<ul style="list-style-type: none"> Comfortable and confident in their decision-making Maintains forward thinking and the need for continuous improvement
ADAPTABILITY	<ul style="list-style-type: none"> Implements creative work strategies to streamline care and maximize efficiencies Stewards resources and strives to improve processes

Effective Leadership

From “Effective Leadership,” Preceding Page

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The authors have no conflicts of interest.

REFERENCES:

- Albright-Trainer B. Leadership philosophy: what makes a great leader? *VSA Update Newsletter*. Fall 2019.
- Sfantou D, Laliotis A, Patelarou A, et al. Importance of leadership style towards quality of care measures in healthcare settings: a systematic review. *Healthcare (Basel)*. 2017;5:73.
- Joint Commission Sentinel Event Alert. The essential role of leadership in developing a safety culture. *Joint Commission*. Issue 57, March 1, 2017.
- Hickson GB, Pichert JW, Webb LE, Gabbe SG. A complementary approach to promoting professionalism: identifying, measuring, and addressing unprofessional behaviors. *Acad Med*. 2007;82:1040–8.
- Tucker A, Singer S. The effectiveness of management by walking around: a randomized field study. *Prod Oper Manag*. 2014;25:1977–2001.
- Delizonna, L. High-performing teams need psychological safety, here's how to create it. *Harv Bus Rev*. 2017 Aug.
- Riddle, D. Executive integration: equipping transitioning leaders for success. 2016. <https://www.ccl.org/wp-content/uploads/2015/04/ExecutiveIntegration.pdf>. Accessed March 5, 2020.
- Kohn LT, Corrigan JM, Donaldson MS, et al. *To err is human: building a safer health system*. Washington, DC: National Academy Press, Institute of Medicine. 1999.
- Tawfik DS, Profit J, Morgenthaler TI, et al. Physician burnout, well-being, and work unit safety grades in relationship to reported medical errors. *Mayo Clin Proc*. 2018;93:1571–1580.
- Caruso CC, Hitchcock EM, Dick RB, et al. Cincinnati, OH: Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2004. Overtime and extended work shifts: recent findings on illnesses, injuries, and health behaviors. DHHS (NIOSH) Publication No. 2004–143.
- Siu O-L, Donald I. Psychosocial factors at work and workers' health in Hong Kong: an exploratory study. *Bulletin of the Hong Kong Psychological Society*. 1995;34/35:30–56.
- Virtanen M, Heikkilä K, Jokela M, et al. Long working hours and coronary heart disease: a systematic review and meta-analysis. *Am J Epidemiol*. 2012;175:586–596.
- Kleppa E, Sanne B, Tell GS. Working overtime is associated with anxiety and depression: the Hordaland health study. *Journal of Occupational and Environmental Medicine*. 2008;50:658–666.
- NORA Healthcare and Social Assistance Sector Council. State of the sector healthcare and social assistance. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Publication No. 2009–139. <http://www.cdc.gov/niosh/docs/2009-139/pdfs/2009-139.pdf>. Accessed on March 5, 2020.

Misfilling the Exhausted Vaporizer

by Jonathan A. Bond, DO, MPH; Charles Barry II, MD, MSE, PE; and Nicole Hollis, DO

A 61-year-old male was urgently taken to the operating room for removal of infected pelvic hardware. Shortly after induction, both isoflurane and sevoflurane appeared on the display (Figure 1), despite only a sevoflurane vaporizer being attached to the device. The vaporizer was removed after switching to a total intravenous anesthetic to avoid the possibility of further vaporizer inaccuracies. No harm was caused to the patient.

After the surgery, biomedical engineers were unable to identify any malfunctioning components of the anesthesia machine or gas analyzer. The vaporizer was then connected to devices in different operating rooms. Specifically, the vaporizer was attached to Dräger Apollo® and Fabius® machines, and each device produced the same finding; detectable levels of both isoflurane and sevoflurane. The offending vaporizer was also replaced by a different vaporizer on the original machine and displayed appropriate sevoflurane concentrations without any detectable amounts of isoflurane. These findings confirmed that the vaporizer was filled with isoflurane.

Analysis showed the records of six previous anesthetics that had measurable amounts of isoflurane documented when administering the assumed solitary anesthetic of sevoflurane. As a result, multiple events were identified that allowed this error to persist. The initial alarm identifying the co-administration of the volatile agents was thought to be due to the gas analyzer malfunctioning, as there were no isoflurane vaporizers attached to the machine nor were any present in the room. The dismissal of an alert speaks to the breadth of alarm fatigue caused by frequent, if not constant, audible alarms in the operating room.

The importance of intraoperative handoffs cannot be overstated as well. Following a person-

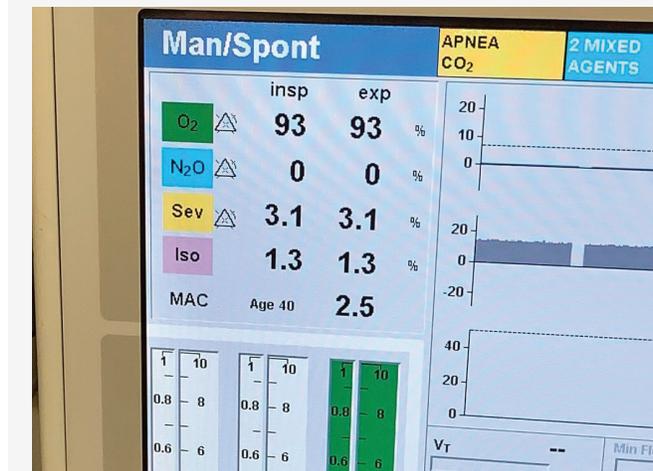


Figure 1: Dräger gas analyzer display showing both isoflurane and sevoflurane delivery when using an incorrectly filled sevoflurane vaporizer.

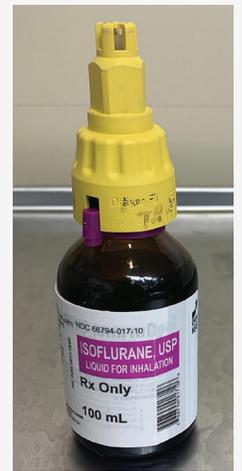


Figure 2: Sevoflurane specific key is able to be forced onto an isoflurane bottle.

nel change, two spinal anesthetics occurred between the identified cases. Because the contaminated vaporizer was not used, no alarms were encountered by the new providers. This allowed the error to persist to an additional unaware team that inherited the remaining cases. The anesthesia professionals and technicians involved were contacted. No source of cross-contamination with the volatile agents or problems with refilling the vaporizer were reported.

The findings were communicated to the entire anesthesia department during our monthly quality improvement conference. While we were unable to identify the exact source, the potential for the incorrect filling of a vaporizer still exists despite safety controls and device specific keys for each volatile agent and vaporizer. Although rare, circumventing these mechanisms by forcing a sevoflurane adapter onto an isoflurane volatile bottle (Figure 2) or

directly pouring the contents from one to another, remains a possibility and should be on the differential if confronted with similar analyzer abnormalities. While these events did not result in patient harm, it is our hope that this case provides awareness on the persistent possibility of misfilled vaporizers.

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Drug Swaps and Compressed Medical Gases

by Sathappan Karuppiah, MD; Roy Kiberenge, MD; and Richard Prielipp, MD

INTRODUCTION:

Safety standards for compressed medical gases and their labelling and delivery have improved over the last several decades. But despite efforts to strengthen standards for labelling and administration of medications, drug errors continue to be a leading cause of adverse events among patients undergoing anesthesia.¹ Misidentification of ampules, vials, and syringes is a well-recognized source of drug swap errors. We report a case where carbon dioxide was administered to a patient from a portable compressed gas cylinder—instead of oxygen—rapidly leading to severe hypoxemia during transport. We suggest that compressed medical gases should be classified in the same category as medications. For instance, safety experts now recommend standards for labelling drug ampoules and vials, as well as a bar code system for drug verification in the operating room.² Our case illustrates that similar identification systems and additional fail-safe delivery systems should be considered with the administration of all portable medical gases.

CASE DESCRIPTION:

A 62-year-old female, status post orthotopic heart transplant complicated by coronary artery vasculopathy, presented for repeat heart transplantation. After anesthesia induction and placement of invasive monitoring, the operation was suspended due to problems with the placement of the donor lungs. After hours of delay, the operation resumed. Re-do cardiac transplantation and separation from cardiopulmonary bypass proceeded without incident. At the conclusion of surgery, the patient was transferred from the operating room table to the transport ICU bed. Surprisingly, as the patient was connected to our standard Air Mask Bag Unit (AMBU—Copenhagen, Denmark) with an E cylinder of (presumed) oxygen (Figure 1), she became hypotensive with a rapid decrease in oxygen saturation (from 99% to 80%). She was immediately reconnected to the anesthesia machine ventilator with FiO₂ = 1.0, while small boluses of vasopressors stabilized her hemodynamics. After several minutes of stability of all vital signs, a second attempt to ventilate the patient with the same AMBU setup began, but again the patient's blood pressure and saturation quickly declined. After a return to the anesthesia machine ventilator, vital signs again quickly normalized. At this point, it was decided to transport the patient with a dedicated ICU transport ventilator. When the E-cylinder was being removed from the bed, it was discovered



Figure 1: Standard oxygen E cylinder (left) and a similar appearing carbon dioxide cylinder (right).



Figure 2: Nearly identical appearing flowmeters but for a thin carbon dioxide label (right).

that it was actually a carbon dioxide cylinder with a regulator, flowmeter and a green administration connector (“nipple”) that can be readily connected to oxygen AMBU delivery tubing (Figure 2). The patient was successfully transported to the ICU and made an uneventful recovery.

DISCUSSION:

Medication errors often increase patient morbidity and even mortality.³ Drug (or syringe) swaps account for nearly 50% of medication errors associated with anesthesia professionals and often result in serious outcomes.^{2,4} In the present case, the substitution of the compressed carbon dioxide gas cylinder—mistaken for an E cylinder of oxygen—represents a drug swap error.⁴ While current anesthesia machines are replete with safeguards and monitors to prevent delivery of a hypoxic gas mixture during anesthesia, no such standards exist during transport of a critically ill patient. Indeed, this case illustrates how easily conventional equipment in the cardiovascular operating room can be assembled and deliver an anoxic

gas mixture. Therefore, we posit that compressed medical gases should be treated with safety protocols such as standardizing the design (as well as color coding) of medical gas cylinders, requirements for a more robust labelling system, a redesign of tubing and connectors to gas cylinders that prevent “drug swaps,” and perhaps the addition of oxygen sensors to portable gas delivery equipment.

Following a root cause analysis (RCA) of this event, our institution made the following changes to operating room (OR) policy and procedures:

1. We eliminated the need for portable cylinders of carbon dioxide within the OR environment. Operating rooms were provided with a central pipeline source of carbon dioxide if needed during cardiac surgery for patients at risk for air emboli during open heart procedures.
2. All carbon dioxide E cylinders with connected flow regulators and nipple were removed from the operating theater.
3. Additional education and awareness training is now provided to all anesthesia professionals to enhance vigilance during transport of critically ill patients.

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REFERENCES:

1. Whitaker DK, Wilkinson DJ. Medical gases: time to adopt the global standard? *APSF Newsletter*. 2014;29:17–18. <https://www.apsf.org/article/medical-gases-time-to-adopt-the-global-standard/>. Accessed October 28, 2019.
2. Wahr JA, Abernathy JH 3rd, Lazarra EH, et al. Medication safety in the operating room: literature and expert-based recommendations. *Br J Anaesth*. 2017;118:32–43.
3. Kothari D, Gupta S, Sharma C, Kothari S. Medication error in anaesthesia and critical care: a cause for concern. *Indian J Anaesth*. 2010;54:187–192.
4. Eichhorn JH. Medication mishap mitigation drives 2008 APSF workshop: “Syringe swaps” in OR still harming patients. *APSF Newsletter*. 2008-9;23:57–59. <https://www.apsf.org/article/syringe-swaps-in-or-still-harming-patients/>. Accessed November 6, 2019.
5. Sarangi S, Babbar S, Taneja D. Safety of the medical gas pipeline system. *J Anaesthesiol Clin Pharmacol*. 2018; 34:99–102.

When Medical Equipment Standards Fail to Protect Patients

by Jeffrey Feldman, MD, MSE

Standards applied to the design of medical equipment have a variety of purposes, with patient safety being paramount. In this issue of the *APSF Newsletter*, we have two examples where patient safety was threatened using equipment where the standards intended to protect patients proved to be inadequate.

Bond and co-authors describe an incident where a sevoflurane vaporizer was misfilled with isoflurane. The result was a mixture of isoflurane and sevoflurane delivered to the patient with the potential for overdosage of the isoflurane. Agent-specific filling systems were adopted many years ago to prevent this type of error. Although the cause of the misfilling is not proven, the authors demonstrate that it is entirely possible to place a keyed sevoflurane filler cap on an isoflurane bottle. In this case, neither the standards for a keyed collar on the bottle nor the color coding were sufficient to prevent misfilling of the sevoflurane vaporizer. The authors are to be congratulated for believing the information provided by the agent monitor in the absence of an obvious explanation and making appropriate changes to patient care.

Kruppiah and co-authors provide a case report of a patient receiving 100% carbon dioxide via an AMBU bag connected directly to a carbon dioxide cylinder. Medical gas cylinders are keyed with a pin index system so that they can only be connected to specific yokes. In this case, the pin index system worked as designed, but the mounted flowmeter (which was labelled Carbon Dioxide) included a green nipple for connecting gas supply tubing. The green color of the nipple indicates an oxygen source, and the design allowed for commonly used oxygen supply tubing to be connected to the flowmeter. Again, the standards in place intended to prevent patient injury from accidental CO₂ administration were insufficient to protect the patient.



Medical equipment design standards will not protect patients 100% of the time. Human error remains a factor in causing patient injury. There are numerous examples of properly connected gas tubing yet patient injury from contamination of gas supply lines or compressed gas cylinders filled with the wrong gas. The risk of this problem is one of the motivations for requiring an oxygen analyzer for every anesthetic to insure that oxygen is indeed being delivered. Some standards are however more robust than others. The Diameter Index Safety System (DISS) is designed to insure that gas supply lines are connected properly between the wall supply and the gas delivery device, e.g., anesthesia machine or ventilator. This standard uses the diameters of both the internal nozzle and external screw connector to insure that gas connections are proper. DISS is a very robust standard in that it is not possible to misconnect gases when using this standard. An older standard, the Pin Index Safety Standard (PISS) is designed for connecting high-pressure medical gas cylinders to a regulator or other ancillary

equipment but has failed to prevent patient injury numerous times.

When standards fail to protect patients, we are reminded of the importance of monitoring devices, and vigilance by care providers, to identify when there are problems and intervene before there is harm. Both of the reports here demonstrate the importance of human intervention. That said, we should seek to make our standards as robust as possible to minimize the risk of harm. These case reports show that both the standards for anesthetic agent key filling and flowmeters that mount to compressed gas cylinders could be improved. It also reminds us all that no standard or monitor takes the place of a vigilant health care professional.

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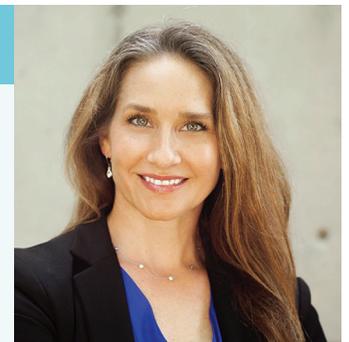
Dr. Feldman has received consulting compensation from Micropore, Inc., and Dräger Medical.

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The APSF is eager to connect with patient safety enthusiasts across the internet on our social media platforms. Over the past year, we have made a concerted effort to grow our audience and identify the best content for our community. We've seen increases in followers and engagement by several thousand percent, and we hope to see that trajectory continue into 2020. Please follow us on Facebook at <http://www.facebook.com/APSForg> and on Twitter at www.twitter.com/APSForg.

Also, connect with us on LinkedIn at <https://www.linkedin.com/company/anesthesia-patient-safety-foundation-apsf/>. We want to hear from you, so please tag us to share your patient safety related work, including your academic articles and presentations. We'll share those highlights with our community. If you are interested in joining our efforts to amplify the reach of APSF across the internet by becoming an Ambassador, please reach out via email to Marjorie Stiegler, MD, our Director of Digital Strategy and Social Media at stiegler@apsf.org, Emily Methangkool, MD, the APSF Ambassador Program Director at methangkool@apsf.org, or Amy Pearson, Social Media Manager at pearson@apsf.org. We look forward to seeing you online!



Marjorie Stiegler, MD, APSF Director of Digital Strategy and Social Media.

Cardiopulmonary Sentinel Event During Endoscopic Retrograde Cholangiopancreatography (ERCP): Oversedation or Gas Embolism?

by Brian Thomas, JD

INTRODUCTION

Gas embolism occurring during endoscopy procedures such as endoscopic retrograde cholangiopancreatography (ERCP), where a mucosal membrane is breached is a rare, but potentially devastating complication that can cause permanent significant neurological injuries or fatal cardiopulmonary collapse.¹ Due to its rarity and lack of clinical suspicion, air embolism during gastroenterology (GI) endoscopy procedures is often unrecognized until it is too late for successful treatment.² The difficulty in diagnosing air embolism often results in confusing the embolism with inappropriate anesthetic care, or with an acute ischemic or hemorrhagic event.¹ The following case demonstrates how a sudden cardiovascular collapse during ERCP due to a suspected, undiagnosed air embolism resulted in a serious adverse event.

CASE STUDY

A 74-year-old, 72.6 kg ASA IV female with past medical history significant for diabetes, chronic renal failure, transient ischemic attacks, coronary artery disease (coronary artery stent placement), congestive heart failure, hypertension, and peripheral vascular disease (status post-below-knee amputation) presented to the emergency department with an abrupt onset of diffuse abdominal pain. The patient was scheduled to have an ERCP due to her choledocholithiasis, biliary obstruction, and abdominal pain.

The anesthesia professional conducted the pre-anesthetic evaluation. He additionally noted that the patient had significant anxiety. The plan was to perform monitored anesthesia care with intravenous sedation sufficient to enable the procedure.

In the endoscopy suite, the patient was placed in the semi-prone position after electrocardiogram, blood pressure cuff, pulse oximetry, and ETCO₂ monitoring were applied. She was administered 2 mg midazolam, 100 mcg fentanyl, 30 mg lidocaine, 0.2 mg glycopyrrolate and 15 mg propofol intravenously in total for her 30-minute procedure.

The endoscopy then began with insertion of the scope accompanied by insufflation of air to enable endoscopic visualization. Approximately five minutes into the procedure, the endoscopist noted difficulty identifying the major duodenal papilla and also documented “a very large peri-ampullary diverticulum” in that area. A few minutes thereafter, the patient became bradycardic and hypotensive. The patient’s blood pressure was treated twice with 10 mg ephedrine, and she was turned supine for mask/bag ventilation. Approximately five minutes later, the patient was pulseless with electrocardiogram unchanged. Cardiopulmonary resuscitation was started with chest compressions, 1 mg epinephrine was given, the patient was intubated and a pulse was immediately restored. Pulse oximeter readings throughout the case ranged from 92 to 100 percent. The procedure



was terminated and the patient was taken to the Intensive Care Unit.

A neurologist consult noted chronic ischemic changes in the right parietal-occipital lobe and a chronic lacunar infarction of the cerebellum on computed tomography. Probable anoxic encephalopathy was noted on electroencephalogram. The patient never regained any neurologic function and she expired one week postoperatively.

The patient’s husband sued the anesthesia team and the hospital alleging the patient was oversedated, which caused cardiopulmonary depression, PEA arrest, and anoxic brain injury.

The plaintiff’s expert opined that the anesthetic was “excessive” and the propofol should not have been administered. He opined further that when the patient first became bradycardic and hypotensive, the certified registered nurse anesthetist (CRNA) should have called the supervising anesthesiologist, immediately intubated the patient, and administered epinephrine. He was also critical that the supervising anesthesiologist was not “carefully and continuously” monitoring the CRNA.

The defense forensic pathology expert did not identify any evidence of an anesthetic overdose. Because of the lack of an autopsy and toxicology reports, there was little evidence to determine the exact cause of death.

The defense anesthesiology expert was fully supportive of the care and treatment provided by the anesthesiologist and CRNA. He opined that appropriate doses of anesthesia were utilized in this case. The defense expert noted that the CRNA and anesthesiologist responded to the changes in the blood pressure and heart rate very rapidly. The immediate response to the epinephrine restored blood pressure and provided adequate perfusion for delivery of oxygen. The expert did not believe the documented timeline supported the theory of anoxia from oxygen deprivation. He opined that the patient’s sudden cardiovascular collapse upon being turned supine was the result of an air embolism caused by the ERCP procedure and the gastroenterologist’s difficulty finding the hepatopancreatic ampulla. The expert cited numerous cases in the medical literature supporting his causation findings.

This case was submitted to a mediation panel prior to trial. Following each side’s submission of their respective briefs and exhibits, the panel awarded the patient’s husband money damages

against both the hospital on behalf of the CRNA and the anesthesiologist. All parties accepted the panel’s awards and the hospital settled for a confidential amount. With the PPM’s insured anesthesiologist’s consent, this case was settled for \$10,000.

DISCUSSION

In GI endoscopy cases, venous gas embolism (VGE) is caused by gas bubbles, under pressure, entering the vasculature allowing the passage of gas into the systemic circulation.³ VGE, including intracardiac and intracerebral air embolism, is highly lethal with a mortality rate of up to 21%, according to a recent study.⁴

Different mechanisms causing gas entry into the venous system have been proposed: invasive procedures (e.g., sphincterotomy, biliary stent), exposure to high gas insufflation pressure, intramural dissection by the gas, and biliary-hepato-venous fistula. Other identified risk factors for VGE include previous procedures of the bile duct system, abdominal trauma, metal stent placement, and digestive system inflammation.⁵ In a series of over 800 patients reported on by Afreen et al., the incidence of VGE as documented by precordial Doppler ultrasound was 2.4% (20/843 patients) of which 10 had significant hemodynamic alterations. In addition, stent removal combined with stent replacement revealed a 4.4% incidence of VGE, while cases during cholangioscopy had a 9.1% incidence.⁵

Unexpected cardiovascular events in the GI endoscopy suite, during or at the end of an endoscopy procedure where a mucosal or vascular barrier may be or had been breached should alert clinicians to consider gas embolism.

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REFERENCES

1. Wills-Sanin B, Cardenas YR, Polanco L, et al. Air embolism after endoscopic retrograde cholangiopancreatography in a patient with Budd-Chiari syndrome, case reports in critical care 2014; <https://doi.org/10.1155/2014/205081>
2. Goins KM, May JM, Hucklenbruch C, et al. Unexpected cardiovascular collapse from massive air embolism during endoscopic retrograde cholangiopancreatography. *Acta Anaesth Scand.* 2010;54:385–388.
3. Chandrasekhara V, Khashab MA, Muthusamy VR, et al. Adverse events associated with ERCP. *Gastrointest Endosc.* 2017;32–47.
4. McCarthy CJ, Behraves S, Sailendra N, et al. Air embolism: diagnosis, clinical management and outcomes. *Diagnostics.* 2017;7:5.
5. Hauser G, Milosevic M, Zelic M, et al. Sudden death after endoscopic retrograde cholangiopancreatography (ERCP)—case report and literature review. *Medicine.* 2014;93, e235. <https://doi.org/10.1097/MD.000000000000235>
6. Afreen LK, Nakayama T, Ness TJ, et al. Incidence of venous air embolism during endoscopic retrograde cholangiopancreatography. *Anesth Analg.* 2018;127:420–423.

Gas Embolism Events in GI Endoscopy: What We Know Now and How We Can Mitigate Them Through the Routine Use of CO₂ Insufflating Gas Instead of Air

by Nikolaus Gravenstein, MD, and Brian Thomas, JD

There is an accumulating pulmonary and/or cardiac adverse event case experience arising out of gastroenterology (GI) endoscopy suites. High morbidity and mortality embolic events have been reported when the insufflating gas from a gastroenterologist's endoscope enters a patient's circulation.¹ It is those gas embolism events that are often conflated with poor anesthetic care, and where there is still, in many cases, a demonstrable opportunity to reduce harm by using carbon dioxide instead of air as the endoscope insufflating gas. We are reminded of this in a recent infographic.²

Anesthesia professionals are involved in endoscopy suite cases to enable patient cooperation, immobility, and amnesia. These cases are variably described as monitored anesthesia care or general anesthesia. We think they are best described as intravenous general anesthetics (drug-induced loss of consciousness during which patients do not arouse during otherwise painful stimulation), i.e., the patient accepts endoscope insertion and manipulation. If one accepts the target patient state as one of at least moderate sedation ranging to general anesthesia, expected monitoring includes capnography. Capnography in the setting of what is often a natural, and in the case of upper endoscopy procedures also a shared, airway is technically more challenging than in an endotracheally intubated patient. Nasal cannula and/or oral airway derived capnography makes it difficult to reliably and quickly identify clinically significant decreases in ET_{CO₂}, as would occur with a gas embolism. In an intubated patient a drop in ET_{CO₂} is much more obvious and unambiguous because there is generally a very stable ventilation and gas sampling relationship with every exhaled breath. The vagaries of natural airway capnography may obfuscate an otherwise significant drop in ET_{CO₂}. This might delay provider recognition of perturbations in pulmonary blood flow, blood pressure, heart rate, or oxygen saturation that are associated with significant gas embolism.

Clinically significant gas embolization during an endoscopy procedure can happen any time there is a connection between the insufflating gas and the vascular system and intraluminal pressure is higher than local vascular pressures. When the venous pressures are generally less than 20 mmHg, the natural question to ask is: Can the gas pressure at the tip of a GI

endoscope be higher than venous pressure? The answer is, perhaps surprisingly, very much so. In an *in vitro* model, it was determined that the gas pressure at the tip of the endoscope may easily exceed 175 or even 300 mmHg depending on the endoscopy system and flow settings.³ This is possible because the GI endoscopy system insufflating gas is flow- and not pressure-limited. Thus, if there is no place for the insufflating gas to decompress around the scope, then the local venous pressure is easily exceeded by the gas pressure which, along with a mucosal or vascular breach (e.g., biopsy, myotomy, ulcer, inflammation, necrosectomy, dilation, or a stent placement), enables a gas embolism scenario.

Not all endoscopy procedures have the same risk. In purely diagnostic procedures, the risk is indeed negligible. There is a strong argument in favor of making CO₂ the default insufflating gas for all GI endoscopy procedures, because we cannot consistently predict when a biopsy will be taken, a mucosal surface to be breached, and the insufflating gas pressure at the tip of the endoscope also exceed venous pressure. Carbon dioxide insufflated laparoscopic surgeries, set a safety precedent for this which we are all familiar with. This is in part, because CO₂ is more readily absorbed and less likely to be lethal than air if it gets into the vascular system.

Using carbon dioxide for GI endoscopy is not novel. In 1974 it was suggested to use carbon dioxide to reduce the risk of explosion with colon polyp cautery.⁴ Yet, in a 2008 survey, fewer than half of the endoscopists reported that they were aware that using CO₂ for insufflation was an option for GI endoscopy procedures and <5% used CO₂ for insufflation.⁵ Another potential benefit of the CO₂ gas use is that it may cause less postprocedure discomfort than air.⁶

We as anesthesia professionals should support the use of CO₂ insufflating gas during GI endoscopic procedures. It is readily available and demonstrably safer.⁷ To help persuade yourselves and gastroenterology colleagues, the 2016 American Society for Gastroenterology Technology Committee reported that, "Several authors recommend the use of CO₂ instead of room air as an insufflation agent during endoscopy because of the rapid tissue

absorption of CO₂, in the event that gas embolism takes place. This recommendation appears to be particularly valid for higher risk interventions including ERCP, cholangioscopy, and endoscopic necrosectomy."⁸

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REFERENCES:

1. Donepudi S, Chavalitthamrong D, Pu L, et al. Air embolism complicating gastrointestinal endoscopy: a systematic review. *World J Gastrointest Endosc.* 2013;5:359–65.
2. Wanderer JP, Nathan N. Bubble trouble: venous air embolism in endoscopic retrograde cholangiopancreatography. *Anesth Analg.* 2018;127:324.
3. Bursian A, Gravenstein N, Draganov PV, et al. GI endoscopy insufflating gas pressure: how regulated is the regulator? Paper presented at: International Anesthesia Research Society Annual Meeting; May 2016; San Francisco, CA.
4. Rogers BH. The safety of carbon dioxide insufflation during colonoscopic electrosurgical polypectomy. *Gastrointest Endosc.* 1974;20:115–117.
5. Janssens F, Deviere J, Eisendrath P, et al. Carbon dioxide for gut distension during digestive endoscopy: technique and practice survey. *World J Gastroenterol.* 2009;15:1475–1479.
6. Wang WL, Wu ZH, Sun Q, et al. Meta-analysis: the use of carbon dioxide insufflation vs. room air insufflation for gastrointestinal endoscopy. *Aliment Pharmacol Ther.* 2012;35:1145–1154.
7. Afreen LK, Bryant AS, Nakayama T, et al. Incidence of venous air embolism during endoscopic retrograde cholangiopancreatography. *Anesth Analg.* 2018;127:420–423.
8. ASGE Technology Committee, Lo SK, Fujii-Lau LL, Enestvedt BK, et al. The use of carbon dioxide in gastrointestinal endoscopy. *Gastrointest Endosc.* 2016;83:857–865.

Additional references:

- Sharma VK, Nguyen CC, Crowler MD, et al. A national study of cardio-pulmonary unplanned events after GI endoscopy. *Gastrointest Endosc.* 2007;66:27–34.
- Ben-Menachem T, Decker GA, Early DS, et al. Adverse events of upper GI endoscopy. *Gastrointest Endosc.* 2012;76:707–18.
- Ali Z, Bolster F, Goldberg E, et al. Systemic air embolism complicating upper gastrointestinal endoscopy: a case report with post-mortem CT scan findings and review of literature. *Forensic Sci Res.* 2016;1:52–57.
- Dellon ES, Hawk JS, Grimm IS, et al. The use of carbon dioxide for insufflation during GI endoscopy: a systematic review. *Gastrointest Endosc.* 2009;69:843–849.

Malignant Hyperthermia Preparedness: Stocking, Drilling, and Offsite Considerations

by Ryan J. Hamlin, MD, and Mohanad Shukry, MD, PhD

INTRODUCTION

This July marks the 60th anniversary of the publication of a Letter to the Editor describing the inherited condition, now known as Malignant Hyperthermia (MH), in a young man who developed metabolic derangements when exposed to halothane.¹ The worldwide scientific community has come a long way since then to characterize the condition. We now have a better understanding of the pathophysiology, presentation, and treatment of this potentially fatal condition. Although difficult to truly characterize, MH crisis prevalence is estimated to be 1 in 100,000 administered anesthetics,² which means, thankfully, most anesthesia professionals may only participate in a true MH crisis once in their career, if at all. This fact, coupled with the possible fatality of an MH crisis, makes the preparation to manage these rare events paramount for the safety and good outcome of those patients.

We focus on two essential steps in the preparation to manage an MH crisis: stocking a dedicated MH Cart to be used during an acute crisis, and developing an institutional multidisciplinary mock MH drill for anesthesia and operating room personnel. Lastly, we discuss the special considerations of MH preparedness for offsite and remote anesthetizing locations.

MH CART

The Malignant Hyperthermia Association of the United States (MHAUS) recommends medications and supplies be readily available for use, within 10 minutes of recognizing an MH crisis.³ Since the likelihood of complications increases 1.6 times with every 30-minute delay in treatment with dantrolene,⁴ having a centrally located cart with the necessary medications and equipment expedites the initiation of treatment. When dantrolene administration was delayed beyond 50 minutes, complication rates increased to 100%.⁵

The organization of the MH cart should be divided into two main categories; (1) medications and (2) supplies necessary for an MH crisis. There are many commercially available MH carts offered for purchase. Regardless of the type of cart use, however, dantrolene is the crux of the treatment of MH and should be the easiest to access (preferably located in the top drawer). Currently two formulations of dantrolene exist. Dantrium®/Revonto® is the older formulation, which provides 20-mg dantrolene sodium in 60 mL following reconstitution in sterile water USP. The second formulation, Ryanodex®, is a new formulation that is an injectable suspension of dantrolene sodium providing 250 mg of dantrolene sodium in 5 mL following reconstitution with sterile water USP. Selection between the two formulations should dictate how many vials should be stocked. If Dantrium®/Revonto® is stocked, MHAUS recommends

having 36 vials available in each institution. If Ryanodex® is stocked, MHAUS recommends having 3 vials available. Sterile water should be stocked alongside the dantrolene in the first drawer as it is necessary to reconstitute the powdered dantrolene. The amount stocked should reflect the formulation of dantrolene (larger volume is required for Dantrium®/Revonto® compared to Ryanodex®). If Dantrium®/Revonto® is the stocked formulation, we would recommend stocking thirty-six 100 ml vials of sterile water rather than one-liter bags of sterile water to prevent the inadvertent intravenous administration of a hypotonic solution. Three 10 ml vials of sterile water can be stocked if Ryanodex® is the stocked formulation. Although clinical effectiveness and dosing are similar between the two formulations, the lower storage space needed for Ryanodex®, the lower number of staff needed to mix it and the increased speed of mixing and administering the loading dose makes Ryanodex® more practical during a crisis, especially when number of staff available is limited.

Other medications stocked in the cart should be focused on the treatment of the sequelae of the hypermetabolic condition, such as severe acidemia, hyperkalemia, cardiac arrhythmias, and severe hyperthermia. Sodium bicarbonate (8.4% 50 ml vials x 4) should be stocked to aid in correction of severe acidemia. Calcium chloride 10% (10 ml vials x 2), Dextrose 50% (50 ml vials x 2), and regular insulin (100 unit/ml 1 vial) should be stocked for treatment of hyperkalemia. Lidocaine (100 mg/5 ml or 100 mg/10 mls x 3) or amiodarone (150 mg vial x 4) should be stocked according to ACLS/PALS guidelines for any cardiac derangements. Refrigerated one-liter saline bags are recommended for cooling (some commercially available MH carts have a small refrigerator for saline and insulin, but every institution can decide on this matter).

Supplies within the MH cart should be focused on the administration of MH medications, temperature management, patient monitoring, and laboratory testing. Central location of equipment can provide a quicker response and more coordinated care. Syringes (60 ml x 5) to dilute Dantrium®/Revonto® or (5 ml x 3) for Ryanodex® should be located close to dantrolene. Two pairs of activated charcoal filters (Vapor-Clean™, Dynasthetics, Salt Lake City, UT) should be included. These filters attach to the inspiratory and expiratory ports of the anesthesia machine to quickly reduce the concentration of gas (<5ppm). Two pairs are recommended as the filters may become saturated after one hour of use and a replacement could be needed. Other patient care equipment includes intravenous catheters of various sizes for intravenous and arterial



access, and a large sterile drape that can be used to rapidly cover a surgical wound.

Temperature management of MH patients is very important as the risk of death increases with increasing temperature.⁴ Following discontinuation of the triggering agent, dantrolene administration is the most important pharmacologic temperature management strategy. Noninvasive treatments for hyperthermia include strategic ice packing, forced air cooling, circulating cool water blankets, cold intravenous fluids, and ice-water immersion.⁶ An ice bucket, large and small plastic bags for ice, and disposable cold packs can be placed next to the patient easily to help with cooling measures. A pressure bag should also be included for rapid administration of cold saline.

Monitoring equipment should focus on accurate and reliable measurements. For temperature monitoring, esophageal or other core (nasopharyngeal, tympanic, or rectal) temperature probes should be considered. Central and arterial lines should be considered for critically ill patients and transducer kits should be available. Foley catheters and a urometer are also important for monitoring urine output to insure adequate diuresis to prevent acute renal injury from myoglobinuria.

The last category of equipment is laboratory supplies. Frequent laboratory testing is performed in a MH crisis and the laboratory testing equipment should be readily available and labeled for use. Equipment for blood gas measurement capability such as heparinized blood gas syringes or syringes for point of care testing should be included. Blood specimen tubes for creatinine kinase, myoglobin, comprehensive metabolic panel (Na⁺, K⁺, Ca⁺, BUN, HCO₃⁻, Mg⁺), lactate, complete blood count, and coagulation studies should be easily accessible. Lastly, a collection device for urine with testing supplies for myoglobin should be considered. Myoglobinuria can be quickly screened for by the presence of pigmenturia and blood on a urine dipstick, if available in your institution, and

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MHAUS Recommends Yearly MH Drills

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should be followed up with a formal urinalysis and quantitative urine myoglobin level.

MOCK MH DRILL

The utility of medical simulation is well demonstrated and its application to rare medical events can improve familiarity while providing hands-on experience.⁷ Each facility is different in their training options, but MHAUS recommends teams perform mock MH drills every year;⁸ we provide a few tips to maximize the team's benefit from these valuable exercises.

Selection of a clinical scenario should be based on the applicability to the team and organization. It would not be worthwhile to use a scenario of an elderly patient if the team solely provides care for pediatrics, for example. The development of a scenario is best drawn from prior experiences inside the organization; otherwise, commercially available ones can be used. Besides the selection of the scenario, selecting a leader or facilitator is also a critical decision. Managing an MH crisis is a team sport and everyone needs to engage and participate. By selecting an anesthesia professional to lead these drills, participants' buy-in improves since most health care providers look to anesthesia personnel for guidance during an MH crisis.

The training during a mock MH drill should focus on two main aspects: rapid recognition of MH signs and symptoms and the logistics of coordinating the clinical management team. Once the diagnosis is made, the leader should assign roles to participants based on skill levels. If personnel resources are limited, such as in a surgery center for example, staff may need to handle multiple roles. The danger of only assigning one role to a participant is that when an actual MH crisis occurs, that person may not be in the facility.

Once roles are clearly delineated, the drill should focus on the logistics of providing care in an MH crisis rather than physically treating the patient. For example, the insertion of lines and a Foley catheter should not be the focus. Rather, the focus should be on locating the MH cart, contents of the MH cart, who is reconstituting dantrolene, who is getting ice, who is calling the MH Hotline, etc. If available, the team should reconstitute an expired vial or two of dantrolene, especially if the institution uses the 20 mg/60 ml formulation, as this process is very laborious.

In a surgery center, the drill should include a post-stabilization transport plan. This is crucial to have in place before an actual MH episode occurs. Depending on how far the facility is, we recommend, whenever staffing allows, an anesthesia professional, from the transferring or receiving facility, accompany the patient to the receiving hospital to allow for the continued

administration of dantrolene during transport and for a formalized face-to-face transfer of care with the receiving team.

As mentioned before, MHAUS recommends MH drills every year, but these authors perform it in their institution every 6 months to keep information relatively fresh with the staff. Another consideration is to rotate between scheduled and unscheduled drills. If the purpose of the drill is to assess readiness, there is no better way than an unexpected drill. This is obviously more time-consuming, but may be more effective.

Following any simulated drill, it is important to have a debriefing session. Debriefing allows team members to discuss what went well and what could be improved. Debriefing also acts as an opportunity to clarify any lingering question team members may have. It is also an opportune time to discuss the importance of contacting the North American MH Registry of MHAUS at 888-274-7899 for all confirmed or suspected MH cases to assist in completing an online form (AMRA) in order to capture valuable MH data. All debriefings should be done in a safe and nonjudgmental way. Lastly, it is important to develop a contingency plan. What if an MH crisis happens in the middle of the night? Who else can be deployed to assist? Will someone be called in? Those questions need to be discussed and ironed out before an actual crisis.

OFFSITE/REMOTE PREPAREDNESS

The growth of free-standing surgical facilities using only intravenous anesthesia techniques without inhalational agents has increased steadily. In an effort to contain cost, MHAUS was requested to reconsider the recommendations related to dantrolene stocking at centers that only have succinylcholine for emergency airway management. The request is related to the perceived infrequent use of succinylcholine, the low incidence of MH susceptibility in the general population, and the cost of stocking dantrolene.

As of today, MHAUS recommends facilities that stock and have the potential to administer any triggering agent, including succinylcholine without volatile agents, should have dantrolene immediately available in the event a patient in that facility develops MH.⁹ In contrast, the Society for Ambulatory Anesthesia (SAMBA) Position Statement on the Use of Succinylcholine for Emergency Airway Rescue permits class B facilities to stock succinylcholine for airway rescue without dantrolene in situations where no volatile agents are used.⁹ Larach et al. demonstrated succinylcholine administered in the absence of volatile agents, over a wide dose range to manage difficult ventilation, can trigger MH events that warrant dantrolene treatment.¹⁰ This report shifts the consideration of succinylcholine-induced MH from the realm of highly unlikely into the realm of similarly rare but devastating emer-

gencies, such as cardiac arrest and anaphylaxis. With such events, successful management depends upon the presence of well-established protocols for early recognition and prompt treatment. Office-based anesthesia professionals also need to consider the relatively remote nature of the practice when establishing their malignant hyperthermia protocol. Dantrolene treatment delay increased complications every 10 minutes, reaching 100% with a 50-minute delay.⁹

As a patient safety organization, MHAUS contends the availability of dantrolene allows clinicians to administer succinylcholine for life-threatening airway emergency without delay due to fear of patients developing MH without the only known antidote immediately available.

CONCLUSION

Early recognition and treatment of MH is essential to improve survival rates. Stocking a dedicated MH cart, routinely performing simulated MH crisis drills, and having enough dantrolene stocked can save lives.

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REFERENCES

- Denborough MA, R Lovell R. Anesthetic deaths in a family. *Lancet*. 1960;2:45.
- Brady JE, Sun LS, Rosenberg H, Li G. Prevalence of malignant hyperthermia due to anesthesia in New York State, 2001-2005. *Anesth Analg*. 2009;109:1162.
- Stocking MH Cart. Malignant Hyperthermia Association of the United States website. <https://www.mhaus.org/faqs/category/frequently-asked-questions-about/stocking-an-mh-cart/> Accessed February 24, 2020.
- Larach MG, Brandom BW, Allen GC, et al. Malignant hyperthermia deaths related to inadequate temperature monitoring, 2007–2012: A report from the North American Malignant Hyperthermia Registry of the Malignant Hyperthermia Association of the United States. *Anesth Analg*. 2014;119:1359–66
- Riaz S, Larach MG, Hu C, et al. Malignant hyperthermia in Canada: characteristics of index anesthetics in 129 malignant hyperthermia susceptible probands. *Anesth Analg*. 2014;118:381–387
- Litman RS, Smith VI, Larach MG, et al. Consensus statement of the Malignant Hyperthermia Association of the United States on unresolved clinical questions concerning the management of patients with malignant hyperthermia. *Anesth Analg*. 2019;128:652–659.
- Henrichs BM, Avidan MS, Murray DJ, et al. Performance of certified registered nurse anesthetists and anesthesiologists in a simulation-based skills assessment. *Anesth Analg*. 2009;108:255–262.
- MHAUS Knowledge Base. <https://www.mhaus.org/cfw/index.cfm?controller=kb&action=view-article&key=3B6A48A5-5056-A852-6BAC-E4538FD554F9&seoTitle=mh-training-frequency>. Accessed April 27, 2020.
- Joshi GP, Desai MS, Gayer S, Vila H. Succinylcholine for emergency airway rescue in class B ambulatory facilities. *Anesth Analg*. 2017;124:1447–1449.
- Larach MG, Klumpner TT, Brandom BW, et al. on behalf of the Multicenter Perioperative Outcomes Group. Succinylcholine use and dantrolene availability for malignant hyperthermia treatment. *Anesthesiology*. 2019;130:41–54.

Educating the Next Generation: A Curriculum for Providing Safe Anesthesia in Office-Based Surgery

by Brian M. Osman, MD, and Fred E. Shapiro, DO, FASA

INTRODUCTION

In 1979, fewer than 10% of all surgeries were performed as outpatient procedures. In just about 25 years, approximately 70% of operative procedures have evolved beyond the walls of hospitals, with 15–20% occurring in office-based practices.¹ In 1985, the Society for Ambulatory Anesthesia (SAMBA) was founded as a national society with a mission statement to “strive to be the leader in the perioperative care of the ambulatory surgical patient.” Their focus includes anesthesia in the ambulatory setting, non-operating room anesthesia (NORA) and office-based anesthesiology (OBA), patient care, medical education, patient safety, research, and practice management.²

As office-based anesthesia became more popular, SAMBA recognized the importance of keeping education initiatives current and published an anesthesia resident educational curriculum designed to provide a comprehensive experience in the anesthetic management of ambulatory surgical patients in an office-based environment. The evolution of this curriculum began in 2006 with Dr. Fred Shapiro creating the first Harvard Medical School office-based anesthesia Continuing Medical Education (CME) course, “The Manual of Office-Based Anesthesia Procedures,” presented to the Academy at Harvard Medical School, which led to the inception of an OBA curriculum, and was later incorporated into the SAMBA national program. In 2010, Dr. Shireen Ahmad and Dr. Fred Shapiro co-authored the SAMBA Anesthesia OBA Curriculum, which was reviewed by the SAMBA taskforce on Ambulatory and Office-Based Anesthesia, approved by the SAMBA Board of Directors, and added to the website.³ It was designed to be an educational guide for a one-month specialty rotation during the final (CA-III) year of residency in Anesthesiology. Since its initial inception in 2010, the number, complexity, and variety of cases in the office-based anesthesia environment has experienced exponential growth. There have been many changes to the literature, practice management, accreditation requirements and office-based practice legislation, and the new 2020 curriculum update strives to be consistent with current standards of safe practice.⁴

UPDATE TO THE LITERATURE 2010 TO 2020

To better understand the trajectory of OBA, it is important to demonstrate a general knowledge of how the literature has changed over

Table 1. Key Studies Addressing Safety in Office-Based Anesthesia Prior to 2010*

Key Papers, Year	Method	Finding
Hoefflin et al, 2001 ⁸	23,000 cases from single plastic surgery office	No significant complications.
Vila et al, 2003 ⁷	2 years of adverse events reported to Florida board	10-fold relative risk in office compared with ASC.
Koch et al., 2003 ⁹	Compared 896 office-based vs. 634 hospital-based intraocular procedures performed from 1983 to 1986	No systemic complications reported in the office-based group.
Perrot et al, 2003 ¹⁰	>34,000 oral and maxillofacial surgeries	Complication rate of 0.4%–1.5% for all types of anesthesia.
Byrd et al, 2003 ¹¹	5316 cases from single plastic surgery office	Complication rate 0.7% (mostly hematoma)
Fleisher et al., 2004 ¹²	Evaluated Medicare patients (age >65 years), more than half a million outpatient procedures from 1994 to 1999.	1-week mortality rates in the office, ASC, and hospital as 0.035%, 0.025%, and 0.05% of outpatient procedures, respectively.
Bhananker et al., 2006 ¹³	Reviewed closed malpractice claims in the ASA Closed Claims Database since 1990	> 40% of MAC claims involved death or permanent brain injury. Respiratory depression accounted for 21% of claims, half of which preventable by better monitoring.
Coldiron et al, 2008 ¹⁴	Self-reported data to Florida board from 2000 to 2007	174 adverse events; 31 deaths in this time frame.
Keys et al., 2008 ¹⁵	1,141,418 outpatient procedures performed at AAAASF facilities	23 deaths observed. PE was the cause of 13 of those deaths. Office-based abdominoplasty most commonly associated with death from PE.

Abbreviations: ASC – Ambulatory Surgical Center; ASA – American Society of Anesthesiologists; AAAASF – American Association for Accreditation of Ambulatory Surgery Facilities; MAC – Monitored Anesthesia Care; DVT – deep vein thrombosis; PE – pulmonary embolism;

*Adapted with permission from: Shapiro FE, Punwani N, Rosenberg NM, et al. Office-based anesthesia: safety and outcomes. *Anesth Analg.* 2014;119:276–85.

the last 25 years. There was a lack of uniform reporting of adverse events in the office setting and also a lack of randomized controlled trials to determine how office-based procedures and anesthesia affect patient morbidity and mortality.⁵ As a result, studies on this topic are retrospective in nature. Some of the early literature expressed concerns about the safety of office-based procedures and anesthesia. A 2001 study by Domino et al. examined the reported complications in the American Society of Anesthesiologists (ASA) Closed Claims Database and reported that office-based claims were approximately three times more severe than Ambulatory Surgery Centers (ASCs).⁶ Vila et al. concluded in 2003 that the relative risk of complications and death was 10 times greater in the office-based practices compared to ASCs.⁷ Other important studies prior to 2010 are listed in Table 1 and demonstrated mixed results.

The literature since 2010 suggests that patient safety and outcomes in the office have

greatly improved. Shapiro et al. concluded in 2014 that this was likely due to proper credentialing of facilities and practitioners, increased accreditation, adherence to national societies guidelines, the incorporation of safety checklists, and the implementation of additional oversight at both state and federal levels.^{5,16} Table 2 highlights some of the important OBA literature from 2010 to 2019.

In 2017, Gupta et al. analyzed a large database of over 183,914 cases from 2008 to 2013 and concluded that complication rates in Office Based Surgery Center (OBSC), ASCs, and hospitals were 1.3%, 1.9%, and 2.4%, respectively.²⁰ This demonstrated that, at least for cosmetic procedures, accredited office-based surgery centers were a safe alternative to ASCs and hospitals. Overall, anesthesia and surgery in the office is becoming increasingly safe and the recent data suggest that it is attributable to

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Implementing Safe Office-Based Anesthesia Practices

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proper patient and procedure selection, as well as adhering to adequate safety protocols.^{1,21} Patients treated in the office seem to be selected based on their low risk for complications.¹ As the popularity of OBA continues to increase, different systematic approaches have been developed to promote the standardization of safe practices. These include published guidelines and position statements, emergency protocols, safety checklists, medication management and surgical risk reduction, new regulations and accreditation measures.²¹

PRACTICE MANAGEMENT

The OBA curriculum highlights system-based practice changes relevant to the office environment in 2020. Ultimately, anesthesia professionals are responsible for ensuring an adequate standard of care and should thoroughly inspect the office-based practices they agree to work in, taking into consideration the administration, facility engineering, equipment, and facility accreditation. In 2010, Kurrek and Twersky responded to this by publishing a provider checklist highlighting common elements that should be reviewed before providing anesthesia services in an office-based practice.²⁴

As the demand for OBA continues to increase, additional efforts have come forward to promote patient safety. Since 1999, the ASA has continued to offer general recommendations for proper patient and procedure selection, as well as insisting on the presence of medical directors responsible for policies that adhere to current regulations, adequately trained and credentialed health care providers, and facility compliance with local and national legislation.²⁵ These guidelines were amended in 2009, reaffirmed in 2014, and have contributed to the creation of other important recommendations such as the Guidelines for Ambulatory Anesthesia (reaffirmed in 2018), and a multi-disciplinary collaboration (ASA, American Association of Oral and Maxillofacial Surgery, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, Society of Interventional Radiology) to create the 2018 Practice Guidelines for Moderate Procedural Sedation.^{25,26}

In 2010, the Institute for Safety in Office-Based Surgery (ISOBS) created a patient safety checklist adapted from the World Health Organization (WHO) Surgical Safety Checklist, customizable to the office-based practice. In 2017, the ISOBS Office-Based Surgery Checklist (Figure 1) was added to the American Academy of Healthcare Risk Management (ASHRM) resource manual for

Table 2. Key Studies Addressing Safety in Office-Based Anesthesia After 2010*

Key Papers, Year	Method	Finding
Twersky et al, 2013 ¹⁷	Review of ASA Closed Claims Data from 1996-2011	Outcomes did not differ between groups, with death in 27% and permanent disabling injury in 17% of OBA claims.
Soltani et al, 2013 ¹⁸	AAAASF data from 2000–2012; only reviewed plastic surgery offices	22,000 of 5.5 million cases; complication rate 0.4%; 94 deaths; 0.0017% death rate.
Failey et al, 2013 ¹⁹	2611 cases from single AAAASF facility under TIVA/conscious sedation	No deaths, cardiac events, transfers; 1 DVT
Shapiro et al, 2014 ⁵	Comprehensive literature review	Improvements in patient outcomes likely with credentialing, accreditation, safety checklists, state and federal regulation, and national societies.
Gupta et al, 2017 ²⁰	Compared outcomes of 183,914 plastic surgery procedures in accredited facilities	Complication rates in OBSC, ASCs, and hospitals were 1.3%, 1.9%, and 2.4%, respectively. Multivariate analysis showed lower risk in OBSC when compared to ASCs or a hospital.
Young et al, 2018 ⁸	Literature review and 2018 update	Rates of complications from the latest publications are similar to or lower than previously reported. The number of primary literature reports is increasing, both retrospective and prospective.
Seligson et al, 2019 ¹	Updated review of the literature from 2017 to 2019	Anesthesia and surgery in the office is becoming increasingly safe, likely due to increased patient selection.
De Lima et al, 2019 ²¹	Updated review of the literature from 2016 to 2019	OBA safe with proper patient selection and adequate safety protocols. Current regulations are focused on reducing surgical risk through the implementation of patient safety protocols and practice standardization. Strategies include cognitive aids for emergencies, safety checklists, facility accreditation standards.
Osman et al, 2019 ²²	Safe anesthesia for office-based plastic surgery: proceedings from the Korean society of plastic and reconstructive surgeons 2018 meeting	72% of the 16.4 million cosmetic procedures performed in 2016 were performed in the office. As of 2018, only 33 states have guidelines, policies, or position statements regarding OBS, makes gathering outcome data difficult.
Osman et al, 2019 ²³	A comprehensive review and 2019 update to OBA	A review of the literature, updates on patient safety, patient and procedure selection, practice management, accreditation, quality improvement programs, and legislations and regulations.

Abbreviations: ASA – American Society of Anesthesiologists; OBA – office-based anesthesia; ASC – AAAASF - American Association for Accreditation of Ambulatory Surgery Facilities; TIVA – total intravenous anesthesia; OBSC – office-based surgery center; ASC - Ambulatory Surgical Center; OBA – Office-based anesthesia ; OBS-Office-based surgery; DVT-deep venous thrombosis.

*Adapted with permission from: Shapiro FE, Punwani N, Rosenberg NM, et al. Office-based anesthesia: safety and outcomes. *Anesth Analg*. 2014; 119:276-85.

Office-Based Surgery and can be found at <https://www.ashrm.org/>. These types of safety checklists have shown promise in the literature for the reduction of medical errors and the improvement of patient safety and outcomes.^{27,28}

With the continued growth of office-based surgery, staff and practitioners should have easy access to critical information to assist with crisis management. The use of cognitive aids, tailored to the office-based practice, can prove to be effective in emergency situations. ISOBS

reviewed the most common emergencies specific to the office and published an OBA emergency manual in 2017 to provide a concise and user-friendly resource tool with treatment algorithms. This emergency manual is based on principles from widely accepted crisis manuals (advanced cardiovascular life support, Malignant Hyperthermia Association of the United States, Stanford, Massachusetts General Hospital), and it offers algorithms for 26 of the most

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Safety Checklists Are Designed for Office-Based Surgery

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common emergency scenarios in the OBA practice.²¹ As of 2018, this manual is available on the Emergency Manuals Implementation Collaborative (EMIC) website (<https://www.emergencymanuals.org/>).

Another practice management consideration with the 2020 update to the SAMBA Office-Based Anesthesia Curriculum was to provide an evidence-based review of anesthesia techniques to improve outcomes and patient satisfaction while mitigating risk during office-based procedures. Several studies prior to 2010 concluded that procedures could safely be performed in the office and, although not clearly

defined, the evidence supports success with general anesthesia, total intravenous anesthesia (TIVA), local anesthesia with moderate sedation, and conscious sedation.^{10,11,19} As of 2020, there are new concepts and improved methods of patient care. For example, Enhanced Recovery After Surgery (ERAS) techniques, such as multimodal therapies and non-opioid-based perioperative analgesia, can be utilized to enhance the patient perioperative experience by reducing postoperative pain, postoperative nausea and vomiting (PONV), opioid pain medication use, and length of stay for inpatient procedures and same-day surgery.²³ Multimodal therapies and non-opioid-based perioperative analgesia are some of the key components of ERAS. These include procedure appropriate regional blocks, oral and intravenous non-opioid adjuncts such

as steroids, pregabalin, NSAIDs, acetaminophen, clonidine, intravenous lidocaine, and intraoperative injection of long-acting liposomal bupivacaine.²³ Improved pain control can be achieved while reducing the opioid-related side effects.

Other useful tools include decision aids developed to incorporate the patient in the decision-making process regarding their own anesthetic and surgical plan. These educational tools can easily be applied to the office setting and are another important aspect of ERAS. The ASA, for example, has several patient-centric decision aids available on their website, which includes decision aids for epidural and spinal anesthesia and peripheral nerve

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Safety Checklist for Office-Based Surgery

from the Institute for Safety in Office-Based Surgery (ISOBS)

Introduction <small>Preoperative encounter; with practitioner and patient</small>	Setting <small>Before patient in procedure room; with practitioner and personnel</small>	Operation <small>Before sedation/analgesia; with practitioner and personnel*</small>	Before discharge <small>On arrival to recovery area; with practitioner and personnel</small>	Satisfaction <small>Completed post-procedure; with practitioner and patient</small>
<p><i>Patient</i></p> <p>Patient medically optimized for the procedure?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No, and plan for optimization made</p> <p>Does patient have DVT risk factors?</p> <p><input type="checkbox"/> Yes, and prophylaxis plans arranged</p> <p><input type="checkbox"/> No</p> <p><i>Procedure</i></p> <p>Procedure complexity and sedation/analgesia reviewed?</p> <p><input type="checkbox"/> Yes</p> <p>NPO instructions given?</p> <p><input type="checkbox"/> Yes</p> <p>Escort and post-procedure plans reviewed?</p> <p><input type="checkbox"/> Yes</p>	<p>Emergency equipment check complete (e.g. airway, AED, code cart, MH kit)?</p> <p><input type="checkbox"/> Yes</p> <p>EMS availability confirmed?</p> <p><input type="checkbox"/> Yes</p> <p>Oxygen source and suction checked?</p> <p><input type="checkbox"/> Yes</p> <p>Anticipated duration ≤ 6 hours?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No, but personnel, monitoring, and equipment available</p>	<p>Patient identity, procedure, and consent confirmed? <input type="checkbox"/> Yes</p> <p>Is the site marked and side identified?</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> N/A</p> <p>DVT prophylaxis provided?</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> N/A</p> <p>Antibiotic prophylaxis administered within 60 minutes prior to procedure? <input type="checkbox"/> Yes <input type="checkbox"/> N/A</p> <p>Essential imaging displayed?</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> N/A</p> <p><i>Practitioner confirms verbally:</i></p> <p><input type="checkbox"/> Local anesthetic toxicity precautions</p> <p><input type="checkbox"/> Patient monitoring (per institutional protocol)</p> <p><input type="checkbox"/> Anticipated critical events addressed with team</p> <p><input type="checkbox"/> Each member of the team has been addressed by name and is ready to proceed</p>	<p>Assessment for pain?</p> <p><input type="checkbox"/> Yes</p> <p>Assessment for nausea/vomiting?</p> <p><input type="checkbox"/> Yes</p> <p>Recovery personnel available?</p> <p><input type="checkbox"/> Yes</p> <p><i>Prior to discharge: (with personnel and patient)</i></p> <p>Discharge criteria achieved?</p> <p><input type="checkbox"/> Yes</p> <p>Patient education and instructions provided?</p> <p><input type="checkbox"/> Yes</p> <p>Plan for post-discharge follow-up?</p> <p><input type="checkbox"/> Yes</p> <p>Escort confirmed?</p> <p><input type="checkbox"/> Yes</p>	<p>Unanticipated events documented?</p> <p><input type="checkbox"/> Yes</p> <p>Patient satisfaction assessed?</p> <p><input type="checkbox"/> Yes</p> <p>Provider satisfaction assessed?</p> <p><input type="checkbox"/> Yes</p>

This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged. *Adapted from the WHO Surgical Safety Checklist.
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Figure 1. Institute for Safety in Office-Based Surgery Safety Checklist for Office-Based Surgery*
Abbreviations: AED – automated external defibrillator; DVT – deep vein thrombosis; EMS – emergency medical services; MH – malignant hyperthermia; NPO – nothing by mouth.
*Adapted with permission from: WHO Surgical Safety Checklist. Courtesy of the Institute for Safety in Office-Based Surgery [ISOBS], Inc., Boston, MA.
Developed by Alex Ariaga, MD, Richard Urman, MD, MBA, and Fred Shapiro, DO.

Office Based Surgery Legislation Seeks to Standardize Safe Office-Based Practices

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blocks, and is currently developing one for Monitored Anesthesia Care.²⁹

These are valuable resources to guide patients through the process of making informed decisions and participating as an active member of the health care team.

ACCREDITATION

The three major nationally recognized accrediting organizations that govern office-based practices include the Accreditation Association for Ambulatory Health Care (AAAHC), The Joint Commission (TJC), and American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF).²³ All three of these agencies have similar requirements for accreditation, but there are some subtle differences. Kurrek and Twersky have a 2010 publication that highlights some of these key differences.²⁴ Over the past 10 years, accreditation agencies have recognized some of the patient safety issues in OBS and have focused greater attention to the office. There are currently 33 states that require offices that perform medical and surgical procedures to obtain accreditation, and this number is expected to increase in the future. It is important for the resident to be familiar with these three agencies and what accreditation means to an office-based practice, as it provides valuable information about how a facility cares for their patients. Some examples include important issues about how a facility is maintained, personnel and their qualifications, infection control, cleaning and maintenance of equipment, emergency preparedness, credentialing and privileging, documentation (i.e., HIPAA), and quality improvement, among others. Accreditation of office-based facilities allows a third party to monitor activities, provide external benchmarking, validation, and acknowledgement of a nationally recommended standard of care.

LEGISLATION

There have been significant changes to office-based legislation in the last 25 years, going from almost completely unregulated to some form of mandated legislation or regulation in all 50 states and the District of Columbia. OBS legislation falls primarily on the individual states, which regulate OBS practices with a wide degree of variability. Some states may not require an OBS practice to register or obtain facility licensure (answering to the respective state’s medical licensing board), while other states require that office-based practices register with the department of health or practitioner’s licensing board. More stringent states may hold offices to the same standard as ASCs or hospitals. As of August 1st, 2016, only 24 states and the District of Columbia had at least one

law that regulated facilities that perform OBS.³⁰ There remained 17 states that did not require adverse event reporting at that time, but several high-profile cases resulting in death or severe injury found their way to the public through media reports.²³ In 2020, one of the major accreditation agencies (The Joint Commission) actively monitors state legislative and regulatory activities, and provides a quick reference tool on their website to review state specific requirements (<https://www.jointcommission.org/accreditation-and-certification/state-recognition/>).³¹ The ultimate focus of OBS legislation is to increase accountability and standardize safe practice in office-based anesthesia and surgery.

CONCLUSION

An update to the SAMBA Office-Based Anesthesia Curriculum was essential as office-based surgery and anesthesia has experienced exponential growth over the last 25 years. There have been many changes to the literature, practice management, accreditation requirements, and OBA legislation. With the increase in procedures, complexity, and variety of cases, and the continued lack of uniform regulation and legislation in the office-based practice, there is a need to maintain the educational curriculum consistent with the most recent safe practices and standards. The 2020 update to the curriculum is deliberately presented as goal-driven and is not prescriptive in nature. The OBA practice is dynamic, fluid, and rapidly changing, and we present the evidence to maintain standards to support the best practices as of 2020.

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REFERENCES

- Seligson E, Beutler SS, Urman RD. Office-based anesthesia: an update on safety and outcomes (2017-2019). *Curr Opin Anaesthesiol*. 2019; 32:756–761.
- About us: our mission, our vision, our goal. The Society for Ambulatory Anesthesia (SAMBA) 2020. Available at: <https://sambahq.org/about-us/>. Accessed Feb. 27, 2020.
- Ahmad S, Shapiro FE. Society for Ambulatory Anesthesia Office-Based Curriculum. The Society for Ambulatory Anesthesia (SAMBA) 2010. Available at: <https://samba.socius.com/p/cm/ld/fid=72>. Accessed Mar. 2, 2020.
- Osman BM, Shapiro FE. Society for Ambulatory Anesthesia Office-Based Anesthesia Revised 2020 Curriculum. The Society for Ambulatory Anesthesia (SAMBA) 2020. Available at: https://samba.memberclicks.net/assets/2019%20Curriculum%20Update_Corrected3.pdf. Accessed Mar. 2, 2020.
- Shapiro FE, Punwani N, Rosenberg NM, et al. Office-based anesthesia: safety and outcomes. *Anesth Analg*. 2014;119:276–85.
- Domino KB. Office-based anesthesia: lessons learned from the Closed Claims Project. *ASA Newsletter*. 2001;65:9–11,15.
- Vila H Jr, Soto R, Cantor AB, Mackey D. Comparative outcomes analysis of procedures performed in physician offices and ambulatory surgery centers. *Arch Surg*. 2003;138:991–995.
- Hoefflin SM, Bornstein JB, Gordon M. General anesthesia in an office-based plastic surgical facility: a report on more than 23,000 consecutive office-based procedures under general anesthesia with no significant anesthetic complications. *Plast Reconstr Surg*. 2001;107:243–251.
- Koch ME, Dayan S, Barinholtz D. Office-based anesthesia: an overview. *Anesthesiol Clin North America*. 2003;21:417–243.
- Perrott DH, Yuen JP, Andresen RV, Dodson TB. Office-based ambulatory anesthesia: outcomes of clinical practice of oral and maxillofacial surgeons. *J Oral Maxillofac Surg*. 2003;61:983–995.
- Byrd HS, Barton FE, Orenstein HH, et al. Safety and efficacy in an accredited outpatient plastic surgery facility: a review of 5316 consecutive cases. *Plast Reconstr Surg*. 2003;112:636–641.
- Fleisher LA, Pasternak LR, Herbert R, Anderson GF. Inpatient hospital admission and death after outpatient surgery in elderly patients: importance of patient and system characteristics and location of care. *Arch Surg*. 2004;139:67–72.
- Bhananker SM, Posner KL, Cheney FW, et al. Injury and liability associated with monitored anesthesia care: a closed claims analysis. *Anesthesiology*. 2006;104:228–234.
- Coldiron BM, Healy C, Bene NI. Office surgery incidents: what seven years of Florida data show us. *Dermatol Surg*. 2008;34:285–291.
- Keyes GR, Singer R, Iverson RE, et al. Mortality in outpatient surgery. *Plast Reconstr Surg*. 2008;122:245–250.
- Young S, Shapiro FE, Urman RD. Office-based surgery and patient outcomes. *Curr Opin Anaesthesiol*. 2018;31:707–712.
- Twersky R, Posner KL, Domino KB. Liability in office-based anesthesia: closed claims analysis. *Anesthesiology*. 2013;2013:2013.
- Soltani AM, Keyes GR, Singer R, et al. Outpatient surgery and sequelae. *Clin Plast Surg*. 2013;40:465–473.
- Failey C, Aburto J, de la Portilla HG, et al. Office-based outpatient plastic surgery utilizing total intravenous anesthesia. *Aesthet Surg J*. 2013;33:270–274.
- Gupta V, Parikh R, Nguyen L, et al. Is office-based surgery safe? comparing outcomes of 183,914 aesthetic surgical procedures across different types of accredited facilities. *Aesthet Surg J*. 2017;37:226–235.
- De Lima A, Osman BM, Shapiro FE. Safety in office-based anesthesia: an updated review of the literature from 2016 to 2019. *Curr Opin Anaesthesiol*. 2019;32:749–755.
- Osman BM, Shapiro FE. Safe anesthesia for office-based plastic surgery: proceedings from the Korean society of plastic and reconstructive surgeons 2018 meeting. *Arch Plast Surg*. 2019;37:317–331.
- Osman BM, Shapiro FE. Office-based anesthesia: a comprehensive review and 2019 update. *Anesthesiol Clin*. 2019; 37:317–331.
- Kurrek MM, Twersky RS. Office-based anesthesia: how to start an office-based practice. *Anesthesiol Clin*. 2010;28:353–367.
- Guidelines for office-based anesthesia. American Society of Anesthesiologists. 2018. Available at: <https://asahq.org/standards-and-guide-lines/guidelines-for-office-based-anesthesia>. Accessed Mar. 4, 2020.
- Practice guidelines for moderate procedural sedation and analgesia 2018: a report by the American Society of Anesthesiologists Task Force on moderate procedural sedation and analgesia, the American Association of Oral and Maxillofacial Surgeons, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, and Society of Interventional Radiology. *Anesthesiology*. 2018;128:437–479.
- Rosenberg NM, Urman RD, Gallagher S, et al. Effect of an office-based surgical safety system on patient outcomes. *Eplasty*. 2012;12:e59.
- Robert MC, Choi CJ, Shapiro FE, et al. Avoidance of serious medical errors in refractive surgery using a custom preoperative checklist. *J Cataract Refract Surg*. 2015;41:2171–2178.
- Resources from ASA Committees. American Society of Anesthesiologists. 2020 Available at: <https://www.asahq.org/standards-and-guidelines/resources-from-asa-committees>. Accessed Mar. 4, 2020.
- Office-Based Surgery Laws. The Policy Surveillance Program: A LawAtlas Project. 2016. Available at: <http://lawatlas.org/datasets/office-based-surgery-laws>. Accessed Mar. 13, 2020.
- State Recognition. The Joint Commission. 2020. Available at: <https://www.jointcommission.org/accreditation-and-certification/state-recognition/>. Accessed Mar. 13, 2020.

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The Anesthesia Professional’s Role in Opioid Stewardship

by Adam C. Adler, MD, and Arvind Chandrakantan, MD, MBA

INTRODUCTION

Health care professional-prescribed opioids have played a significant role in the growing opioid epidemic. In 2017, more than 70,000 drug-related deaths occurred in the United States with over 47,000 a result of opioids.¹ Opioid-related deaths have surpassed deaths related to breast cancer, gun violence, and automotive accidents (Table 1). According to the National Institutes of Health, the yearly estimated cost of the opioid epidemic exceeds \$78.5 billion including the costs of health care, lost productivity, addiction treatment, and criminal justice-related expenses.¹

A significant driver of the opioid addiction issues relates to medically prescribed opioids. Specifically, examination of perioperative opioid prescribing suggests a fair degree of both indiscretion and overprescribing. One study suggests that as many as 80% of opioid-naïve adult patients filled a prescription for opioids following low-postoperative-pain-risk surgical procedures (e.g., carpal tunnel release, laparoscopic cholecystectomy, inguinal hernia repair, or knee arthroscopy).² Additionally, between 2004–2008, the mean number of doses prescribed increased following these low-risk procedures.² A study of 88,637 opioid-naïve adolescents and young adults ages 13–21 years undergoing surgery revealed that 4.8% continued to fill prescriptions for opioids 90 days following low-risk surgery.³

HEALTH CARE PROFESSIONALS AND THE UNINTENDED CONSEQUENCES OF OPIOID PRESCRIPTIONS

Opioids prescribed by health care professionals have resulted in a significant number of opioid-related toxicity cases in children.⁴ From



Figure 1: Process of opioid stewardship from education to retrieval.



Table 1: Comparison of Death Rates Amongst Common Causes in the United States

Cause of Death (year)	Death per reported year	Deaths per day
Opioids (2017)	47,600 ¹	130
Breast Cancer (2016)	41,487*	113
Firearms (2017)	39,773 [†]	109
Automotive Accidents (2018)	36,560 [‡]	100

¹CDC data 2016: <https://gis.cdc.gov/Cancer/USCS/DataViz.html>

[†]NHTSA: <https://www.nhtsa.gov/traffic-deaths-2018>

[‡]CDC: <https://www.cdc.gov/nchs/fastats/injury.htm>

2000–2015, there were 188,468 cases of opioid-related exposures reported to the National Poison Data System in persons < 20 years of age.⁴ Children most at risk were those between ages 0–5 years and adolescents ages 12–17 years with small children at risk of accidental exposures and adolescents at risk of deliberate ingestion.⁴ Pediatric opioid related exposures have resulted in > 3600 pediatric critical care unit admissions between 2004–2015.⁵

Unused opioids following surgery endanger adult and pediatric patients by allowing for non-therapeutic use as well as accidental ingestion. A meta-analysis of studies reviewing postsurgical opioid prescriptions suggested that 42–71% of opioid tablets went unused.⁶ The vast majority of these unused opioids are often stored in the home unsecured and serve as a source for abuse and misuse.⁶

A study of adults undergoing orthopedic surgical procedures suggested that the preopera-

Table 2: Perioperative suggestions to enhance opioid safety and perform risk assessment

- Screen patients for previous opioid use and abuse
- Identify family members at risk for opioid abuse
- Educate patients and families on the dangers of unsecured household opioids
- Discuss proper disposal methods for opioids following the acute pain period
- Invite discussion with perioperative prescribers using nonopioid adjuncts as well as careful consideration on the number of doses prescribed.

tive use of opioids is associated with an increase in the following perioperative complications: respiratory failure, surgical site infections, need for mechanical ventilation, pneumonia, myocardial infarction, postoperative ileus or other gastrointestinal events, and an increase in all-cause mortality.⁷ Additionally, preprocedural long-term opioid use by a family member has been associated with persistent opioid use in opioid-naïve adolescents and young adults following surgical and dental procedures for which opioids are prescribed.⁸ While it is unclear as to who is consuming these opioids (patient vs. family member), it suggests that physicians should be screening patients prior to prescribing opioids to potentially mitigate the long-term use of them by either group.

Health care professionals may have a unique opportunity during the perioperative period to

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address critical issues pertaining to opioid stewardship (Table 2). Anesthesia professionals typically screen patients for recent illness, smoking, and illicit drug use. During the perioperative period, they may also be able to ascertain the opioid risk by inquiring about the patient's personal opioid history as well as those in the patient's home that may be at risk for abuse or misuse. Additionally, the anesthesia encounter provides the opportunity to educate patients on the dangers of opioids and the requirement for proper storage and disposal.

OUR OWN EXPERIENCE IN COMBATING THE OPIOID CRISIS

At our institution, we recently completed an initiative to combat the opioid crisis by combining patient and family education with a simple method for families to dispose of their unused medication.⁹ This project involved providing a pre-addressed and postage-paid envelope for patients to return their unused opioids, followed by an automated reminder email two weeks postoperatively. This was combined with patient and parental education on safe storage and disposal. This pilot had 64 of 331 participants return unused opioids with a total of nearly 3000 mg of oral morphine equivalents removed from these homes (Figure 1). For those that returned opioids, the median rate of return was 58% (interquartile range = 34.7%–86.1%) of the amount prescribed. Demographic variables associated with increased likelihood for return of medication were Caucasian, married, and holding a postgraduate degree. At present we are working with our pharmacy team to enroll all perioperative patients receiving opioids at

discharge in this project with hopes to understand pediatric prescribing on a larger scale.

CONCLUSION

Efforts have been taken to reduce the prescribing of opioids while tracking prescriptions through implementation of individual state prescription monitoring programs. Anesthesia professionals are uniquely positioned to address opioid-related safety issues during the perioperative period. We may be able to reduce patient exposure by identifying patients at risk, educating patients and families on safe opioid storage, and disposal and advocating for appropriate dosing.

REFERENCES

- Scholl L, Seth P, Kariisa M, et al. Drug and opioid-involved overdose deaths - United States, 2013–2017. *MMWR*. 2018;67:1419–1427.
- Wunsch H, Wijeyesundera DN, Passarella MA, Neuman MD. Opioids prescribed after low-risk surgical procedures in the United States, 2004–2012. *JAMA*. 2016;315:1654–1657.
- Harbaugh CM, Lee JS, Hu HM, et al. Persistent opioid use among pediatric patients after surgery. *Pediatrics*. 2018;141:e20172439
- Allen JD, Casavant MJ, Spiller HA, et al. Prescription opioid exposures among children and adolescents in the United States: 2000–2015. *Pediatrics*. 2017;139:e20163382.
- Kane JM, Colvin JD, Bartlett AH, Hall M. Opioid-related critical care resource use in US children's hospitals. *Pediatrics*. 2018;141:e20173335
- Bicket MC, Long JJ, Pronovost PJ, et al. Prescription opioid analgesics commonly unused after surgery: a systematic review. *JAMA Surgery*. 2017;152:1066–71.
- Menendez ME, Ring D, Bateman BT. Preoperative opioid misuse is associated with increased morbidity and mortality after elective orthopaedic surgery. *Clin Orthop Relat Res*. 2015;473:2402–12.
- Harbaugh CM, Lee JS, Chua KP, et al. Association between long-term opioid use in family members and persistent opioid use after surgery among adolescents and young adults. *JAMA Surgery*. 2019;154:e185838.
- Adler AC, Yamani AN, Sutton CD, et al. Mail-back envelopes for retrieval of opioids after pediatric surgery. *Pediatrics*. 2020;145:e20192449

2020 APSF Trainee Quality Improvement (TQI) Recognition Program

SRNA and AA Graduate Students
Project submission deadline:
August 17, 2020 at 5:00 PM CDT

The APSF Committee on Education and Training announces the fifth annual APSF Trainee Quality Improvement Program. The 2020 program will host tracks for student registered nurse anesthetists and anesthesiologist assistant graduate students. The APSF invites all US anesthesia professionals in these two training categories to demonstrate their program's work in patient safety and QI initiatives. The APSF will accept up to two completed submissions from each US-based training program.

More information and details on the submission process are listed on the APSF website ([APSF TQI Program Award](#)). Additionally, please email any inquiries to tqi@apsf.org. The top three projects in each track will receive APSF recognition and financial rewards of \$1,000, \$500, and \$250, respectively. Winners will be notified in late September and announced on the APSF, AANA, and AAAA websites.



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NEW

ASA/APSF Quality Improvement Abstract Award Program

Anesthesia Residents
Project submission deadline:
June 30, 2020 at 11:59 PM ET

APSF and ASA are collaborating in 2020 on a separate Quality Improvement Abstract Award program. Information on how to submit QI abstracts to the ASA Annual Meeting can be found at [ASA MCC/QI Submission Guidelines](#). The top abstracts will receive both ASA and APSF recognition and financial awards. Abstracts invited to be presented at a virtual session will be notified in September. The winners will be chosen after the presentations and announced on the APSF and ASA websites.

Safety and Utility of Nitrous Oxide for Labor Analgesia

by David E Arnolds, MD, PhD, and Barbara M Scavone, MD

This article pertains to non-COVID-19 patient care. There is currently insufficient information about the cleaning, filtering, and potential for aerosolization associated with use of nitrous oxide for labor analgesia in the setting of the ongoing COVID-19 pandemic. As such the Society for Obstetric Anesthesia and Perinatology reported that, “individual labor and delivery units should discuss the relative risks and benefits and consider suspending use.” <https://soap.org/education/provider-education/expert-summaries/interim-considerations-for-obstetric-anesthesia-care-related-to-covid19/>.

Nitrous oxide was discovered in 1772, first used as an analgesic in the 1800s, and has been incorporated into anesthetic practice for over 150 years. It is a colorless, non-pungent, poorly soluble gas with minimal metabolism and rapid onset and offset. Nitrous oxide’s anesthetic action is mediated by noncompetitive inhibition of the NMDA receptor, and its analgesic action is thought to be mediated through supraspinal activation of opioidergic and noradrenergic neurons.¹ While not sufficient to serve as a sole agent for general anesthesia, it possesses analgesic and anxiolytic properties at sub-anesthetic doses, and is useful as a component of general anesthesia and for procedural and dental sedation.² Nitrous oxide is used for management of labor pain in many parts of the world, although significant geographic variation exists. In the United Kingdom, for example, nitrous oxide is used by 50–75% of women, and use is also common in Finland, Australia, and New Zealand.³ In contrast, until recently, nitrous oxide labor analgesia was extremely rare in the United States; as of 2014, nitrous oxide was known to be in use for management of labor pain at only five United States centers.⁴ Since that time and concomitant with the introduction of FDA-approved devices for self-administration of a blended mixture of 50% N₂O and 50% O₂, interest in the use of nitrous oxide for labor analgesia in the United States has rapidly increased, and at least 500 centers in the United States are thought to currently offer nitrous oxide for labor pain management.⁵ While anesthesia professionals in the United States are familiar with the use of nitrous oxide in the operating room, the rapid introduction of nitrous oxide in obstetrics has raised questions about the utility and safety of nitrous oxide in this setting.^{6,7} These concerns are primarily centered around the effectiveness of nitrous oxide for labor analgesia, as well as ensuring maternal, fetal, and occupational safety.

Epidural analgesia is the most effective form of pain relief in labor. Compared to the wealth of data on the effectiveness of neuraxial analgesia or parenteral opioids, there is relatively little regarding the degree of pain relief provided by nitrous oxide. Much of the available data suggests a modest analgesic effect at best. One study found no decrease in pain scores with nitrous oxide compared to placebo in early labor,⁸ and use of nitrous oxide did not lead to a significant decrease in pain scores in a recent study in the United States.⁹ Several studies on the effectiveness of nitrous oxide for labor pain relief have included comparators that are not



used in contemporary obstetric analgesia, such as methoxyflurane¹⁰ or sevoflurane,¹¹ making interpretation of the degree of pain relief relative to modern analgesic strategies challenging. A recently conducted systematic review concluded that evidence regarding the effectiveness of nitrous oxide for labor analgesia is insufficient or of low strength.⁴ Establishing the degree of labor pain relief provided by nitrous oxide is an area ripe for future research.

Many women are satisfied with nitrous oxide, even if they report that it does not provide good pain relief.¹² Nitrous oxide has known nonanalgesic effects, such as anxiolysis, which may be valued by some women, and qualitative analysis of women’s experience with nitrous oxide during labor suggests that these nonanalgesic and partial analgesic effects contribute to maternal satisfaction.⁵ These findings highlight that pain relief is not the only driver of satisfaction with anesthetic care during labor and delivery and point to the complexities of the labor and birth experience.¹³ Nitrous oxide may be of particular benefit to women who place more value on the ability to freely ambulate during labor, the sense of control resulting from use of a self-administered, noninvasive agent, or non-analgesic effects than on maximal pain relief. Nitrous oxide may also be valuable for women who prefer to avoid neuraxial analgesia and parenteral opioids as part of a birth plan, or who have contraindications to neuraxial analgesia.

A key consideration in the use of nitrous oxide for labor analgesia focuses on ensuring maternal safety. Nitrous oxide can expand air-filled spaces, and conditions such as a recent pneumothorax or inner ear or retinal surgery represent contraindications to nitrous oxide use (Table 1). While these conditions are rare on labor and delivery, they must be considered. Patients should be counseled regarding known

side effects of nitrous oxide, which include nausea, dizziness, sedation, and a sense of claustrophobia from the mask.¹⁴ Nitrous oxide irreversibly inhibits the vitamin B-12 dependent enzyme methionine synthase, which has key roles in the folate and S-adenosyl methionine (SAM) cycles. Concerns exist regarding the potential hematologic, neurologic, and cardiovascular risks associated with nitrous oxide use in general anesthesia,¹ although the bulk of the available evidence supports the overall safety of nitrous oxide in most settings and populations.² Nitrous oxide exposure has rarely been associated with subacute combined degeneration of the spinal cord in vitamin B12 or folate deficient patients,¹⁵ and known vitamin B-12 or folate deficiency is a contraindication to nitrous oxide use. Unfortunately, levels are not routinely checked during pregnancy, despite the fact that up to 29% of women in the third trimester may have vitamin B-12 insufficiency.¹⁶ Testing for B-12 and folate levels or avoiding nitrous oxide should be considered for patients at elevated risk for vitamin B-12 or folate deficiency, such as those following a vegan diet or with extensive bowel resections.

Nitrous oxide at high concentrations has the potential to cause diffusion hypoxia, although this would not be expected to occur with the commonly used mixture of 50% O₂/50% N₂O.⁴ Nitrous oxide is also contraindicated for patients who require supplemental O₂ therapy, either for maternal oxygen desaturation or for intrauterine fetal resuscitation. Finally, nitrous oxide is a recreational drug of abuse with serious consequences from long-term use,¹⁷ and the possibility of an increased future risk for recreational abuse in women first exposed to nitrous oxide for labor analgesia has not been studied. In summary, while labor nitrous oxide is generally considered safe for the mother and is not known to have significant effects on labor progress,^{3,18} mothers must be screened for known contraindications to nitrous oxide use to minimize maternal risk.

Fetal concerns surrounding maternal nitrous oxide utilization include the possibility of immediate neonatal effects as well as the potential for long-term hematopoietic or neurodevelopmental sequelae. While nitrous oxide freely crosses the placenta, the rapid offset of nitrous oxide predicts a limited immediate neonatal effect, and studies examining short-term outcomes such as umbilical cord gases and Apgar

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Parturients Should Be Appropriately Screened Before Using Nitrous Oxide

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scores have not found any evidence of short-term adverse neonatal outcomes associated with maternal nitrous oxide use.^{3,4} Thus, while intrapartum nitrous oxide does not appear to have immediate adverse neonatal consequences, the long-term effects are unknown. In adults, nitrous oxide exposure for greater than 6 hours as part of a general anesthetic inhibits hematopoiesis,¹⁹ but no similar studies have been done in the immediate neonatal period. Neurologic toxicity in the form of subacute combined spinal cord degeneration has been reported only in the setting of prolonged recreational abuse, in the setting of rare congenital disorders, or in patients that are vitamin B-12 or folate deficient.¹² In addition, nitrous oxide acts at the NMDA receptor, and NMDA receptor antagonists have been associated with neuroapoptosis in the developing brain in animal models in a time- and agent-dependent fashion.²⁰ Nitrous oxide as a sole agent has not been linked to neuroapoptosis,¹ and the relevance of these animal models to pediatric anesthesia or anesthetic agents administered in pregnancy has not been established and is widely debated. No studies on neurologic toxicity or sequelae have been conducted in neonates of mothers utilizing nitrous oxide in labor, although the lack of case reports of neurotoxicity despite the long history of nitrous oxide use in labor worldwide may be somewhat reassuring. The influence of nitrous oxide on either short- or long-term neonatal outcomes in premature infants, who may be particularly vulnerable to any potential adverse effects of nitrous oxide, has not been examined. The rapid offset of nitrous oxide mitigates potential concerns about its transfer into breast milk, although the influence, if any, of intrapartum nitrous oxide use on the initiation of breastfeeding is unknown. In summary, nitrous oxide use in labor does not appear to have immediate neonatal adverse effects, but the potential for long-term impact on the neonate has not been well studied.

In addition to concerns regarding maternal and neonatal safety, the use of nitrous oxide during labor and delivery raises occupational safety concerns. These concerns have been driven primarily by retrospective survey data suggesting the possibility of an increased risk of spontaneous abortion and/or low birth weight among women with occupational exposure to nitrous oxide.¹ While there is no clear evidence for toxicity associated with occupational exposure, long-term prospective epidemiological data are lacking. The National Institute of Occupational Safety and Health recommends a maximal time-weighted average level of exposure to nitrous oxide of no more than 25 ppm over an 8-hour period. Compared to well-ventilated operating rooms where nitrous oxide is most commonly delivered through a closed circuit, nitrous oxide utilization in a labor suite presents unique challenges. Without scavenging of

exhaled gases, occupational exposure to nitrous oxide during labor and delivery can exceed recommendations.²¹ Scavenging requires not only appropriate equipment, but also that the patient exhale into a tight-fitting mask. Even some centers utilizing appropriate scavenging are not able to achieve compliance with recommended occupational exposure limits.²² It is clear that a monitoring plan is a key component of safe nitrous oxide implementation on labor and delivery.

In summary, the use of nitrous oxide for labor analgesia is rapidly expanding in the United States. The history of nitrous oxide use in this setting in other countries, as well as limited experience in the United States, suggests that it is likely safe for the mother, neonate, and for those who work on labor and delivery. Rigorous evidence demonstrating this, however, is lacking and should be a research priority. The availability of nitrous oxide is not a substitute for neuraxial analgesia, and 40%–60% of women who initially choose nitrous oxide later convert to neuraxial analgesia.^{9,12} Furthermore, the introduction of nitrous oxide did not change the neuraxial labor analgesia utilization rate in one center.²³ The impact of nitrous oxide labor analgesia on the general anesthesia rate for intrapartum cesarean delivery has not been investigated. Women choosing nitrous oxide in labor should be screened for possible contraindications and counseled appropriately regarding the expected modest analgesic effects, side effects, and particularly the uncertainty regarding the long-term effects of fetal exposure. Additional research into these important questions should be a priority. Finally, appropriate patient education, scavenging, and monitoring is essential to prevent potential toxicity from occupational exposure.

Table 1: Contraindications to Nitrous Oxide Use for Labor Analgesia

Absolute	Relative
Pneumothorax	Risk for B-12 or folate deficiency (i.e., vegan diet, history of bowel resection)
Recent retinal surgery	
Middle ear or sinus infection	Recent opioid administration
Pulmonary Hypertension	Acute intoxication
Vitamin B-12 or folate deficiency	Requirement for supplemental O ₂

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REFERENCES:

- Sanders RD, Weimann J, Maze M. Biologic effects of nitrous oxide: a mechanistic and toxicologic review. *Anesthesiology*. 2008;109:707–722.
- Buhre W, Disma N, Hendrickx J, et al. European Society of Anaesthesiology Task Force on Nitrous Oxide: a narrative review of its role in clinical practice. *Br J Anaesth*. 2019;122:587–604.
- Rosen MA. Nitrous oxide for relief of labor pain: a systematic review. *Am J Obstet Gynecol*. 2002;186:S110–S126.
- Likis FE, Andrews JC, Collins MR, et al. Nitrous oxide for the management of labor pain: a systematic review. *Anesth Analg*. 2014;118:153–167.
- Richardson MG, Raymond BL, Baysinger CL, et al. A qualitative analysis of parturients' experiences using nitrous oxide for labor analgesia: it is not just about pain relief. *Birth*. 2019;46:97–104.
- King TL, Wong CA. Nitrous oxide for labor pain: is it a laughing matter? *Anesth Analg*. 2014;118:12–14.
- Vallejo MC, Zakowski MI. Pro-con debate: nitrous oxide for labor analgesia. *Biomed Res Int*. 2019;2019:4618798–12.
- Carstoniu J, Levytam S, Norman P, et al. Nitrous oxide in early labor. Safety and analgesic efficacy assessed by a double-blind, placebo-controlled study. *Anesthesiology*. 1994;80:30–35.
- Sutton CD, Butwick AJ, Riley ET, et al. Nitrous oxide for labor analgesia: utilization and predictors of conversion to neuraxial analgesia. *J Clin Anesth*. 2017;40:40–45.
- Jones PL, Rosen M, Mushin WW, et al. Methoxyflurane and nitrous oxide as obstetric analgesics. II. A comparison by self-administered intermittent inhalation. *Br Med J*. 1969;3:259–262.
- Yeo ST, Holdcroft A, Yentis SM, et al. Analgesia with sevoflurane during labour: II. Sevoflurane compared with Entonox for labour analgesia. *Br J Anaesth*. 2006;98:110–115.
- Richardson MG, Lopez BM, Baysinger CL, et al. Nitrous oxide during labor: maternal satisfaction does not depend exclusively on analgesic effectiveness. *Anesth Analg*. 2017;124:548–553.
- Hodnett ED. Pain and women's satisfaction with the experience of childbirth: a systematic review. *Am J Obstet Gynecol*. 2002;186:S160–S172.
- Richardson MG, Lopez BM, Baysinger CL. Should nitrous oxide be used for laboring patients? *Anesthesiol Clin*. 2017;35:125–143.
- Patel KK, Munne JC, Gunness VRN, et al. Subacute combined degeneration of the spinal cord following nitrous oxide anesthesia: a systematic review of cases. *Clin Neurol Neurosurg*. 2018;173:163–168.
- Sukumar N, Rafnsson SB, Kandala N-B, et al. Prevalence of vitamin B-12 insufficiency during pregnancy and its effect on offspring birth weight: a systematic review and meta-analysis. *Am J Clin Nutr*. 2016;103:1232–1251.
- Garakani A, Jaffe RJ, Savla D, et al. Neurologic, psychiatric, and other medical manifestations of nitrous oxide abuse: a systematic review of the case literature. *Am J Addict*. 2016;25:358–369.
- Rooks JP. Safety and risks of nitrous oxide labor analgesia: a review. *J Midwifery Womens Health*. 2011;56:557–565.
- O'Sullivan H, Jennings F, Ward K, et al. Human bone marrow biochemical function and megaloblastic hematopoiesis after nitrous oxide anesthesia. *Anesthesiology*. 1981;55:645–649.
- Vutskits L, Xie Z. Lasting impact of general anaesthesia on the brain: mechanisms and relevance. *Nat Rev Neurosci*. 2016;17:705–717.
- Henderson KA, Matthews IP, Adisesh A, et al. Occupational exposure of midwives to nitrous oxide on delivery suites. *Occup Environ Med*. 2003;60:958–961.
- Morley B, Paulsen AW, et al. Nitrous oxide for labor analgesia: is it safe for everyone? *APSF Newsletter*. 2017;32:19–20. <https://www.apsf.org/article/nitrous-oxide-for-labor-analgesia-is-it-safe-for-everyone/>. Accessed May 5, 2020.
- Bobb LE, Farber MK, McGovern C, et al. Does nitrous oxide labor analgesia influence the pattern of neuraxial analgesia usage? An impact study at an academic medical center. *J Clin Anesth*. 2016;35:54–57.

Successful Evidence-Based International Emergency Manual Implementation Strategy

by Kyle Sanchez and Jeffrey Huang, MD

It has been suggested that increasing access to resources and decreasing reliance on rote memory are two potential methods to combat medical errors;¹ both of which can be achieved through the use of cognitive aids, such as emergency manuals (EMs).

Operating room (OR) EMs are paper or digital books with a series of current, medically established guidelines that detail how health care professionals should respond to specific perioperative critical events.^{2,3} The use of EMs by health care providers, especially anesthesia professionals, to guide their performance during nonroutine critical events has been shown to reduce errors and maximize productivity.⁴ It has been demonstrated that health care providers can respond to crises more efficiently,⁴ confidently,^{5,6} and collaboratively^{5,6} with the aid of OR EMs. Additionally, utilizing EMs reduced the likelihood of failure to adhere to lifesaving processes of care by four times.⁷

International awareness of the benefits of EM utilization continues to increase over time,⁸ but implementation itself remains a challenge. Some specific challenges for EM implementation include difficulty building consensus on content and format of EMs, resistance by health care providers who prefer to rely solely on their own skills and experience, infeasibility of ideal studies that measure the effect of EMs on clinical outcomes, and lingering concerns about the pitfalls of EM use, such as fixation on an incorrect diagnosis.⁹

WORKSHOP:

The Anesthesia Patient Safety Foundation (APSF) sponsored a workshop in 2015 entitled *Implementing and Using Emergency Manuals and Checklists to Improve Patient Safety*, where audience discussion elicited recommendations such as the development of a strong social media presence of EMs, inclusion of EMs in the presurgical timeout, creation of a public APSF education packet on EM usage, and use of research to design an EM simple enough to be used without training.⁹

SIMULATION TRAINING:

A lack of sufficient training programs on EMs is reported as the single greatest barrier to EM usage,⁵ and thus choosing an effective method to train providers on the proper use of EMs is critical. Simulation-based education allows for continuous, directed practice that supports the development and advancement of knowledge and clinical skills without risking harm to



patients.¹⁰⁻¹² Since simulation-based medical education has been shown to be superior to traditional education for teaching other technical skills,^{10,13,14} the effectiveness of simulation training on EM usage was studied. Participation in simulation training events has indeed been associated with increased routine use of EMs during critical events.^{4,5,10,15} Additionally, the location of the simulation training (OR versus simulation center) likely has no impact on a provider's propensity to use EMs in future critical events.¹⁰ Thus, the implementation of EMs may be facilitated by participation in simulation competitions or other hands-on educational experiences.

SIMULATION COMPETITION:

Simulation Wars was created in 2017 by the Zhongshan City Society of Anesthesiology in China as a competition to promote simulation training.¹⁶ Participating hospitals were instructed to create a video that demonstrates the application of EMs to an anesthesia-related critical event, with a specific focus on the use of crisis resource management skills.⁹ During the competition's final round, each hospital performed an in-person crisis management demonstration.¹⁶ A 2018 study performed by Huang et al. one year after the inaugural competition found that EM usage during real critical events increased significantly following a simulation training competition.¹⁵

TRAIN THE TRAINER:

With more hospitals adapting simulation training, it is important to ensure that the EM training instructors are proficient and able to organize their own workshops, especially given that many anesthesia professionals report not participating

in simulation trainings because no one organized them.⁵ A two-hour EM simulation instructor training was given at the Chinese Association of Anesthesiologists annual meeting and was shown to be successful in allowing participants to organize their own EM simulation training workshops in their home institutions.¹⁷

FREE BOOKS:

Another potential barrier of EM implementation is the required resources and cost of distributing EMs in every OR of a hospital or health care system. Since there is currently a lack of research on OR EM utilization in China, translated versions of EM were distributed free of charge to anesthesiology departments throughout several hospitals in China in 2018. Clinicians who received EMs demonstrated higher levels of EM simulation training participation, EM usage during critical events, self-review of EMs, and group study of EMs than anesthesia professionals who did not receive free books.⁵ While free EM placement alone is likely unable to provoke actual implementation,¹⁸ free books can enhance the implementation of EMs and actual EM use during critical events,⁵ especially when combined with simulation training and other methods to increase implementation.

BOOK LOCATION:

Currently, there is still no standardized protocol for EM usage, despite the widespread usage of EMs, abundant evidence to support the benefit of EMs when used during critical events, and ongoing national and international efforts to enhance implementation. An obstacle to using EM may be that events in the operating room

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Emergency Manuals Can Come in Book and Electronic Forms

From “Emergency Manual,” Preceding Page happen too quickly.⁵ This obstacle may be overcome by developing a concrete set of instructions regarding the time-sensitive access, handling, and utilization of EMs in routine daily practice. A standardized protocol would be especially beneficial for health care providers with minimal exposure to EMs who become acutely involved in a critical event. The preferred location for EM placement during critical events is the anesthesia station of the OR,⁶ which is congruent with Stanford University EM group’s recommendation.² This location should minimize the time spent retrieving the EM and, thus, facilitate the development of a standardized protocol that allows all providers to quickly and efficiently use an EM in a critical situation.

THE READER’S ROLE:

The preferred reader of EMs during critical events is the most experienced health care professional,⁶ which suggests that the leading team member should assume the reader role. The distinction between the reader and leader is critical because the reader of EMs temporarily assumes a leader-like role with no actual responsibility for the clinical outcome. By assigning the reader role to the most experienced anesthesia professional, any effect of EM usage on clinical outcome—whether positive or negative—will be ascribed to the reader. More research is needed to determine whether the preferred location and reader of EMs have a significant influence on clinical outcomes. Moreover, other parameters related to EM usage should be identified, explored, and standardized to gain a more comprehensive picture. We propose that perhaps the next step toward increasing EM implementation is the development of a standardized protocol for EM usage.

PAPER VERSUS ELECTRONIC EMs:

Determining the most effective format for EMs is critical in creating a standardized protocol for use. There are several potential advantages and disadvantages to the use of hard copy versus digital EMs. Advantages to hard-copy books include familiarity among all providers, independence from electronic platforms or Wi-Fi, and simple modification by replacing or adding pages. However, some disadvantages of paper copies include the requirement to take up OR space and their tendency to get misplaced.¹⁹ On the contrary, electronic EMs may facilitate user-EM interaction, allow a more patient-specific response via input of patient data, and enable decision-making based on elapsed time.¹⁹ Disadvantages of electronic EMs include difficulty with navigation or manipulation of the application, limited display size, and the obvious risk of technological failures. Despite the proposed advantages and disadvantages of these formats, the mode of delivery of EMs—whether paper versus electronic—likely does not affect clinician performance or clinical outcome.¹⁹ Moreover, clinician compli-



ance with the use of EMs and other cognitive aids is also likely unaffected by format.¹⁹

In conclusion, the use of simulation training was among the first methods shown to facilitate the implementation and usage of EMs.^{4,5,10,15,16} Providing formal EM simulation instructor training may nurture the growth and effectiveness of EM simulation programs.¹⁷ Free distribution of EMs may further enhance implementation.⁵ A universal, standardized protocol for EM usage, which specifies parameters such as location of placement and reader role,⁶ is critical to support the development and implementation of EMs worldwide.

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REFERENCES:

1. Leape LL. Error in medicine. *JAMA*. 1994;272:1851–1857.
2. Goldhaber-Fiebert SN, Howard SK. Implementing emergency manuals: can cognitive aids help translate best practices for patient care during acute events. *Anesth Analg*. 2013;117:1149–1161.
3. Goldhaber-Fiebert SN, Lei V, Nandagopal K, Bereknyei S. Emergency manual implementation: can brief simulation-

based or staff trainings increase familiarity and planned clinical use?. *Jt Comm J Qual Patient Saf*. 2015;41:212–220.

4. Goldhaber-Fiebert SN, Pollock J, Howard SK, et al. Emergency manual uses during actual critical events and changes in safety culture from the perspective of anesthesia residents: a pilot study. *Anesth Analg*. 2016;123:641–649.
5. Huang J, Hoang P, Simmons W, Zhang J. Free emergency manual books improve actual clinical use during crisis in China. *Cureus*. 2019;11:e4821.
6. Huang J, Sanchez K, Wu J, Suprun A. Best location and reader role in usage of emergency manuals during critical events: experienced emergency manual users’ opinions. *Cureus*. 2019;11:e4505.
7. Fowler AJ, Agha RA. In response: simulation-based trial of surgical-crisis checklists. *Ann Med Surg*. 2013;2:31.
8. Simmons W, Huang J. Operating room emergency manuals improve patient safety: a systemic review. *Cureus*. 2019;11:e4888. 10.7759/cureus.4888
9. Morell RC, Cooper JB. APSF sponsors workshop on implementing emergency manuals. *APSF Newsletter*. 2016;30:68–71. <https://www.apsf.org/article/apsf-sponsors-workshop-on-implementing-emergency-manuals/>. Accessed October 7, 2019.
10. Huang J, Wu J, Dai C, et al. Use of emergency manuals during actual critical events in China: a multi-institutional study. *Simul Healthc*. 2018;4:253–260.
11. Kneebone R. Simulation in surgical training: educational issues and practical implications. *Med Educ*. 2003;37:267–277.
12. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med*. 2004;79:570–581.
13. McGaghie WC, Issenberg SB, Cohen ER, et al. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. *Acad Med*. 2011;86:706–711.
14. Daniels K, Arafeh J, Clark A, et al. Prospective randomized trial of simulation versus didactic teaching for obstetrical emergencies. *Simul Healthc*. 2010;5:40–45.
15. Huang J, Parus A, Wu J, Zhang C. Simulation competition enhances emergency manual uses during actual critical events. *Cureus*. 2018;10:e3188. 10.7759/cureus.3188
16. Zhang C, Zeng W, Rao Z, et al. Assessment of operating room emergency manual simulation training. [Article in Chinese]. *Perioperative Safety and Quality Assurance*. 2017;5:260–262.
17. Huang J. Successful implementation of a two-hour emergency manual (EM) simulation instructor training course for anesthesia professionals in China. *APSF Newsletter*. Oct 2018;33:60–61. <https://www.apsf.org/article/successful-implementation-of-a-two-hour-emergency-manual-em-simulation-instructor-training-course-for-anesthesia-professionals-in-china/>. Accessed May 5, 2020.
18. Neily J, DeRosier JM, Mills PD, et al. Awareness and use of a cognitive aid for anesthesiology. *Jt Comm J Qual Patient Saf*. 2007;33:502–511.
19. Watkins SC, Anders S, Clebone A et al. Mode of information delivery does not effect anesthesia trainee performance during simulated perioperative pediatric critical events: a trial of paper versus electronic cognitive aids. *Simul Healthc*. 2016;11:385–393.

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Ketamine: A Review of an Established Yet Often Underappreciated Medication

by Jason Kung, MD; Robert C. Meisner, MD; Sheri Berg, MD; and Dan B. Ellis, MD

THE ORIGIN OF KETAMINE

Since its synthesis in a Detroit laboratory nearly six decades ago, ketamine has proven to be a complex medication with unusual properties, heterogeneous, interconnected mechanisms, and diverse, sometimes contested, clinical uses.

Ketamine's story begins in 1956 when scientists identified a new class of anesthetic medications called cyclohexaylamines.¹ The first of this class of medications was called phencyclidine (PCP). In 1962, a new compound was discovered (CI-581) that possessed all of the positive qualities of PCP without major negative side effects such as severe excitation and profound psychosis.² This new medication would eventually be called ketamine. In its initial study, several subjects who received ketamine described feeling as though they had "no arms or legs." Others felt "like they were dead" and experienced vivid hallucinations. These descriptions led researchers to coin the term, "dissociative anesthesia".^{2,3}

BASIC SCIENCE

Ketamine's antagonism of the NMDA receptor is believed to be primarily responsible for its amnestic, anesthetic, and dissociative effects.⁴ NMDA receptor blockade has been shown to block memory formation in rodents.⁵ In addition, spinal NMDA receptors are intimately involved in central sensitization and therefore, repeated agonism may lead to hyperalgesia. Activity with NO synthase, GABA, and acetylcholine may also contribute to the unique and complex actions and side effects seen with ketamine.⁶

Metabolism of ketamine primarily occurs in the liver where ketamine is converted into norketamine, an active metabolite which also has potent anesthetic properties. In addition to the actions of norketamine, the lipophilicity of ketamine may be responsible for ketamine's prolonged distributive half-life of 10–15 minutes following a standard intravenous induction dose of 1 to 2 mg/kg. Unlike other induction medications, patients who receive large doses of ketamine may develop nystagmus, pupillary dilation, and their eyes may not close despite reaching general anesthetic levels of the medication. Table 1 summarizes some of the common benefits and side effects of ketamine.

The physiological and psychotropic effects associated with ketamine have been well described following the first human studies

Table 1. Potential Benefits and Side Effects of Ketamine

Benefits
Maintenance of respiratory drive
Minimal cardiovascular depression
Attenuation of perioperative opiate induced hyperalgesia
Adjunctive treatment of acute/chronic pain syndromes
Antisuiicidal and antidepressive properties
Side Effects
Increased airway secretions; minimal airway reflex attenuation
Elevated heart rate, blood pressure, and SVR; myocardial ischemia in pateints with severe CAD
Hallucinations, confusion, vivid dreams, delirium
Prolonged duration in patients with liver dysfunction
Double vision, blurry vision

SVR, systemic vascular resistance; CAD, coronary artery disease

(Table 1). Increases in blood pressure, heart rate, contractility, and systemic vascular resistance led to the initial description of a sympathomimetic effect of ketamine.² It is now known that this observed increase in sympathetic tone is secondary to adrenal catecholamine release triggered by ketamine. Interestingly enough, ketamine in isolation has a direct negative inotropic effect which is usually muted by this sympathetic surge. Caution should be used when inducing patients with high sympathetic tone (i.e., trauma patients) with ketamine as the cardio-depressive effects of ketamine may overwhelm potential catecholamine release by already-stressed adrenal glands. Prudence should also be exercised in administering ketamine to patients with severe coronary artery disease, as myocardial oxygen demand is disproportionately greater than increased oxygen delivery from ketamine administration.

Ketamine is one of the few intravenous anesthetics that has minimal effects on respiratory patterns. Furthermore, its bronchodilatory effects may be beneficial specifically in asthmatic patients.⁷ The paucity of large randomized control trials along with heterogenous and unreported dosing regimens makes it difficult to determine an optimum bronchodilatory

dose. Adverse respiratory effects such as increased airway secretions may be mitigated with the use of anti-sialogogues.

There are distinct electroencephalogram (EEG) patterns associated with escalating doses of ketamine as patients develop a gamma burst pattern (gamma oscillations interrupted by slow-delta oscillations), followed by a stable beta/gamma pattern.⁸ This EEG progression follows closely with a transition into the ketamine-induced unconscious state. Thus, because there is no isoelectric EEG state associated with ketamine, titrating anesthetic depth to this pattern is not recommended.

Several historical papers have reported that ketamine increases intracranial pressure (ICP).^{9,10} It was postulated that increases in cerebral blood flow (CBF) and cerebral oxygen consumption led to this increase. Therefore, classic teaching was to avoid ketamine in neurological procedures. However, several of these studies allowed patients to breath spontaneously following an induction dose of ketamine, which may have falsely elevated the ICP due to hypercarbia induced vasodilation.¹¹ There have been many recent challenges to this dogma. Current research suggests that when used in mechanically ventilated patients, in conjunction with other sedative medications, there is no increase in ICP.^{12–14} Data for the effect of sub-anesthetic ketamine on ICP is lacking, but when given at this lower, nonsedating dose, the effects on ICP are likely to be minimal.

CURRENT USE IN ANESTHESIOLOGY

After ketamine was approved by the Food and Drug Administration in 1970, its first major widespread use was as a battlefield anesthetic during the Vietnam war.³ In 1985, the World Health Organization labeled ketamine an "Essential Medicine," and it is now thought to be the most commonly used anesthetic in the world.¹⁵

In acute care settings such as the intensive care unit or emergency room, procedural sedation with ketamine has been used safely for decades.¹⁶ Its use intraoperatively has seen a renewed interest with the rise of the opioid epidemic. Ketamine, when given in sub-anesthetic doses, may reduce opiate tolerance and decrease opiate-induced hyperalgesia following surgery.¹⁷ When given to patients with chronic pain undergoing back surgery, ketamine has been shown to reduce pain scores

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Safety Considerations For the Use of Ketamine

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and opiate consumption at various time points postoperatively.¹⁸ It may even be beneficial in opiate-naïve patients undergoing procedures with expected painful postoperative courses.¹⁹ Table 2 summarizes some commonly used dosing ranges of ketamine.

Ketamine’s use in neuraxial anesthesia has been controversial due to the potential for neurotoxicity from preservatives and direct neuronal cell apoptosis.²⁰ However, both etiologies have only been seen in select animal models,^{21,22} and later studies have not demonstrated clinically relevant neurotoxicity in humans.²³ This has led to several studies examining ketamine’s role in blocking the development of post-amputation stump pain²⁴ and reduction of post-thoracotomy pain.²⁵

Ketamine is used often by acute pain services to treat postoperative pain not relieved with standard opioid patient-controlled analgesia (PCA) regimens. Nonsurgical patients presenting with acute or chronic pain exacerbations such as vaso-occlusive crises from sickle cell disease may also benefit from ketamine.²⁶ Dosing is generally lower with infusions less than 0.3 mg/kg/hr, with or without a bolus. The addition of ketamine infusions can reduce opioid consumption and enhance the transition from PCA to oral opioids. There is even evidence to suggest ketamine-containing PCA solutions (1 to 5 mg/bolus) can improve pain control and reduce opioid consumption.²⁷

SAFETY CONSIDERATIONS

Contraindications to ketamine include pregnancy, liver dysfunction, significant coronary disease, and psychosis (Table 3). Elevated ICP, as described previously, does not occur in sedated patients under controlled ventilation.



Two doses of intravenous ketamine, 50mg/ml and 10mg/ml. Source: Wikipedia. <https://creativecommons.org/share-your-work/licensing-considerations/compatible-licenses>

Table 2. Administration Suggestions^{30,35,36}

Route	Dosing range
Anesthetic induction	1–2 mg/kg
Loading dose (for sedation and analgesia)	0.1–0.5 mg/kg given over 60 seconds to avoid respiratory depression and sympathetic response
Bolus/supplemental dose	0.1–0.5 mg/kg as needed
Sedation/analgelsia (for intubated patients)	5–30 mcg/kg/min
Analgesia (for nonintubated patients)	1–5 mcg/kg/min
Treatment resistant depression	0.5 mg/kg over 40 minutes

Elevated intra-ocular pressure (IOP) is a commonly listed contraindication based on early studies,²⁸ but recent evidence suggests minimal fluctuations of IOP.²⁹ The mechanism is thought to be due to changes in extraocular muscle tone.²⁸

Given intra-operatively, standard American Society of Anesthesiologists (ASA) monitoring should be applied whether ketamine is used as the sole anesthetic or as an analgesic adjunct. Sub-anesthetic dosing of ketamine still carries risk of airway compromise, cardiovascular perturbances, and psychomimetic events. In acute care settings, blood pressure, electrocardiogram, and pulse oximetry should be available. According to The Consensus Guidelines on The Use of Intravenous Ketamine for Chronic Pain from the American Society of Regional Anesthesia and Pain Medicine (ASRA), the American Academy of Pain Medicine (AMPA), and the American Society of Anesthesiologists (ASA),³⁰ supervising practitioners should be Advanced Cardiovascular Life Support (ACLS) certified and meet ASA requirements for moderate sedation. Individuals who administer ketamine should hold at least a registered nursing degree, received training in moderate sedation and ketamine pharmacology, and be ACLS certified.

KETAMINE AS AN ANTIDEPRESSANT

Ketamine is produced as a racemic mixture of esketamine and arketamine. In March 2019, scientific and public interest in ketamine erupted with the FDA’s approval of esketamine, racemic ketamine’s positive enantiomer, as a first-in-class antidepressant medication for the management of treatment-resistant depression.³¹

Ketamine demonstrates robust antisuicidal and antidepressant properties.³² But as an antidepressant, it may exert categorically different effects at different serum concentrations, and its effects may not follow standard dose-response curves. At doses well above full induction anesthetic doses, ketamine’s antidepressant effect does not appear to be greater

Table 3. Indications/Contraindications

Indications
Analgesia <ul style="list-style-type: none"> • Acute post operative pain • Chronic pain
Acute or chronic pain exacerbations
Sedation (mechanical ventilation)
Procedural sedation
Rapid sequence intubation
Treatment-resistant depression
Contraindications
Psychosis
Active substance abuse
Severe liver dysfunction
Significant coronary disease
Poorly controlled hypertension

than at sub-anesthetic doses. In this regard, it resembles other psychiatric medications such as trazadone, a common multimechanism medication that functions as a sedative at doses below 150 mg but as an antidepressant at doses above 150 mg.³³

Ketamine’s antisuicidal and antidepressant mechanism of action may be due to serum glutamate concentrations following AMPA activation. In general, clinicians at academic centers who administer intravenous ketamine to patients as a treatment for depression have, until somewhat recently, gravitated toward a dosing regimen of 0.5 mg/kg over 40 minutes (Table 2).³⁴ This tendency reflects the preponderance of research at this dose, which corresponds to a serum concentration of approximately 2000–3000 ng/mL. Treatments are typically administered 1 to 3 times per week. However, ketamine protocols are not widely shared, and a variety of different dosing regimens exist in various centers, with both research and experience in practice suggesting the utility of cautiously up-titrating doses.

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Ketamine May Be Used for Treatment Resistant Depression

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Similar to anesthesia society guidelines,^{30,36} the American Psychiatric Association recommends that providers administering ketamine in outpatient settings should be ACLS certified.³⁴ Ketamine's low likelihood of producing respiratory suppression when used at low doses has contributed to its perception as a relatively “safe” medication at low doses. While the sympathomimetic effects (elevated heart rate and blood pressure) are often seen with anesthesia induction doses, these changes are uncommon when sub-anesthetic doses are administered.³⁵ Monitoring during sedation, at a minimum, should include continuous pulse oximetry and blood pressure checks every ten minutes.³⁵ Likewise, when used in the context of active suicidal ideation or severe depression, the psychiatric effects, both short and long-term, must be followed and managed to ensure patient safety.³⁴ Prior to treatment, patients are interviewed to assess their baseline symptoms and response to treatment. After the infusion is complete, patients typically recover for 30 minutes to 2 hours before they are discharged with an escort. It should be noted that these guidelines are specific to our practice and other institutions are likely to have different monitoring and treatment pathways. Further evidence-based recommendations are needed before widespread adoption of one set of guidelines.

CONCLUSION

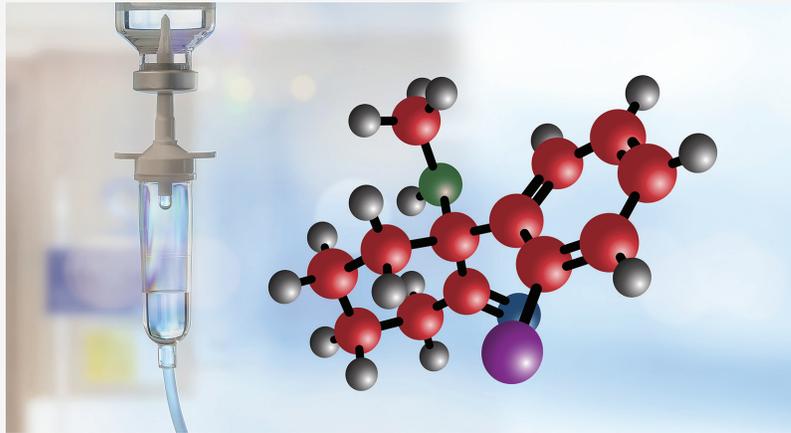
Ketamine is an old drug that is experiencing a new emergence of interest among clinicians in perioperative medicine and depression management. With progressively more patients suffering from chronic pain who require pain management without opioids, and with evolving utility at minute doses in the treatment of depression and potentially other psychiatric disorders, this old drug now has further applications for patient care. However, further investigation is forthcoming as to the appropriate monitoring for administration of this drug in postoperative and outpatient settings.

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Drs. Kung, Berg, and Ellis have no conflicts of interest. Dr. Meisner has served on advisory boards for Janssen Pharmaceutical.

REFERENCES

- Maddox VH, Godefroi EF, Parcell RF. The synthesis of phenacyclidine and other 1-arylcyclohexylamines. *J Med Chem.* 1965;8:230–235.
- Domino EF, Chodoff P, Corssen G. Pharmacologic effects of CI-581, a new dissociative anesthetic, in man. *Clin Pharmacol Ther.* 1965;6:279–291.
- Mion G. History of anaesthesia. *Clin Pharmacol Ther.* 2017;34: 571–575.
- Persson J. Wherefore ketamine? *Curr Opin Anaesthesiol.* 2010;23:455–460.
- Mathews MJ, Mead RN, Galizio, M. Effects of N-Methyl-D-aspartate (NMDA) antagonists ketamine, methoxetamine, and phencyclidine on the odor span test of working memory in rats. *Exp Clin Psychopharmacol.* 2018;26:6–17.
- Kohrs R, Durieux ME. Ketamine. *Anesth Analg.* 1998;87: 1186–1193.
- Agrawal A, Goyal S. Ketamine in status asthmaticus: a review. *Indian J Crit Care Med.* 2013;17:154–161.
- Akeju O, Song AH, Hamilos AE, et al. Electroencephalogram signatures of ketamine anesthesia-induced unconsciousness. *Clin Neurophysiol.* 2016;127: 2414–2422.
- Gardner AE, Dannemiller FJ, Dean D. Intracranial cerebrospinal fluid pressure in man during ketamine anesthesia. *Anesth Analg.* 1972;51:741–745.
- Gardner AE, Olson BE, Lichtiger M. Cerebrospinal-fluid pressure during dissociative anesthesia with ketamine. *Anesthesiology.* 1971;35:226–228.
- Wang X, Ding X, Tong Y, et al. Ketamine does not increase intracranial pressure compared with opioids: meta-analysis of randomized controlled trials. *J Anesth.* 2014;28:821–827.
- Chang LC, Raty SR, Ortiz J, et al. The emerging use of ketamine for anesthesia and sedation in traumatic brain injuries. *CNS Neurosci Ther.* 2013;19:390–395.
- Zeiler FA, Teitelbaum J, West M, et al. The ketamine effect on ICP in traumatic brain injury. *Neurocrit Care.* 2014;21: 163–173.
- Zeiler FA, Teitelbaum J, West M, Gillman LM. The ketamine effect on intracranial pressure in nontraumatic neurological illness. *J Crit Care.* 2014;29:1096–1106.
- Fact file on ketamine. (2016, March). Retrieved from https://www.who.int/medicines/news/20160309_FactFile_Ketamine.pdf?ua=1.
- Sheikh S, Phyllis H. The expanding role of ketamine in the emergency department. *Drugs.* 2018;78:727–735.
- Nielsen RV, Fomsgaard JS, Siegel H, et al. Intraoperative ketamine reduces immediate postoperative opioid consumption after spinal fusion surgery in chronic pain patients with opioid dependency. *Pain.* 2017;158:463–470.
- Loftus RW, Yeager MP, Clark JA, et al. Intraoperative ketamine reduces perioperative opiate consumption in opiate-dependent patients with chronic back pain undergoing back surgery. *Anesthesiology.* 2010;113:639–646.
- Laskowski K, Stirling A, McKay WP, Lim HJ. A systematic review of intravenous ketamine for postoperative analgesia. *Can J Anaesth.* 2011;58:911–923.
- Schmid R, Katz J. Neural toxicity of ketamine and other NMDA antagonists. *Pain.* 2000;88:312.
- Borgbjerg FM, Svensson BA, Frigast C, Gordh T Jr. Histopathology after repeated intrathecal injections of preservative-free ketamine in the rabbit: a light and electron microscopic examination. *Anesth Analg.* 1994;79:105–111.
- Olney JW, Labruyere J, Price MT. Pathological changes induced in cerebrocortical neurons by phencyclidine and related drugs. *Science.* 1989;244:1360–1362.
- Subramaniam K, Subramaniam B, Steinbrook RA. Ketamine as adjuvant analgesic to opioids: a quantitative and qualitative systematic review. *Anesth Analg.* 2004;99:482–495.
- Wilson JA, Nimmo AF, Fleetwood-Walker SM, et al. A randomised double blind trial of the effect of pre-emptive epidural ketamine on persistent pain after lower limb amputation. *Pain.* 2008;135:108–118.
- Feltracco P, Barbieri S, Rizzi S, et al. Perioperative analgesic efficacy and plasma concentrations of s(-)-ketamine in continuous epidural infusion during thoracic surgery. *Anesth Analg.* 2013;116:1371–1375.
- Puri L, Morgan KJ, Anghelescu DL. Ketamine and lidocaine infusions decrease opioid consumption during vaso-occlusive crisis in adolescents with sickle cell disease. *Curr Opin Support Palliat Care.* 2019;13:402–407.
- Wang L, Johnston B, Kaushal A, et al. Ketamine added to morphine or hydromorphone patient-controlled analgesia for acute postoperative pain in adults: a systematic review and meta-analysis of randomized trials. *Can J Anaesth.* 2016;63:311–325.
- Yoshikawa K, Murai Y. The effect of ketamine on intraocular pressure in children. *Anesth Analg.* 1971;50:199–202.
- Drayna PC, Estrada C, Wang W, et al. Ketamine sedation is not associated with clinically meaningful elevation of intraocular pressure. *Am J Emerg Med.* 2012;30:1215–1218.
- Cohen SP, Bhatia A, Buvanendran A, et al. Consensus guidelines on the use of intravenous ketamine infusions for chronic pain from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, and the American Society of Anesthesiologists. *Reg Anesth Pain Med.* 2018;43:521–546.
- Kim J, Farchione T, Potter A, et al. Esketamine for treatment-resistant depression—first FDA-approved antidepressant in a new class. *NEJM.* 2019;381:1–4.
- Ionescu DF, Swee MB, Pavone KJ, et al. Rapid and sustained reductions in current suicidal ideation following repeated doses of intravenous ketamine secondary analysis of an open label study. *J Clin Psychiatry.* 2016;77:e7-19-25.
- Stahl SM. Mechanism of action of trazodone: a multifunctional drug. *CNS Spectr.* 2009;14:536–546.
- Sanacora G, Frye MA, McDonald W, et al. A Consensus Statement on the Use of Ketamine in the Treatment of Mood Disorders. *JAMA Psychiatry.* 2017;74:399.
- Riva-Posse P, Reiff CM, Edwards JA, et al. Blood pressure safety of subanesthetic ketamine for depression: a report on 684 infusions. *J Affect Disord.* 2018;236:291–297.
- Schwenk ES, Viscusi ER, Buvanendran A, et al. Consensus guidelines on the use of intravenous ketamine infusions for acute pain management from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, and the American Society of Anesthesiologists. *Reg Anesth Pain Med.* 2018;43:456–466.

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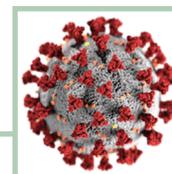


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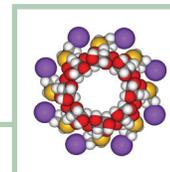
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