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NEWSLETTER

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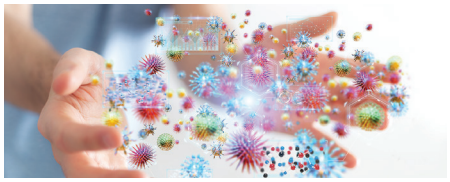
We Can All Shoulder the Responsibility of Decreasing Health Care-Associated Infections

by Jennifer M. Banayan, MD

This issue of the *APSF Newsletter* focuses on the responsibility of health care providers to reduce infections associated with perioperative procedures and equipment. The APSF supports the effort to combat health care-associated infections, and, as evidence of its support, made "Hospital-acquired infections and environmental microbial contamination and transmission" one of its 12 Perioperative Patient Safety Priorities.[1] Increasing provider awareness of the importance of consistent hand hygiene and proper disinfection practices for the operating room may lead to a reduction in bacterial contamination that may result in patient-acquired nosocomial infection.[1,2]

There is growing evidence for an increased risk of hospital-associated infections that appear to be originating from the operating



room and the associated work spaces. Our medications, unused syringes, anesthesia machines and carts, and intravenous tubing are all susceptible to bacterial contamination.[3] In an effort to decrease health care-associated infections, The Society for Healthcare Epidemiology of America (SHEA) published guidelines which describe in detail steps that may prevent and mitigate the risk for infection.[2] In this issue of the *APSF Newsletter*, a variety of articles from multidisciplinary experts focus on these guidelines and other important issues revolving around this important patient safety problem.

Dr. Banayan is an associate professor in the Department of Anesthesiology at Northwestern University. Dr. Banayan serves as associate editor of the APSF Newsletter.

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Health Care-Associated Infections: A Call to Anesthesia Professionals

by Richard C. Prielipp MD, MBA, and David J. Birnbach MD, MPH

This issue of the *APSF Newsletter* sheds new light on an old issue and challenges clinicians to refocus their attention on health care-associated infections (HCAI) and even more relevant, surgical site infections (SSI). Infection control practices that were appropriate for the anesthesia work environment at the middle and end of the 20th century are largely irrelevant today as medical, technical, environmental, and microbiological challenges are infinitely more complex and far less predictable than the operating room of the 1960s. New and thought-provoking recommendations for anesthesia professionals are summarized in a recent seminal publication by the Society for Healthcare Epidemiology of America (SHEA).[1] This guidance was generated by 15 individuals with expertise in this field, representing input from the American Society of Anesthesiologists (ASA), American Association of Nurse Anesthetists (AANA), American Academy of Anesthesiologist Assistants (AAAA), American College of Surgeons (ACS), SHEA, and others.[1] This expert compendium issues guidance on how hospitals and health care providers may reduce infections associated with anesthesiology procedures and equipment in the operating room and highlights the importance of improved hand hygiene, increased environmental disinfection, and safer medication injection practices.

WHY IS THERE CONCERN FOR THIS ISSUE?

Two million hospitalized patients develop HCAI annually, contributing to over 90,000 deaths each year in the United States.[2] The source of these infections is multifactorial, but there is increasing evidence that a significant fraction of these infections originate while patients are in the operating room—and routine anesthesia practices may contribute.[3,4] Alarmingly, a survey of 49 U.S. and international facilities as part of the SHEA guidance showed infection control policies and practices for providers are generally inconsistent, misunderstood, or nonexistent.[1]

However, some in the anesthesia community question if the issue of anesthetic practice contributing to HCAI is real. Two factors likely contribute to this misunderstanding: the "fecal patina" (coating of enteric organisms that are on patient's skin and on surfaces in the health care environment that are contacted by patients and

See "Infections," Page 31

To Our AANA Readers

As of July 1, 2019, the American Association of Nurse Anesthetists members will no longer be receiving a printed copy of the ***APSF Newsletter*** as the AANA is no longer providing funds for distribution. However, because of our shared interest in patient safety, the APSF would like to provide the following two options for AANA members to receive the ***APSF Newsletter***:

1. Please visit our website at www.apsf.org and download current issues under the Newsletter tab.
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TABLE OF CONTENTS, NEXT PAGE

TABLE OF CONTENTS

ARTICLES:

LETTERS TO THE EDITOR:

EDITORIALS:

APSF ANNOUNCEMENTS:

Guide for Authors

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Poor Hand Hygiene is Major Suspect in Hospital-Acquired Infections

From "Infections," Cover Page

health care professionals in the operating room) is invisible[3] and difficult to sterilize, and most SSI infections present several days after surgery. Meanwhile, there is no debate about the profound consequences of HCAI that include increased costs, selection pressure for drug-resistant organisms, patient and family dissatisfaction, significant morbidity and mortality, and potential liability. Surgical site infections are especially relevant as they account for 20% or more of all HCAI. Indeed, SSIs afflict up to 3% of all surgical patients (depending on the type of surgery, patient co-morbidities, length of operation, etc.) increasing the hospital length of stay from 3 to 10 days and increasing mortality 2- to 10-fold.[2]

How can anesthesia practices contribute to HCAI? Poor hand hygiene is a primary suspect. Observed risk factors for poor hand hygiene include status as a physician, working as an anesthesia professional, short duration of care, and interruption in patient care activities.[3,4] A recent study also identified bacterial contamination of drugs and drug syringes during routine administration of anesthesia in the operating room.[5] Over 6% of microbial filters placed in standard IV tubing of anesthetized patients were contaminated with *Staphylococcus, Corynebacterium*, and *Bacillus* species.[5] Equally alarming, 2.4% of fluid samples from the residual drug within syringes at the end of surgical cases grew these same and additional organisms.

WHAT CAN BE DONE? THE SHEA DOCUMENT PROMOTES SEVERAL KEY RECOMMENDATIONS

- **Hand hygiene** should be performed, at a minimum, before aseptic tasks, after removing gloves, when hands are soiled, before touching the anesthesia cart, and upon room entry and exit. Every anesthetizing site should have strategic placement of alcohol-based hand sanitizer dispensers.
  - The interactions between anesthesia professionals and operating room equipment, the anesthesia machine, monitor surfaces, computers and keyboards, vascular catheters, stopcocks, and intravenous tubing were documented during eight hours of operating room observation in a recent study.[6] Anesthesia providers, on average, touched these surfaces 1,132 times, completed 66 stopcock injections, and inserted four vascular catheters.[6] Unfortunately, appropriate hand hygiene preceded only a small fraction of these actions.

Table 1: Infection and Larygnoscopes: Comparison of Reusable and Single-Use Laryngoscopes[7]

Traditional, Reusable Laryngoscopes	Single-Use Disposable Laryngoscopes
Batteries wear out, need replacement	Batteries always brand new
Bulbs dim and eventually burn out	Light source always new
On-off switch prone to wear and failure	Switch is new; testable while still in package
Handles require disassembly to disinfect	No cleaning or maintenance of device
Requires sterilization or high-level disinfection after each use	Provided sterile in new, transparent package
Costs rise rapidly with newly required processing and sterilization	Costs at parity or even less expensive depending on the institution
Performance is well known with a familiar feel	Performance now usually rated at parity with reusable laryngoscopes

With permission to reuse from Prielipp RC, Birnbach DJ. *APSF Newsletter*. 2018;32:65. https://www.apsf.org/article/hca-infections-can-the-anesthesia-provider-be-at-fault/ Accessed August 13, 2019.

- As part of **airway management**, clinicians need to use high-level disinfection of reusable laryngoscope handles or adopt single-use laryngoscopes.
  - Flexible and rigid larynoscopes—both blades and handles—are classified as semicritical devices (because they contact mucous membranes), and therefore require both cleaning and "high-level disinfection or sterilization." Medical literature documents outbreaks of virulent organisms like *Pseudomonas aeruginosa* attributed to dirty laryngoscopes. Moreover, many institutions are discovering that the cost of reprocessing reusable laryngoscopes to this new standard is substantial.[7] While cost allocation data depend on your specific organization, adopting single-use products may actually be quite cost favorable. Table 1 compares several aspects of these two laryngoscope options.[7]
- For **environmental disinfection**, the guidance statement recommends disinfecting high-touch surfaces on the anesthesia machines, as well as keyboards, monitors and other items in work areas in between surgeries, while also exploring the use of disposable covers and re-engineering of the work surfaces to facilitate quick decontamination in what is often a short window of time.
  - Surfaces in a typical operating room are likely to grow pathogens such as MRSA, VRE, MSSA, *E. coli*, and *Acinetobacter* even after routine room cleaning. Decontamination of the environment becomes critical as additional evidence highlights that the probability of bacterial growth in injection stopcocks is a function of the number of bacterial colonies contaminating the anesthesia machine as well as baseline hand contamination of anesthesia professionals.[3,4]
  - In addition, contamination of multiple clean OR surfaces occurs rapidly and in wide distribution around the anesthesia workplace following intubation and airway management. Of particular alarm, a simulation study demonstrates 100% contamination of the IV hub, anesthesia circuit, and anesthesia cart within six minutes of induction and endotracheal intubation of patients.[8] Moreover, there is compelling evidence of contamination of unused syringes placed on the work surface of the anesthesia cart or machine, suggesting that all syringes (even if unused) be discarded at the end of each case.[8]
- **IV drug injection** recommendations include using syringes and vials for only one patient; and that injection ports and vial stoppers should only be accessed after disinfection.
  - Stopcocks should preferentially be converted to "closed injection ports", or, if not being used immediately to inject medications, should at least be covered with sterile caps (see Figure 1).

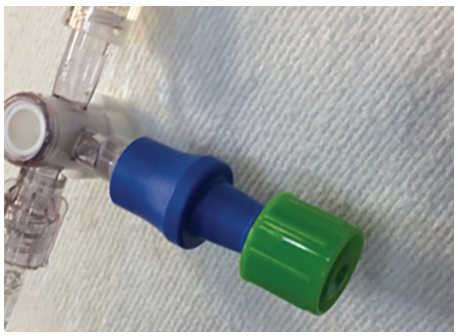

Figure 1: A sterile cap with a closed injection port.

See "Infections," Next Page

A Pharmacist's Role in Intraoperative Resuscitation

by Adam A. Dalia, MD, MBA, FASE; Parita Chowatia, PharmD; and Jevon Oliver, PharmD, MS

PROBLEM

One of the current problems with intraoperative resuscitation is the lack of organization. More precisely, there is often times no clear recognition of defined roles and responsibilities for members participating in an intraoperative code (nursing, surgery, and anesthesia, etc.).[1–3] At our institution, we have quality and safety officers who review each intraoperative code event with the anesthesia team members to identify areas for improvement. Recurring themes included the need to more clearly identify who the code leader was and added burden on anesthesia technicians who are asked to leave the operating room (OR) to retrieve medications or refill the medication drawer within the anesthesia workstation.

SOLUTION

The "Perioperative Pharmacy Attendance for Intraoperative Codes" safety initiative attempts to tackle this problem by addressing the role of "medication procurement, compounding, and time recording." Pharmacists can quickly assess and provide dosing recommendations for medications not in the Advanced Cardiovascular Life Support (ACLS) algorithm that providers may have to utilize when there are drug shortages.[4] Previously these responsibilities were delegated to the anesthesia attending who was also in charge of running the code; this led to an overburdened code leader. Pharmacist attendance also allows anesthesia professionals to perform alternative tasks during a code, as they are usually responsible for running the code.[1,2] The anesthesia team and nursing staff can more efficiently procure equipment and supplies because the pharmacy team is now responsible for obtaining the medications.

INITIATING THE PROGRAM

At our institution, adding the perioperative pharmacists to the intraoperative code response team was relatively seamless as they already had a familiarity with and thorough knowledge of where medications are stocked, appropriate concentrations for mixing, and proper doses (Table 1). Prior to the initiation of the program, all OR Pharmacists were ACLS-certified and oriented to the locations of the ORs and off-site locations (e.g., OB suite, Radiology, Endoscopy, and the Cardiac Catheterization Lab). Additionally, we created a travel bag of emergency medications as well as additional agents not usually stocked in the anesthesia workstation to be brought by the responding pharmacist (Table 2). This code bag may facilitate faster medication procurement and can be utilized in lieu of the large bulky code cart. This ensures reduced clutter in some of the smaller ORs and helps maintain a sterile surgical field/back table. This standardized, travel-size code bag is restocked after every code event by the responding pharmacist and is available across all operating rooms, OB suites, and off-site locations.

See "Pharmacist's Role in OR Resuscitation," Next Page

Infection Control in the Anesthesia Workspace

From "Infections," Preceding Page

CONCLUSION

The reality is that health care providers who work in the OR are subject to the inevitable variability of human performance, both individually and collectively. In addition, the motivation of health care workers to adopt new, safer—but more demanding—interventions such as those detailed in the SHEA guidelines is often counteracted by instincts to simply maintain old, familiar, and "comfortable" habits. Common reasons for this are fear of the unknown, work overload, scientific uncertainty, and lack of individual and organizational adaptability. Last but not least, production pressure in most OR situations prioritizes efficiency rather than being thorough. Indeed, safety management characterizes this principle with the acronym ETTO—the efficiency-thoroughness trade-off.[9] The ETTO fallacy is that people can always be simultaneously be both efficient and thorough at the same time.

In summary, we encourage anesthesia professionals to embrace these new principles, practices, and opportunities to improve patient care. The SHEA guidance and similar algorithms are a starting point. In the words of the 18th century physicist Georg Lichtenberg, "I cannot say whether things will get better if we change; what I can say is they must change if they are to get better." We hope these SHEA guidelines will tip the balance in favor of thoroughness and safety for every patient, every case, every time as we again lead the medical community in patient safety.

Dr. Richard C. Prielipp is professor of Anesthesiology at the University of Minnesota in Minneapolis and serves on the speaker's bureau for Merck & CO., Inc. He is a consultant for Fresenius Kabi, the executive section editor, Patient Safety for Anesthesia & Analgesia*, and is on the APSF Board of Directors.*

Dr. Birnbach is Miller Professor of Anesthesiology, and director, UM-JMH Center for Patient Safety, University of Miami.

***"Clean Care is Safer Care"** is not a choice but a basic right. Clean hands prevent patient suffering."*

—World Health Organization

Drs. Prielipp and Birnbach served as members of the taskforce for the development of the SHEA Guidelines.

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Pharmacists May Play Vital Role in OR ACLS

From "Pharmacist's Role in Resuscitation Codes," Preceding Page

An unintended benefit of creating this program was the identification of the lack of standardization within perioperative codes; therefore, we created an interdisciplinary Intraoperative Code Committee (Surgery, Anesthesia, OR Nursing, Quality and Safety Nursing, and Pharmacy) to define standardized roles during code responses and review all intraoperative codes.

LOGISTICS

When there is an intraoperative code or emergent event, a broadcast call of "Anesthesia STAT OR" is made over Vocera® (voice activated communication system, San Jose, California). The OR pharmacists also carry this communication system and thus are alerted of an intraoperative code. Two pharmacists respond to the code (one from the post-anesthesia care unit [PACU] and one from the central OR pharmacy), bringing the portable emergency drug bags. Upon arrival at the OR, the pharmacists announce their presence to the code leader to ensure close looped communication. If the pharmacists need additional drugs or supplies, they communicate back to the central OR pharmacy to procure any supplies. After the code or emergent event concludes, the pharmacist working in the central OR pharmacy restocks both portable emergency drug bags and ensures they are returned to their storage locations (one in the PACU and one in the central OR pharmacy)

For smaller community hospitals without the resources to provide an intraoperative pharmacist the addition of a travel-size "code bag" may amplify the code team's preparedness. This bag, as described previously, would contain all the relevant code medications in a more compact form. For hospitals without an OR Pharmacy satellite, perioperative leadership can reach out to pharmacy leadership to determine whether pharmacists attend codes in other areas of the hospital and whether this service might be extended to the OR environment. This dialogue may uncover areas for improvement and may lead to adoption of a similar model as our institution.

Table 1: Potential benefits of having perioperative pharmacist attend Intraoperative Codes/Rapid Response Events

Timely medication procurement and compounding
ACLS Medication (epinephrine) dose, timekeeping, and adherence
Differentiation of roles to allow anesthesia staff to perform alternative tasks (establish airway, lines, etc.)
This addition closely follows the inpatient model of code response
Familiarity with drug dosing and concentrations
Recommendation of alternative agents during drug shortages

Table 2: Proposed contents of travel code bag

DRUGS:	NON-DRUG ITEMS:
Epinephrine 1 mg	IV Tubing
Atropine 1 mg	MGH Emergency Manual
Dilute Epinephrine (10 mcg/ml)	Stop Watch for Time Keeping
Amiodarone (150 mg/100 mL bag)	
Vasopressin (20 units/mL)	
Sodium Bicarbonate 50mEq/50mL	
Sugammadex 200 mg/2 mL	
Calcium Chloride 10% 10 mL	
Albuterol (MDI) with Metered Dose Inhaler (MDI) adapter	
Insulin (1 unit/ml)	
Common Anticoagulant reversals	

ACLS = Advanced Cardiovascular Life Support; MGH = Massachusetts General Hospital.

RECEPTION AND TRACKING SUCCESS

At first glance, this safety initiative was well received by both anesthesia professionals and OR pharmacists. Therefore, we plan on formally evaluating satisfaction among the team members and investigate the time it takes to procure necessary drugs outside of the usual ACLS algorithm. Furthermore, our team will track adherence to the ACLS algorithm, time recording, and the incidence of medication errors during code situations.

Data on the location of the code, length of the code, time to respond to the code, medications given during the code, and any other issues related to personnel encountered during the code are being collected in a HIPAA compliant database. The database is used at our monthly Intraoperative Code Committee meeting to discuss opportunities for improvement, perform quality and safety analysis, and allow for other scientific research. We hope that these evaluations will further perpetuate adoption of this initiative in our own institution and validate it for other institutions.

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The authors have no conflicts of interest as they relate to this article.

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Anesthetic Monitoring Recommendations: How Consistent Are They Across The Globe?

by Jan Hendrickx, MD, PhD

Monitoring recommendations for patients during anesthesia care are intended to increase patient safety. Professional organizations develop these recommendations to provide guidance for safe anesthesia practice. One might expect recommendations across the world to be consistent because patient safety is a universal concern for all anesthesia professionals. There are, however, important differences in the approach to patient monitoring advocated by professional societies around the world.

We compared the monitoring standards of six different organizations (presented in alphabetical order):

1. "Standards for basic anesthetic monitoring" (American Society of Anesthesiologists, ASA)[1]
2. "Recommendations for standards of monitoring during anaesthesia and recovery" (Association of Anaesthesists of Great Britain and Ireland), AAGBI[2]
3. "Recommendations for minimal monitoring during anaesthesia and recovery" (European Board of Anaesthesiology, EBA)[3]
4. "Guidelines on monitoring in anaesthesia" (Hong Kong College of Anaesthesiologists, HKCA)[4]
5. "Code of Ethics, Standards of Practice, Monitoring, and Education" (International Federation of Nurse Anesthetists, (IFNA)[5]
6. "International standards for a safe practice of anesthesia" (World Health Organization and World Federation of Societies of Anaesthesiologists, WHO-WFSA)[6]

These organizations were selected as a cohort representative of standards in different parts of the world. The comparison between these organizations illuminates the differences that exist and potential for reconciliation. Other professional organizations throughout the world such as the American Association of Nurse Anesthetists (AANA), and Australia and New Zealand College of Anaesthetists (ANZCA) publish monitoring standards that offer important patient safety guidance to their constituents and should be included in any efforts to reconcile the standards.[7,8]

"STANDARDS"—WHAT'S IN A NAME?

The ASA (Table 1), IFNA, WHO-WFSA, and AAGBI include the word "Standards" in their title whereas the EBA uses "Recommendations" and the HKCA uses "Guidelines." Further evaluation of these documents reveals nuances of language that are important to the practitioner. In particular, it is important to understand what is considered an absolute monitoring requirement for every anesthetic, versus monitoring modalities that are useful but not essential and how these distinctions are determined. Reconciling the various approaches will require agreement on the implications of the terms used.

The EBA document defines "core standards" for monitoring as those to "be used whenever a patient is anaesthetized."[3] The WHO-WFSA uses a tiered approach. A "highly recommended" standard is considered mandatory, which, if not met, means providing anesthesia for elective surgical procedures is unsafe and unacceptable. "Recommended" and "suggested" standards should be practiced "when resources allow and if appropriate for the health care being provided."[6]

Table 1: The ASA Policy Statement on Practice Parameters Definitions[9]

Evidence-based **standards**	• Provide rules or minimum requirements • Are regarded as generally accepted principles of patient management • May be modified only under unusual circumstances • Are supported by meta-analyses of findings from multiple clinical trials • Are agreed upon by all or nearly all expert consultants and surveyed ASA members	• Most stringent recommendation • Failing to comply with a standard would constitute a practice breech and not only put the patient at risk, but expose the provider to liability that would be difficult to defend if an adverse event occurred
Evidence-based practice **guidelines**	• Provide recommendations that describe a basic management strategy supported by meta-analyses of multiple clinical trials • Are agreed upon by a majority of expert consultants and surveyed ASA members	• Not intended to be standards or minimum requirements
Evidence-based practice **advisories**	• Provide statements to assist decision-making in areas of patient care where there is not a sufficient number of adequately controlled studies to permit meta-analysis	• Not intended to be standards or minimum requirements

The ASA Committee on Standards and Practice Parameters is one committee that supervises the creation of new and revision of practice parameters.

INCONSISTENT MONITORING REQUIREMENTS

Keeping in mind the "semantic modifiers" alluded to in the previous paragraph, we provide a brief review of the recommendations contained in the "standards" from these different organizations. All societies require that every anesthetized patient be continuously attended by a qualified anesthesia professional and have requirements for clinical monitoring. All require alarms to be activated and audible, with limits properly applied. There are, however, differences in recommendations for individual parameters. For purposes of this discussion, the term standard will be used to indicate an absolute requirement.

Oxygenation

Blood oxygenation monitoring by pulse oximetry is a universal standard among all organizations. Monitoring of the inspired O_2 concentration accompanied by a low threshold alarm is a standard for all except the WHO-WFSA document where it is "recommended." Monitoring skin color is a standard for all except the AAGBI and EBA where they state it "may be included as an appropriate clinical observation."[2,3]

Ventilation

All organizations surveyed require end-expired CO_2 to be detected after intubation or supraglottic airway placement, and all but the WHO-WFSA require end-expired CO_2 to be monitored thereafter. WHO-WFSA cites cost and lack of robustness as the reasons for only "recommending" continuous CO_2 monitoring.[6] Qualitative assessment of ventilation (movement of chest and breathing bag, auscultation) is considered standard by WHO-WFSA, IFNA, and EBA, but not by ASA, AAGBI, HKCA. Monitoring inspired CO_2 concentration and cuff pressure of airway devices is considered a standard by HKCA. Standards for monitoring during mechanical ventilation differ: ASA "strongly encourages" and WHO-WFSA "suggests" expired volume to be measured[1,6]; all but ASA, IFNA and WHO-WFSA consider airway pressure monitoring a standard; and a disconnection detector with alarm is a standard for all except the WHO-WFSA which "recommends" it.

See "Recommendations," Next Page

International Anesthesia Monitoring Recommendations Vary By Organization

From "Recommendations," Preceding Page

Circulation

Electrocardiogram (ECG), intermittent blood pressure measurements, and heart rate monitoring are consistent standards, except for the WHO-WFSA who only "recommends" ECG for rhythm monitoring. In the AAGBI and EBA guidelines, heart rate monitoring is present implicitly in the ECG and pulse oximetry monitoring requirement. All guidelines require confirmation of a pulse (i.e., mechanical activity resulting in cardiac output) in the form of at least one of these: palpation of a pulse, auscultation of heart sounds, monitoring of a tracing of intra-arterial pressure, ultrasound peripheral pulse monitoring, or pulse plethysmography or oximetry. The AAGBI and HKCA standards require a stethoscope "be available."

Temperature

Temperature is not advocated as a standard to be adhered to throughout the entire procedure by any of the organizations. Recommendations are inconsistent and range from "a means to measure temperature has to be available" to "recommended" to "essential for procedures > 30 min," to "when clinically significant changes in body temperature are intended, anticipated or suspected."

Kidney function

Monitoring urine output is either not mentioned, or "suggested in appropriate cases" (WHO-WFSA, AAGBI).

Neuromuscular blockade monitoring after administration of muscle relaxants

Recommendations range from being a standard (AAGBI) to not being mentioned (ASA) to variations in between. For example, the WHO-WFSA "recommends" it, the EBA states that a nerve stimulator has to be available, and the HKCA states that "it should be used whenever the anesthetist is considering extubation following the use of non-depolarizing neuromuscular blockade."[3,4,6] The IFNA states that professionals should "measure, assess, and score neuromuscular function by a neuromuscular monitor (if available) when neuromuscular blocking agents are being used."[5]

Concentration of inhaled anesthetics

Monitoring the end-expired concentration of inhaled anesthetic agents is a standard for the AAGBI, EBA, and the HKCA (the latter, in addition, requires automated agent detection). The WHO-WFSO "suggests" both inhaled and exhaled concentrations be measured.[6] The IFNA recommends that both inspiratory and expiratory anesthetic concentrations of volatile agents be measured continuously "if possible."[5] The ASA standards do not mention inhaled anesthetic agent concentration monitoring.

Measure of drug effect on the central nervous system/unconsciousness

According to the HKCA, "equipment to monitor the anaesthetic effect on the brain should be applied, especially for patients at high risk of awareness, for example, those receiving total intravenous anaesthesia with a muscle relaxant."[4] The IFNA states that the application of an electronic device intended to measure cerebral function, particularly in cases with high risk of awareness under general anesthesia should be "considered."[5] The WHO-WFSA states that its "use... while not universally recommended or used, is suggested, particularly in cases at risk of awareness under general anesthesia or postoperative delirium."[6] The AAGBI recommends the "use of depth of anaesthesia monitors, for example processed EEG monitoring...when patients are anaesthetised with total intravenous techniques and neuromuscular blocking drugs, to reduce the risk of accidental awareness during general anaesthesia. However, there is no compelling evidence that routine use of depth of anaesthesia monitoring for volatile agent-based general anaesthetics reduces the incidence of accidental awareness when end-tidal agent monitoring is vigilantly monitored and appropriate low agent alarms are set."[2] According to the EBA, "their routine use has yet to be fully considered as part of our recommended minimum monitoring standards."[3] ASA does not consider EEG or EEG-derived indices in its Standards for Basic Anesthetic monitoring.

This brief review has identified a number of inconsistencies between the anesthesia monitoring recommendations promoted by professional organizations in different parts of the world. In general, monitoring standards for parameters that describe the cardiopulmonary system are mostly consistent. This is less true for other physiological systems or for other aspects of the anesthetic state like immobility or unconsciousness.

IF SAFETY IS UNIVERSAL, WHY ARE RECOMMENDATIONS NOT?

Published recommendations are developed by consensus within each organization, so it is not surprising that the results are different around the world. For the developing world, professional organizations are sensitive to resource limitations and are reluctant to impose requirements that are difficult to comply with. Nevertheless, the importance of patient safety does not change by geography. The WHO-WFSA has made a major effort to reconcile guidelines by different societies and develop practical recommendations that can be followed anywhere in the world. In the developed world, the differences in recommendations are more difficult to understand since the resource constraints are not as significant.

WHICH IMPORTANT RECOMMENDATIONS MIGHT MERIT RECONCILIATION?

The recommendations for end-expired agent monitoring and anesthetic depth monitoring are different from each organization yet can be important tools for assessing anesthetic effect and should be considered when thinking of aligning the various recommendations. During surgery under general anesthesia, the patient expects to be unconscious and to not experience pain.[10] Both inhaled and intravenous agents are commonly employed to achieve that goal. When inhaled agents are used, end-expired anesthetic agent monitoring can insure that the inhaled anesthetic agent and appropriate dose are being delivered. As noted above however, only three organizations of those reviewed consider end-expired agent monitoring a standard. WHO-WFSA "suggests" that it be used whereas the ASA monitoring standard does not even mention inhaled agent monitoring. When intravenous agents are used, we cannot assess the serum concentration quantitatively so we are left with measures of drug effect such as processed EEG. Despite the technology limitations of processed EEG monitoring, more than one organization (but not all) advocates that it be used, especially for patients at high risk for awareness.

The primary responsibility of the anesthesia professional is to keep the patient safe. Resources, liability concerns, patient needs, and clinical scenarios all play a role in determining the monitoring needs for any given patient. Standards are essential to patient safety and we should seek to insure they provide common protections for all patients no matter where they live.

SUMMARY

Across the globe, anesthetic monitoring standards for parameters that describe the cardiopulmonary system are mostly consistent. For other physiological systems or for other aspects of the anesthetic state like immobility or unconsciousness, this is less true. In related articles in this issue, Jin, Gan, and Feldman review the capabilities and limitations of EEG-based anesthetic depth monitoring to assess the potential for this technology to become a standard.

See "Recommendations," Next Page

Anesthesia Monitoring Recommendations: Inconsistencies are Worldwide

From "Recommendations," Preceding Page

Drs. Philip and Hendrickx consider whether inhaled agent monitoring should be considered a standard.

Dr. Hendrickx is a staff anesthesiologist at OLV Hospital, Aais, Belgium.

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LETTER TO THE EDITOR:

A Time-out For Anesthesia Professionals

"The single biggest problem in communication is the illusion that it has taken place."

—George Bernard Shaw

Promoting and establishing a health care safety culture is one of the foundations for better patient care.[1] One particular factor, poor/inefficient or ineffective communication among health care workers continues to be an important cause of medical errors and potential adverse events, some with devastating consequences have been identified. Teamwork and proper communications have been identified as a key component for the successful management of complex tasks during critical times and crisis management. Standardized hand-off of patient information has been addressed extensively, but other communication issues have received less attention.[2]

Anesthetic and airway management issues during induction/emergence of anesthesia continue to be an important cause of severe morbidity and even mortality. When airway-related complications occur, the consequences can be irreversible and even catastrophic. Individual, team, and coordinated effective group efforts utilizing special equipment are needed to successfully deal with these high impact events that many times are unexpected.[3,4]

The World Health Organization (WHO), Association of periOperative Registered Nurses (AORN), and the Joint Commission have recommended pre- and post-procedure team briefings to attempt to encourage surgical team engagement, efficiency, safety, and team satisfaction by potentially improving communication of critical information before and after controversial and variable issues.[5–7] There are still controversial and variable issues regarding these briefings: when, what information, and who must participate in them is not always clear cut. Some degree of variation and customization among institutions and services is allowed and expected, but the real question is whether we should allow key anesthetic issues to be left out of such group discussion opportunities. Many institutions do not mandate team briefings. Instead a pre-procedural time-out that can even occur after the anesthesia technique has been initiated, with the goal to determine correct patient identity, type of procedure, surgical site, and antibiotic prophylaxis, is performed. Many times no post-intervention debriefing is ever performed.

The absence of team briefings implies that critical events such as anesthesia induction and emergence with all airway-related matters that take place during procedures are not always being included as part of these team safety efforts. If these pauses/meetings are intended to promote effective teamwork, improve communication, enhance quality of care, and use them as an opportunity to decrease adverse medical events, then not implementing them, doing them in a hasty manner, or not including or discussing anesthetic-airway developments should be viewed as systemic issues and latent safety factors. We, as anesthesia professionals should strongly consider making anesthesia induction and emergence and its associated operations

part of an organized "time-out." We should voice our plans, concerns, and needs during safety team efforts, so that, in the event something unexpected or adverse occurs, the entire perioperative team is ready to give much-needed support and assistance without delays or hesitation.

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The Hospital Epidemiologist's Perspective on the Anesthesia Operating Room Work Area

by Joshua Schaffzin, MD, PhD, Lynn Johnston, MD, MSc, FRCPC, and L. Silvia Munoz-Price, MD, PhD

For decades, the field of hospital epidemiology has studied the transmission of infections within the health care setting. We know that the spread of organisms in hospitals occurs through the interactions of patients, health care providers, and their environments. Patients are colonized with organisms (both pathogenic and non-pathogenic) in their airways, gastrointestinal tracts, and on their skin. These organisms contaminate the hospital environment and patient equipment.[1]

Environmental contamination has two direct consequences: contaminating health care provider hands, and exposing the next patient admitted to the same area. Providers' hands become contaminated not only after touching a patient, but also after touching contaminated surfaces in the patient's environment (i.e., "patient zone").[2] Gloves do not reliably prevent hand contamination, as 13–29% of provider hands have been found to be contaminated after glove removal.[3,4] Patients admitted to rooms previously occupied by patients colonized or infected with vancomycin-resistant *Enterococci* (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), or *Clostridium difficile* are at higher risk of acquiring these bacteria than other patients throughout the hospital.[5] This evidence supports the premise that patient-to-patient transmission of organisms takes place through a contaminated environment. Further supporting this point is the finding that proper disinfection of the hospital environment is associated with decreased transmission of multidrug-resistant bacteria.[6] Most of our knowledge of organism-based cross-transmission in the hospital environment comes from studies involving inpatient units, with operating rooms not as extensively studied. However, hand and environmental contamination has been shown to transmit *S. aureus, Enterococcus spp*., and Gram-negative bacilli in the operating room environment.[7-9] Additionally, contamination of stopcocks by organisms present on patients, equipment, and provider hands has been linked to transmission during and between cases.[10-12]

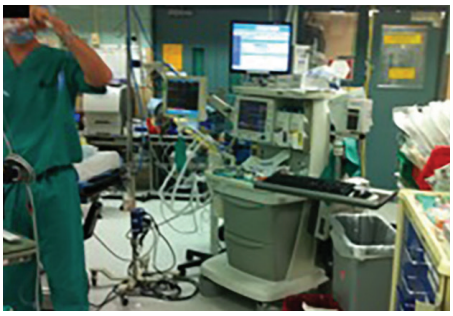

Figure 1: Photo of typical busy operating room displaying clutter, crowded conditions, and use of multiple pieces of equipment that increase the likelihood of pathogen transmission. Photo by L. S. Munoz-Price, MD, PhD.

From the hospital epidemiologist's perspective, perioperative areas and specifically operating rooms, where the three necessary components for transmission (patients, environment, and health care providers), are in close proximity (Figure 1), create the ideal situation for cross-transmission of organisms. Operating rooms accommodate multiple patients each day, with numerous opportunities for environmental transmission. In the confined space of operating rooms, health care professionals touch patients, devices (e.g., intravenous hubs), environmental surfaces, and equipment at a high rate, and perform limited hand hygiene.[13] Additionally, equipment and environmental disinfection in the operating room may not be sufficient.[14]

Contamination of operating room surfaces has been demonstrated both through environmental culturing[15] and the use of fluorescent markers.[14,16,17] These markers are transparent gels visible with ultraviolet light that can be wiped off with a moist cloth; their presence 24–48 hours following their application signify the absence of cleaning (at least once).[14,17] Observational studies suggest that room cleaning across the country, both terminal and between cases, is suboptimal.[14,17] In two separate studies, fluorescent markers were used to evaluate cleaning over a 24-hour period. More than half of marked surfaces had the markers still present, indicating inadequate cleaning.[14, 17]

The potential role of health care providers' hands in contaminating the operating room environment was examined using a simulated operating room environment.[16] Fluorescent gel was applied to the mouth of a human patient simulator before intubation and the simulator and operating room were evaluated after the encounter (Figure 2). More than half of forty areas evaluated were positive for the fluorescent marker in at least nine of ten simulations, thirteen of which were contaminated during all ten simulations.[16]

Equipment and environmental contamination may, in part, be due to facility design and operational factors that are not conducive to cleaning and disinfection between cases. Additionally, while hospitals closely monitor and track the turnaround time of operating rooms, they are less likely to measure the effectiveness of cleaning and disinfection.[18,19] A possible association between shorter turnaround times to cleaning effectiveness and disease transmission deserves further study. From our perspective, turnaround times of less than 30 minutes[20] (and even 60 minutes) are likely to make effective cleaning and disinfection extremely challenging, considering all the cluttered horizontal surfaces inside and on top of anesthesia carts and the convoluted surfaces of the anesthesia machine.

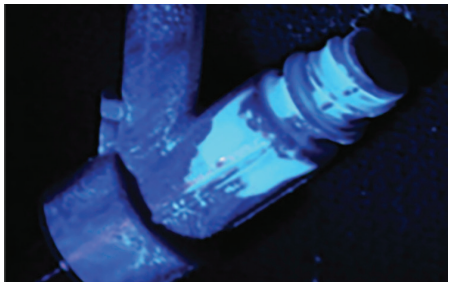

Figure 2: Gross contamination of patient and environment (IV hub) following application of fluorescent marker to a mannequin's mouth in a simulated operating room.[16]

With permission to use from Anesthesia & Analgesia. Birnbach DJ, Rosen LF, Fitzpatrick M, et al. The use of a novel technology to study dynamics of pathogen transmission in the operating room. *Anesth & Analg.* 2015; 120:844-847.

Disinfecting hands frequently enough to prevent transmission of organisms in the anesthesia work area can be challenging as well. Hand contamination opportunities are very frequent—averaging about 150 surface contacts per hour during induction, and 60 per hour during maintenance.[13] Due to the nature of the work, performing hand hygiene according to World Health Organization (WHO) guidelines[21] may be impractical, leading to infrequent hand hygiene performance despite numerous WHO-recommended opportunities for hand hygiene (before touching the patient, after touching the patient, after touching patient's surroundings, after contact with bodily fluids, and before aseptic techniques).[22] Making alcohol-based hand sanitizers more accessible has had mixed results. Placing dispensers on the anesthesia machine showed minimal improvement, while electronic reminders increased the rate of hand hygiene ten-fold.[23,24] The use of portable alcohol-based hand sanitizers may significantly increase the frequency of hand disinfection and reduce contamination of stopcocks.[25] While gloves might protect anesthesia professionals from contact with contaminated surfaces, they will not eliminate the contamination of patients or equipment.

See "Hospital Epidemiologist's Perspective," Next Page

Contamination of the Anesthesia Workspace

From "Hospital Epidemiologist's Perspective," Preceding Page

Birnbach et al. noted that contamination was found 60% of the time on the operating room door handle, even though none of the health care providers had gloves on at the time of exit during a simulation exercise.[16] This suggests the importance of not only glove replacement, but also of hand hygiene even when gloves are worn.

To address these challenges, the Society for Healthcare Epidemiology of America (SHEA) collaborated with the American Society of Anesthesiology (ASA), the Anesthesia Patient Safety Foundation (APSF), the Association of periOperative Registered Nurses (AORN), and the American Association of Nurse Anesthetists (AANA) to publish infection control guidance for the anesthesia work area.[26] This guidance was designed to provide practical and evidence-based practices, with advice on how to implement them (Table 1). However, for these recommendations to be effective, anesthesia professionals need to change their behavior accordingly.

As hospital epidemiologists, we call upon anesthesia professionals to acknowledge that transmission of organisms exists within hospitals, including operating rooms, and that change is needed in the anesthesia work area. We challenge you to help prevent organism transmission within operating rooms by improving your hand hygiene adherence, advocating better environmental and equipment disinfection, and identifying opportunities for anesthesia work area re-engineering that will facilitate disinfection and prevent cross-transmission. For example, hand hygiene is hindered by workflow and lack of easy availability of products.[26] Engaging perioperative teams and human factors engineers to redesign workflows could better support proper hand hygiene. Similarly, engaging biomedical engineers to redesign equipment could both support hand hygiene and disinfection. We realize that some of the guidance recommendations[26] may be dismissed as unrealistic, unreasonable, or unsubstantiated; however, patient-to-patient transmission of pathogens is an undeniable occurrence and needs to be addressed.

See "Hospital Epidemiologist's Perspective," Next Page

Table 1: Summary of Recommendations, SHEA Expert Guidance: Infection Prevention in the Anesthesia Work Area[26]

Hand Hygiene
Performed at the minimum:
• Before aseptic tasks
• After removing gloves
• When hands are soiled or contaminated
• Before touching anesthesia cart contents
• When entering and exiting the OR
Consider double gloves during airway management
• Remove outer gloves immediately after airway manipulation
• Remove inner gloves and perform hand hygiene as soon as possible
Locate alcohol-based hand rub dispensers at OR entrance and near anesthesia providers in the OR
Insufficient evidence for use of alcohol-based hand rub on gloves
• Changing gloves with hand hygiene between donning and doffing is preferred

Environmental Disinfection
Laryngoscopes/Video-laryngoscopes
• Standard direct laryngoscope and video-laryngoscope reusable handles and blades-complete high-level disinfection
• Consider replacement with single-use devices
Anesthesia machine and cart
• Insufficient evidence for disposable cover use
• Wipe accessible outer surfaces between cases
• Perform hand hygiene before opening and handling drawer contents
• Avoid storing supplies on top of cart
OR preparation between uses
• Clean and disinfect high-touch surfaces on the anesthesia machine and anesthesia work area between OR uses
Injection ports
• Only use disinfected ports for intravenous access
• Port disinfection
• Scrubbing with a sterile alcohol-based disinfectant immediately prior to each use
• Cover ports continuously with sterile isopropyl alcohol containing caps
• Disinfect before individual drug injection or at the beginning of a rapid succession of injections (e.g., anesthesia induction)
Medication vials
• Wipe rubber stopper and ampule neck with 70% alcohol prior to each access
• Use single-dose vials and flushes whenever possible
• Multi-dose vials should be used for 1 patient, use sterile needle and syringe for each entry
• Never reuse syringes or needles for another patient
Full barrier precautions
• Use of cap, sterile gown, mask, sterile gloves, and large sterile drape
• Use for insertion of all CVCs and femoral and axillary arterial catheters
Needleless syringes
• Recap if administering multiple doses to same patient from same syringe
Provider prepared sterile injectables
• Use as soon as practicable following preparation
Spiked IV bags
• Minimize the time between spiking and administration
Keyboards and touchscreens
• Clean and disinfect after each case
Contact isolation
• Follow all institution-specific policies for hand hygiene, personal protective equipment, and environmental cleaning

Implementation
• Conduct regular evaluation and monitoring of practice, hand hygiene, and environmental cleaning and disinfection
• Encourage collaboration of frontline providers and leadership
• Insufficient evidence to recommend technology-based monitoring

SHEA Guidelines May Provide Infection Control Guidance for Anesthesia Professionals

From "Hospital Epidemiologist's Perspective," Preceding Page

We and our infection prevention colleagues are often asked: so what? So what if patients are exposed to the organisms from previous patients? So what if hand hygiene is not performed? The answer is that the evidence shows these practices pose risks for bacterial transmission. The path to addressing these challenges has been established, and we in health care epidemiology stand ready to assist you. We look for leadership from within the operating room to seize the opportunity to prevent patient harm.

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Drs. Schaffzin, Johnston, and Munoz-Price all served on the task force for the development of the SHEA Guidelines.

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Infection Control During Emergencies: Protecting the Patient

by Michael Anderson, DNP, CRNA; Leslie Jeter, DNP, CRNA; Lynn Reede, DNP, CRNA; Marjorie Everson, PhD, CRNA; and Charles Griffis, PhD, CRNA

INTRODUCTION

The medical literature recommends that infection control interventions be conducted for any contact with a patient, every time a clinical interaction of any kind occurs.[1] Anesthesia practice involves many "patient contacts," which can be divided into two categories depending upon the clinical circumstances: "elective," where activities can be accomplished with a relative flexible time requirement given the lack of acute patient safety needs; and "urgent/emergent," where activities must be accomplished in the shortest time possible to prevent patient injury. Recommended Infection control activities can take critical minutes during emergency care.

Anesthesia professionals must prepare "stat rooms" (trauma rooms; heart rooms; delivery rooms) for urgent/emergent patient care. There is a need for advance preparation of these rooms with equipment and drugs to prevent patient death or injury in accordance with principles of emergency and critical medical care.[2] In contrast, the infection control literature recommends that the drugs and equipment used in these rooms be prepared only at time of use.[1,3]

This leads us to questions such as: What can a responsible anesthesia professional do to protect patients in an urgent/emergent situation from infection? How can infection control be applied to the essential advance preparation necessary to prevent undue safety risks in settings that provide complex emergency care? Answers to these questions are difficult to determine. Infection control guidance documents from both the American Society of Anesthesiologists[4] and American Association of Nurse Anesthetists[5] state that providers must use clinical judgment to determine appropriate infection control actions in life-threatening situations, but little specific guidance is provided. This gap in the literature presents the anesthesia professional with a conundrum: how should infection control measures be rationally and acceptably altered during urgent/emergent care—to accomplish rapid intervention, yet prevent or decrease infection risk to patient and provider? In order to address these concerns, selected literature offering guidance on prevention of infection during anesthesia and clinical care were consulted and basic principles are summarized in Table 1.[1-7]

See "Infection Control," Next Page

Table 1: Strategies for Maintaining Infection Control During Urgent/Emergent Care[1-7]

1.	Plan ahead, anticipating emergency situations that will or might arise in each clinical situation, using anesthesia and critical care training to appropriately prioritize and plan for associated infection control practices.
2.	During emergency care, prioritize life-protecting and sustaining interventions, but include infection control activities as permitted without significant delay thereby increasing risk of patient injury.
3.	Ensure immediate availability of all infection control supplies—PPE, alcohol-containing IV port caps, sterile needles and syringes and angiocatheters and IV infusion sets, and alcohol-based hand rubs.
4.	Keep uncontaminated supplies clean, covered (e.g., in the anesthesia cart) and segregated from contaminated materials until needed.
5.	Keep all IV and arterial line ports covered with alcohol-containing IV port caps.
6.	Keep syringes covered with sterile tip caps when not in use.
7.	Keep prepackaged sterile saline syringes immediately available for drug dilution and flushes.
8.	In emergencies, consider double-gloving, removing outer gloves as these become contaminated, and removing inner gloves followed by HH as soon as possible.
9.	Consider asking a colleague to monitor and debrief after patient stabilization regarding infection control activities such as equipment contamination and patient exposure during emergency care.
10.	Clean and disinfect the patient and environment as soon as the patient is stabilized.
11.	If contamination and exposure to infectious pathogens is likely to have occurred, consult with the patient's primary care provider and/or an infectious disease specialist for monitoring and follow-up as indicated in the setting of care.
12.	Prepare stat rooms (e.g., trauma rooms) as close to the time of use as possible, label all supplies with date and time of preparation, assure all supplies are kept clean and covered as allowed by the resuscitation requirements of the anticipated situation. Devise department policies governing the protection, care, and length of time such supplies may remain unused before being discarded.

PPE= Personal Protective Equipment

Infection Control During Emergencies, (cont'd)

From "Infection Control," Preceding Page

REVIEW OF BASIC INFECTION CONTROL PRACTICES

"Universal Precautions" refer to the basic set of infection control activities (ICA) that all health care providers should engage in during each patient contact. They include hand hygiene (HH), wearing clean non-sterile gloves, donning personal protective equipment (PPE) depending on the situation, applying transmission-based precautions as indicated, performing clinical care by assuring appropriate single-patient use of clean or sterile equipment and preparation of intravascular entry points with alcohol cleansing, and then carefully doffing contaminated equipment and performing HH again.[1,8]

"Safe injection practices" are recommendations based on numerous sources in the infection control literature.[1,3-7] These include HH prior to and following any injections. Glass ampule necks and rubber diaphragms should be cleansed with alcohol prior to entry. One sterile syringe and one sterile needle should be used to prepare and administer each medication and then discarded. Injection materials are to be used for one patient only and discarded at end of care. Syringes should be kept capped, and intravenous ports covered with single-use alcohol-containing luer lock caps. Intravenous administration sets and solution bags should be used for one patient and assembled only at time of use.

Recommendations for airway infection control include wearing two pairs of non-sterile gloves (double gloving) prior to instrumentation, removing the outer gloves immediately prior to necessary respiratory support activities, and then removing inner gloves and completing HH as soon as the airway is secured.[4,5,6] It is advised that no airway equipment should be opened before use; single-use disposable equipment is suggested. Reusable equipment must be decontaminated and packaged appropriately until use.[4,5,6]

The challenge during urgent/emergent care is the time required to perform ICA such as repeatedly donning and doffing gloves, HH prior to and following every patient contact, cleansing ports for injection, and so forth. So many of these activities arise during regular anesthesia care, that the time to performing these ICAs may prevent more timely intervention, resulting in adverse outcomes. For example, sudden, unexpected coughing or movement during surgery must be rapidly treated to prevent patient injury. Airway loss or compromise bleeding and hypotension must be dealt with immediately to prevent hypoxic damage to the brain and vital organs.[2] Anesthesia care involves all of these urgent care situations and more, which require immediate action. To address this challenge, a commonsense approach is proposed to combine the principles of acute care and emergency medicine with recommended infection control actions. It is important to note that many of these infection control practices, with the exception of HH—are based on relatively low quality evidence. It is hoped that the resulting list of strategies will be useful to anesthesia professionals in meeting patient safety goals, and that the research community will test the efficacy of these recommendations in future investigations.

Infection control during urgent/emergent care may not conform perfectly to proposed recommendations, but with careful planning, anesthesia professionals have the requisite background to appropriately prioritize life-saving actions, and infection control should and can be incorporated into this care as we work toward the goal of ensuring patient survival and eliminating complications including infection.

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Depth of Anesthesia Monitoring—Why Not a Standard of Care?

by Zhaosheng Jin, MBBS, BSc; Jeffrey Feldman, MD; and Tong J Gan, MD, MHS, MBA, FRCA

INTRODUCTION

Achieving the appropriate depth of anesthesia is vital. Too light, and patients may become aware of the surgical stimulus; too deep, and patients are at risk of vasomotor depression and complications. Traditionally, the depth of anesthesia is approximated through clinical signs such as heart rate and blood pressure changes or end tidal anesthetic concentration and estimated plasma concentration. Despite the use of these surrogates, complications of too little or too much anesthesia still may occur indicating that they are unreliable estimates of anesthetic depth.

Electroencephalogram (EEG) is a surface recording of the summed cortical electrophysiological activity and is altered by the level of consciousness. EEG-based monitoring could, in theory, directly monitor the neurological response to anesthetic agents, and account for the inherent variation in anesthetic sensitivity. In reality, measuring the EEG in the clinical setting and turning it into a reliable tool for monitoring anesthetic depth is challenging. Despite these challenges, several methods of EEG acquisition and processing have been developed and approved for clinical use. Bispectral (BIS) index™ (Boulder, CO, USA), based on frequency domain analysis, is the most studied method to date. Other examples include Patient State Index (PSI, Hospira Inc, Lake Forest, IL, USA, now Masimo Corp., Irvine, CA) which is derived from EEG power, frequency and phase information; M-entropy (GE Healthcare, Helsinki, Finland) which measures the amount of disorder in the EEG (state entropy), in addition to frontalis electromyogram (response entropy)[1]; and auditory evoked potential (AEP), which measures the latency of cortical response to auditory stimulation.[1] While these devices have potential clinical utility, they also have inherent limitations. EEG remains a crude measure of anesthetic effects on the brain in that the threshold and type of EEG changes that identify lack of awareness are still not known with complete certainty for every patient. The signals are prone to interference by artifact and all of the devices depend upon algorithms developed using a certain patient population.

DEPTH OF ANESTHESIA MONITORING AND AWARENESS

Accidental awareness under general anesthesia (AAGA) is a potentially devastating complication due to inadequate depth of anesthesia. AAGA is estimated to occur in 0.2% of adults receiving general anesthesia and potentially greater in children.[2,3] The main factors contributing to awareness are equipment failure, intentional light anesthesia used to limit physiologic instability (e.g., hemodynamically unstable and trauma patients), and high anesthesia requirement of the patient. Total intravenous anesthesia (TIVA) has a particularly high risk of awareness, as there is no real-time measure like exhaled agent concentration to measure the anesthetic load *in vivo*.[4] It is thought that EEG-based depth of anesthesia monitoring may act as a "safety net" against AAGA, especially with TIVA. Several studies have compared BIS™ to the Patient State Index (PSI) and Entropy, and reported comparable effectiveness in predicting the depth of anesthesia.[5-7]

Despite the promising results from earlier small studies, Avidan et al. published a randomized control trial (RCT) of 5,713 patients receiving inhalational anesthesia monitored with BIS or end-tidal gas monitoring with alarm set to maintain within a minimum alveolar concentration (MAC) range and reported no significant difference in the risk of awareness between the groups.[8] Mashour et al. published a larger RCT of 18,836 patients, and again reported no significant difference between BIS and end-tidal anesthetic gas monitoring. Mashour reported equipment failure in almost a third of their BIS-monitored patients, and when cases with equipment failure were excluded in a *post hoc* analysis, there was a significantly lower rate of awareness in the BIS cohort.[9] Messina conducted a meta-analysis and concluded that BIS-monitoring was not associated with a significantly lower risk of awareness during inhalation anesthesia.[10]

To date, there is one large-scale study investigating the use of BIS during propofol TIVA. Zhang et al. conducted an RCT of 5,228 patients with propofol TIVA and found that the risk of awareness was significantly lower in the BIS-guided cohort (0.14%) compared to the BIS-blinded cohort (0.65%).[11]

DEPTH OF ANESTHESIA MONITORING AND ANESTHETIC REQUIREMENT

Depth of anesthesia monitoring may also be used to prevent excessively deep anesthesia, which may be associated with delayed emergence from anesthesia and increased risk of perioperative complications.

Several studies have reported that BIS monitoring is associated with lower anesthetic requirement with both intravenous[12-15] and volatile agents[16-18]; and similar findings have also been reported with Entropy™ and with AEP monitoring.[19-20] Punjasawadwong et al. conducted a meta-analysis of the anesthetic requirement with and without BIS monitoring, which reached the same conclusion.[21]

It is thought that by minimizing the amount of anesthetic agent administered, depth of anesthesia monitoring may result in faster recovery from anesthesia. Gan et al. found that BIS monitoring is associated with significantly quicker emergence from anesthesia as well as shorter stay in PACU.[12] Similar findings were subsequently reported in several other studies,[13,17,18] and meta-analyses.[21,22]

See "Depth of Anesthesia Monitoring," Next Page

Other Applications for Depth Monitoring, (cont'd)

From "Depth of Anesthesia Monitoring," Preceding Page

BIS monitoring may also reduce the incidence of vasomotor complications as a result of unnecessarily deep anesthesia. Jildenstål et al. reported that AEP-guided anesthesia was associated with significantly lower vasopressor requirement.[19] Low BIS index as well as "double low" events (low BIS and low mean arterial blood pressure [MAP], typically defined as case-based time-weighted average BIS and MAP below the sample mean) have been associated with increased mortality.[23,24] While the concept of 'triple low' (low BIS, low MAP, and low-end tidal anesthetic concentration) has also been introduced, the combination of low BIS and low-end tidal concentration is suggestive of sensitivity to anesthetic agent, rather than excessively deep anesthesia.[25] Several studies have also suggested that use of BIS monitoring may be associated with reduced hypotensive episodes and vasopressor rescue.[15-16] However, the only large RCT on the use of "double low" alarms (low MAP, low BIS) reported that despite the use of alarms, 60% of double-low events continued on for more than 15 minutes, which suggested a lack of intervention, and the postoperative mortality rate was not significantly different between the cohorts.[26]

Lastly, it has been proposed that excessively deep anesthesia in high-risk (pre-existing neurocognitive disorders, cerebral vascular disease, frailty, etc.) patients is associated with the development of postoperative delirium and postoperative cognitive dysfunction.[27] Postoperative delirium (POD) is associated with increased morbidity and mortality, as well as long-term cognitive and functional decline. Several studies have demonstrated that BIS-guided anesthesia is associated with a significantly lower risk of POD.[28-30] On the other hand, the ENGAGES trial recently published by Wildes et al. reported that despite lower anesthetic requirement and less EEG suppression in the BIS cohort, there was no significant difference in the risk of delirium, but they did report significantly lower 30-day mortality.[16] MacKenzie et al. conducted a meta-analysis of 13 studies and reported lower risk of POD with depth of anesthesia monitoring.[31]

DISCUSSION

Depth of anesthesia monitoring may be a useful tool to help the clinician prevent the complications of too little or too much anesthesia. Whereas, anesthetic gas measurement may be sufficient for preventing awareness during inhalation anesthesia, tools like EEG-based depth monitoring add insight into anesthetic effect during TIVA. Excessive anesthetic dosages are well known to cause hemodynamic instability, but we are learning there may be other consequences of too much anesthesia such as neurocognitive dysfunction. Depth of anesthesia monitoring becomes more compelling if it can be used to guide the clinician to the "sweet spot" where anesthetic dose is sufficient to prevent awareness but not greater than needed.

Some patients are especially vulnerable to anesthetic dosage complications and it is likely we have not yet identified all of those patient populations. RCTs to date examining anesthetic depth monitoring have focused on large populations undergoing general anesthesia rather than focusing on at-risk populations, where the impact of depth monitoring would be more readily apparent. If benefits are demonstrated in at-risk populations, the cost-effectiveness arguments for using the technology in these populations would further improve.

Studies suggest there is a role for anesthetic depth monitoring in vulnerable patients and we should work to refine the technology and define the important clinical indications. More data are needed to determine the value of various technologies and their potential to prevent awareness and excessive anesthetic dosage. The threshold of evidence that supports a device as a monitoring standard is not clear. Pulse oximetry could not be shown to improve outcome, yet it is a well-established monitoring standard. Although the potential benefit of improved outcomes may be difficult to show, the potential to cause harm for example, by failing to detect awareness, is important to understand. It is not difficult to argue that once depth of anesthesia monitoring technology is proven more reliable, our monitoring recommendations should address the appropriate role for this technology in clinical practice.

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See "Depth of Anesthesia Monitoring," Next Page

EDITORIAL:

Importance of End-Tidal Agent Monitoring as a Standard of Care

by James H. Philip ME(E), MD, CCE, FACA, DABA, FASA, and Jan Hendrickx, MD, PhD

In some countries anesthetic agent monitoring is a written Standard of Care while in others it is not even mentioned.[1] Most anesthesia care providers use an anesthetic agent monitor to measure agent concentrations in their everyday practice and in much of the world it has become a *de facto* Standard of Care.[2] Thus, although widely adopted in patient care, agent monitoring is not considered to have the same importance as other monitoring modalities that have been adopted as standards, such as those that address the various components of oxygenation, ventilation, and perfusion which are rather consistent across the globe.[1] But anesthesia providers induce and manage certain behavioral states; in particular, unconsciousness and immobility. Patients expect to be unconscious, and preventing awareness is an important safety imperative. Even though lack of awareness is an essential component of anesthesia, monitoring the hypnotic state is not consistently addressed in standards due to controversy over the reliability of the technology.[3] When inhalation anesthetics are used, we have the ability to monitor inspired and end-tidal expired agent (ETA) concentrations to help ensure lack of awareness. We believe that anesthetic agent concentration monitoring provides sufficient information to allow care providers to prevent awareness and that it should be universally adopted as a Standard of Care.

Three properties of inhaled agents provide the rationale for ETA monitoring: the steep dose response curve of volatile anesthetics[4,5]; the small effect opioids have on this relationship (only a 10–15% reduction in minimal alveolar concentration (MAC) Awake, the median anesthetic level for patients to respond to verbal command)[6]; and the ease of continuous measurement of their concentration. The end-tidal agent concentration is a good indicator of how likely it is the patient is unconscious[8] after taking into account the short delay for the brain partial pressure to equilibrate with that in the blood and alveoli.[8-12] With an ETA concentration of 0.7 MAC, awareness is extremely unlikely.[13,14]

So, how is it that anesthesia continues to be administered without ETA monitoring? An anesthesia care professional without an ETA monitor could titrate the vaporizer output to maintain stable vital signs like blood pressure and heart rate. Underdosing of the volatile anesthetic is generally recognized by a rising heart rate or blood pressure in response to surgical stimulus, and, in the un-paralyzed patient, movement. But without a measure of the partial pressure of anesthetic agent in the body, which is indicated by the ETA concentration, the etiology of vital sign changes is less obvious and can result in incorrect diagnosis and treatment including unnecessary vasopressor use or excessive fluid administration. In addition, clinical signs per se are unreliable indicators of the hypnotic state especially in patients taking sympatholytic medications.

More compelling reasons exist to use ETA monitoring. Forgetting to turn on the vaporizer or an empty vaporizer going unnoticed can result in unappreciated awareness, especially in the patient given a muscle relaxant. In addition, the concentration selected on the vaporizer may not match the end-tidal agent concentrations, putting the patient at risk for under- or overdosing. Efforts to reduce fresh gas flow to reduce waste and environmental contamination also increase the challenge of managing the relationship between the delivered and actual alveolar concentration. Keeping the ETA concentration and thus anesthetic depth constant can require increasing the vaporizer setting well above the desired inspired and ET concentrations. The lower the fresh gas flow, the greater the difference between the vaporizer setting and the inspired agent concentrations, and that difference is only apparent when using an anesthetic agent monitor.

Given the readily available technology for measuring ETA concentration, as well as the well documented relationship between ETA agent concentration and risk of awareness, we believe the use of ETA concentration monitoring should be an official Standard of Care for all anesthesia-related professional organizations.

Dr. Philip is senior consultant anesthesiologist and director of Anesthesia Clinical Bioengineering, Brigham and Women's Hospital, and professor of Anaesthesia, Harvard Medical School.

Dr. Hendrickx is a staff anesthesiologist at OLV Hospital, Aais, Belgium.

Dr. Philip has received honoraria from Getinge and GE. Dr. Hendrickx has received lecture support, travel reimbursements, equipment loans, consulting fees, and meeting organizational support from AbbVie, Acertys, Air Liquide, Allied Healthcare, Armstrong Medical, Baxter, Dräger, GE, Getinge, Hospithera, Heinen & Lowenstein, Intersurgical, Maquet, MDMS, MEDEC, Micropore, Molecular, NWS, Philips, Piramal, Quantium Medical.

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Depth of Anesthesia Monitoring (cont'd)

From "Depth of Anesthesia Monitoring," Preceding Page

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RAPID Response
to questions from readers

PEA Arrest During Transport of a Ventilated Patient Due to a Clogged Respiratory Filter on Ambu® Bag

by Madina Gerasimov, MD, and Jaspreet Toor, DO

Editor's Note: The clogged filter in this case is not unique to this product and can be seen in any device similar to this particular one.

A 65-year-old intubated woman with sepsis and new onset end-stage renal disease requiring dialysis presented to the interventional suite for dialysis catheter insertion. The procedure was uneventful, and the patient remained intubated for transport to the ICU. During transport, it became increasingly difficult to manually ventilate the patient with the self-inflating Ambu® bag (Ambu Inc., Columbia, Maryland) attached to the endotracheal tube (ETT). The patient then developed hypotension, hypoxemia, and subsequent PEA arrest. During resuscitation, the anesthesia professional noted that the Ambu® bag expiratory valve filter was obstructed with secretions. Therefore, the ETT was disconnected from the Ambu® bag, which led to an audible rush of air that subsequently resulted in return of circulation.

With inadequate expiratory time, incomplete exhalation, and so called auto positive end-expiratory pressure (auto-PEEP) can occur in mechanically ventilated patients.[1,2,3] It is most commonly seen in patients with severe asthma or chronic obstructive pulmonary disease, but can occur in patients without lung disease. It can result in increased work of breathing, inadequate ventilation, barotrauma, and hemodynamic instability.[1,2] Professionals should be aware of preventative strategies, detection, and treatment of auto-PEEP.[2,3] We present a case of cardiac arrest secondary to auto-PEEP with return of spontaneous circulation after relief of the mechanical expiratory airflow obstruction (Figure 1).

PEEP is defined as positive pressure in the alveoli at the end of exhalation. Auto-PEEP is an unintended increase in alveolar pressure when complete exhalation is not achieved and may progressively increase.[1] This may occur due to several reasons. In our case, it was obstruction of exhalation secondary to a clogged expiratory filter (Figure 1). Over-ventilation is always a concern with manual ventilation; however, in our case this possibility was exacerbated by the fact that exhalation was blocked and "stacked" breaths (auto-PEEP) quickly led to cardiovascular collapse. Subsequently, the filter was removed from all Ambu® bags in our system and instead replaced with a splash guard (Figure 2). The guard provides protection for the professionals while eliminating the risk of expiratory filter obstruction due to soiling with secretions or blood. The expiratory filter is still commercially available for Ambu® bags, and we believe it is important to share this case report to increase awareness and prevent further catastrophic events similar to this.

Dr. Gerasimov is an assistant professor in the anesthesia department at Donald and Barbara Zucker School of Medicine at Hofstra Northwell.

Dr. Toor is a pain fellow at Northwestern University Medical Center at Northwestern Memorial Hospital.

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Reply:

The use of detachable accessories such as filters is very common with disposable resuscitators of all kinds, whether they come prepackaged with the device or are purchased and attached separately. Expiratory filters are designed to protect the caregiver by filtering out various potentially harmful pathogens on a microscopic level, and are not designed to overcome clogging due to a patient vomiting or expelling thick lung secretions. The expiratory filter we package with the Ambu SPUR II resuscitator is not an Ambu-manufactured product, but has been tested to perform within the requirements of the ISO standard for bacterial/viral filters. These same filters are used in conjunction with manual resuscitators from various manufacturers with the same restrictions and standards applied.

This being the case, the unfortunate patient scenario that has been described by Drs. Gerasimov and Toor would have likely played out the same way regardless of what type of resuscitator was being used to ventilate the patient. As soon as the patient secretions were discovered, the filter should have been removed and the airway cleaned out. If this didn't resolve the issue, a new resuscitator should have been used to resume ventilation. Additionally, the auto-PEEP described in the report is to be expected when adding accessories like filters or PEEP valves to resuscitators or airway circuits. Our product information for use (IFU) describes potential scenarios like these and how they should properly be addressed when they occur. Similar language should be found in the IFU from any device manufacturer, suggesting the risks presented by using these accessories are common across the spectrum of manual disposable resuscitators on the market.

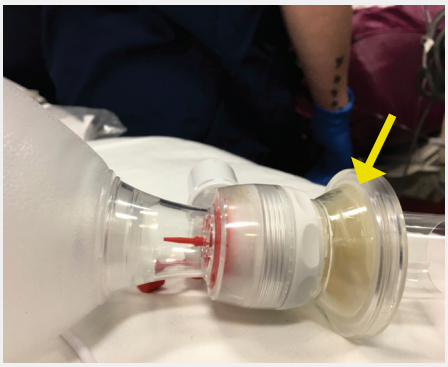

Figure 1: Ambu® Bag with Clogged Filter. Yellow arrow indicates filter.

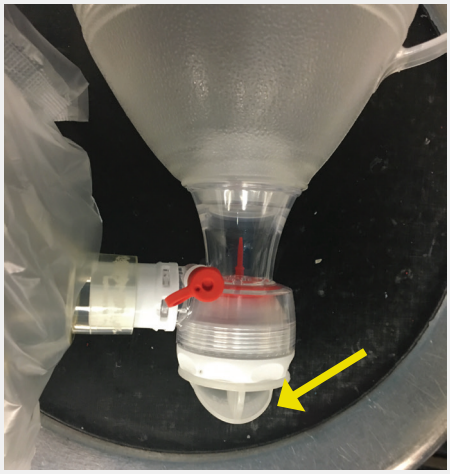

Figure 2: Ambu® Bag with Splash Guard. Yellow arrow indicates splash guard.

Respectfully,
Sanjay Parikh, Director, QA/RA
Ambu Inc., 6230 Old Dobbin Lane, Suite 250
Columbia, MD

RAPID Response
to questions from readers

Considerations for Mechanical Support of Ventilation During Patient Transport

by Nelson N. Algarra, MD, and Nikolaus Gravenstein, MD

Supporting ventilation during transport is not a trivial exercise and is reported to be associated with some complication in 10% to 31% of cases.[1,2] While patient safety concerns during transport of the intubated patient are similar to those in the operating room, the logistics of how we ventilate and monitor the intubated patient during transport are unique. As highlighted by the preceding report by Gerasimov and Toor, the devices used for ventilation during transport can lead to undesired consequences.[3] In the operating room, anesthesia professionals have all of the resources needed to manage ventilation safely including both manual and mechanical ventilation, patient monitors and alarms, suction, and additional colleagues to help with emergencies. During transport, these resources are more limited and there is the added burden of pushing the bed through halls and into elevators.

SAFER TRANSPORT THROUGH DEVICE SELECTION AND MONITORING

Drs. Gerasimov and Toor describe a case of significant expiratory airflow obstruction leading to pulseless electrical activity (PEA) arrest caused by secretions in a filter placed over the expiratory valve of a self-inflating resuscitation bag to protect the environment.[3] Obstruction of a filter either directly connected to the endotracheal tube or anywhere downstream in the expiratory flow path is possible with any ventilation circuit and is always a consideration when there are elevated airway pressures. An obstruction may also occur within the endotracheal tube itself. In the reported case, the solution implemented to prevent a recurrence of the filter obstruction to exhalation scenario was to use a shield to deflect exhaled secretions instead of a filter that can become obstructed. This would certainly work to solve the ventilation circuit filter obstruction problem, but it still leaves the potential for environmental and personnel contamination.

Our informal sense is that when the resources are available, in-hospital transports of unstable patients between the operating room and the intensive care unit are increasingly being conducted with a transport ventilator of some type, and a respiratory therapist in attendance. This might be the safest option for transport as long as there is an adequate oxygen supply. In patients who remain intubated for airway control reasons but are otherwise clinically stable, the use of a self-inflating bag or a Mapleson is a matter of provider preference or institutional protocol. Both have advantages and disadvantages (Table 1). As transport ventilators become more available, there appears to be a trend towards more routine use of them.

The lesson in the case report is that anything added to a breathing circuit that can obstruct exhalation can impair exhalation to the point of hemodynamic collapse and further[4] that monitoring the manual ventilation process is useful to detect changes before they become significant. Perhaps with an "educated hand," expiratory obstruction would be more readily detected with a Mapleson-type circuit, although that remains to be proven. With manual ventilation, continuous assessment of respiratory parameters with visual and tactile control of the circuit of choice is paramount. Some manual bags incorporate an airway pressure manometer to help monitor the ventilation process. Finally, use of capnography during transport is quite possible and verifies both inspiration and exhalation. If tidal volume is reliably achieved, the end-tidal carbon dioxide concentration can confirm adequate ventilation.

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Neither author has any conflict of interest pertaining to this article.

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Table 1: Comparison of Commonly Used Devices to Support Ventilation During Transport*

Transport Device	Advantages	Disadvantages
Self-Inflating (AMBU® type) Bag	• Can ventilate even if gas supply fails • Lightweight, easy to use • Familiar apparatus	• No visual indication of inspiration or exhalation—problems with gas delivery are more difficult to appreciate • Monitoring inspiration and expiration is not standard • Lower compliance of the bag can obscure detection of changes in patient compliance • Tidal volume is variable • Respiratory rate is variable
Mapleson-Type Circuit	• Inspiration and exhalation can be appreciated manually • Visual indication of patient respiratory efforts	• Requires a compressed gas supply • Delivered tidal volumes depend upon gas flow and APL setting • Monitoring inspiration and expiration is not standard • Tidal volume is variable • Respiratory rate is variable
Transport Ventilator	• Ventilation is stable and reliable • Hands free • Monitoring patient-ventilator interaction is built into the device	• Resource intensive, both device and trained personnel • Requires a compressed gas supply

*Use of capnography during transport mitigates many of the disadvantages of self-inflating and Mapleson transport ventilation devices

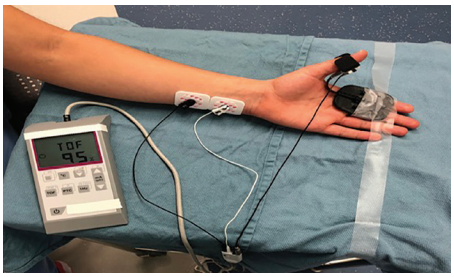
Avoiding Postoperative Residual Weakness—A Cornerstone of Any ERAS Protocol

by J. Ross Renew, MD

While neuromuscular blocking agents (NMBAs) are a useful class of medications in the perioperative setting, their use is not without risk. Unfortunately, postoperative residual weakness following NMBA administration persists as a significant patient safety threat.[1-4] This phenomenon has been implicated in a number of significant complications including prolonged time spent in the recovery room, hypoxemia, and airway obstruction.[5,6] Additionally, one of the most common complaints from patients with postoperative residual weakness is unpleasant subjective symptoms related to incomplete neuromuscular recovery that can interfere with early mobilization.[7] Despite an abundance of literature documenting the detrimental effects of postoperative residual weakness, many anesthesia professionals underestimate the scope of this problem.[8] As such, residual weakness and its associated complications remain a serious patient safety concern.

Significant advances in the field of perioperative care have emerged, even in the face of these unresolved hazards. Enhanced recovery after surgery (ERAS) protocols represent comprehensive, multidisciplinary efforts to expedite postoperative recovery while reducing avoidable complications.[9] These standardized efforts have been shown to improve a number of important perioperative outcomes, such as reduced postoperative nausea and vomiting (PONV)[10] and improved patient satisfaction.[11] While effective, ERAS protocols must be constructed with the best available evidence and conform to the specific context of the implementing institution in order to have significant benefit to patients.[12] The avoidance of postoperative residual weakness is an evidence-based practice to improve patient safety and should be a cornerstone of any ERAS protocol.

Several strategies have emerged to reduce the incidence of postoperative residual weakness. Not surprisingly, these strategies overlap with common principles of enhanced recovery programs. The use of reversal agents to antagonize the effects of NMBAs, such as neostigmine or sugammadex, is an evidence-based practice that can reduce the incidence of postoperative residual weakness and its associated complications.[13] A recent meta-analysis has expanded on this matter and suggests that the administration of sugammadex results in fewer adverse events, less PONV, and faster return of neuromuscular function when compared to neostigmine.[14] In addition to safely expediting recovery and reducing PONV, ERAS also emphasizes the maintenance of homeostasis during the perioperative period. Although not commonly described, the restoration of neuromuscular function may represent a key principle of ERAS. Furthermore, the use of quantitative neuromuscular monitoring can confirm that



neuromuscular homeostasis has been restored postoperatively.[15] Quantitative monitoring has been linked to reducing postoperative pulmonary complications that would undoubtedly have served as a significant hindrance to a patient's enhanced recovery.[13] These strategies can be implemented to not only reduce adverse events from postoperative residual weakness, but also to expand and advance comprehensive ERAS protocols.

While enhanced recovery protocols are being implemented at an increasing rate and growing in popularity, we cannot overlook persistent patient safety threats that could also prove to be significant impediments to such programs. As ERAS protocols rely upon well-established evidence, well-described strategies to avoid postoperative residual weakness should be incorporated as the perioperative community continues efforts to advance patient safety and improve outcomes.

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Dr. Renew has received industry funding for research, including from Merck & Co., with all funding accruing to Mayo Clinic.

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PRO AND CON: Using a Labor Epidural for Cesarean Delivery

PRO: Dose the Epidural for Surgical Anesthesia

by Michael Block, MD

Labor patients requiring intrapartum cesarean delivery (CD) may present with an indwelling epidural catheter to anesthesia professionals on Labor and Delivery (L&D). Dosing the labor epidural to achieve surgical anesthesia should be considered as the first-line approach. Effective surgical anesthesia and postoperative analgesia can be accomplished using an *in-situ* epidural catheter, while acknowledging that an incomplete or one-sided level of anesthesia may occur.[1]

The use of an indwelling epidural catheter allows for rapid yet controlled titration of anesthetic medications to achieve surgical anesthesia. For example, administration of local anesthetics (e.g., lidocaine 2% with epinephrine and sodium bicarbonate, or 3% 2-chloroprocaine) in combination with a lipophilic opioid (e.g., fentanyl, hydromorphone) typically provides rapid onset of surgical anesthesia.[2] In clinical circumstances where avoidance of abrupt sympathetic blockade is necessary (e.g., reduced volume status, limited cardiac reserve), gradual titration of anesthesia using an epidural catheter is a key advantage over spinal anesthesia alone.

In the event that the CD outlasts the duration of the initial epidural loading dose, the level of anesthesia can be maintained or extended using further local anesthetic administered through the epidural catheter. Examples may include a CD where the time for surgical exposure is prolonged due to adhesions, morbid obesity, or placental pathology.[3] For unanticipated complications such as postpartum hemorrhage requiring return to the operating room for re-exploration or hysterectomy, maintaining the epidural catheter allows for the redosing of epidural anesthesia, thus potentially precluding general anesthesia and its inherent risks.[4] An added benefit of maintaining the epidural postoperatively is the ability to provide appropriate analgesia with patient-controlled epidural analgesia using a dilute solution of local anesthetic and opioid.

A known challenge with relying on an indwelling epidural catheter for CD is failure to achieve adequate anesthesia.[5] However, measures taken during epidural placement can maximize the successful conversion from labor epidural analgesia to surgical anesthesia. For example, the use of combined-spinal epidural dosing and/or dural puncture epidural may increase the reliability of epidural catheter

insertion and enhance the effectiveness of medications administered through an epidural.[6]

The effective management of labor epidural analgesia relies on effective communication and coordination of care between anesthesia and obstetric professionals in L&D. Since a labor epidural catheter remains indwelling for prolonged periods of time without an anesthesia professional in continuous attendance, it is important that inadequate analgesia is promptly brought to the attention of anesthesia professionals so necessary interventions (catheter bolus, adjustment, or replacement) are undertaken.[7,8] Ensuring a functional epidural catheter during labor can reduce the need for a repeat neuraxial block or conversion to general anesthesia particularly when under time pressure for urgent CD.

Finally, administration of spinal anesthesia for intrapartum CD subsequent to an infusion through an epidural catheter carries risks of high or total spinal given the uncertain amount of drugs in the neuraxial space that were administered.[1] Moreover, conversion to general anesthesia in lieu of dosing an indwelling epidural catheter, introduces further risks associated with instrumenting the maternal airway and increasing maternal and neonatal exposure to anesthetic agents.

When a laboring patient receiving epidural analgesia presents for CD, anesthesia professionals should utilize the epidural catheter for surgical anesthesia as opposed to abandoning use of the epidural and proceeding with spinal or general anesthesia. Approaches to promote effective use of epidural anesthesia such as combined spinal epidural or dural puncture epidural are described above. When clinically applied as the first-line approach, the added risks of performing spinal or general anesthesia for CD or additional postpartum procedures such as tubal ligation can be averted.

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The author has no conflicts of interest to disclose.

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See "Pro and Con," Next Page

PRO AND CON: Using a Labor Epidural for Cesarean Delivery

CON: Pull the Epidural Catheter and Perform a Spinal

by Unyime Ituk, MBBS, FCARCSI

Pain during cesarean delivery (CD) is distressing for a patient, and a leading cause of litigation in obstetric anesthesia.[1] It is critical that when providing anesthesia for CD that the parturient is as comfortable as possible.[2,3] In parturients who require CD with a labor epidural catheter *in situ*, surgical anesthesia is frequently initiated by administering a bolus of local anesthetic (LA) via the epidural catheter. The ability to convert a labor epidural to surgical anesthesia for CD is often cited as a benefit of labor epidural analgesia. However, conversion of a labor epidural for surgery is not always successful and may lead to pain and anxiety in the parturient.

Reported epidural conversion failure rates range from 0% to 21%.[4-8] The variable incidence may reflect an inconsistent definition. For example, a low reported rate of epidural conversion failure may exclude patients who maintain spontaneous ventilation while receiving significant supplemental intravenous medications (e.g., opioids, propofol, or ketamine). These medications are commonly administered during CD to avoid general endotracheal anesthesia when an epidural anesthetic is inadequate. Realistically then, such practice should be considered as epidural conversion failure. We note that the use of intravenous sedating medications confers drawbacks of aspiration risk, suboptimal pain control, and poor maternal satisfaction.

Multiple factors have been associated with epidural conversion failure (Table 1).[9] However, the continued preference of attempted conversion of labor epidural analgesia to anesthesia in parturients requiring CD is somewhat perplexing.[10] Stratification of patients more likely to fail epidural conversion with consideration of spinal anesthesia as an alternative may be warranted.

A recent randomized trial compared patients who had epidural anesthesia to those who had an epidural catheter removed and subsequent spinal anesthesia for CD. Maternal comfort during CD was higher in the spinal anesthesia group compared to the epidural anesthesia group.[11] The main limitations of this study included recruiting only patients with CD urgency classification of category 3 (needing early delivery but no maternal or fetal compromise) and not reporting the time taken to initiate spinal anesthesia. In two observational studies, patients receiving spinal anesthesia rather than conversion of a labor epidural reported better quality of anesthesia with a side-effect profile similar to patients under spinal anesthesia with no prior epidural catheter.[12,13]

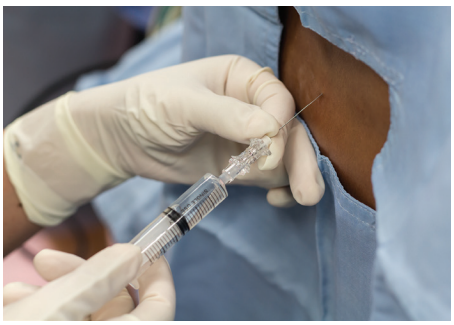

Table 1: Factors Associated with Epidural Conversion Failure

Breakthrough pain/number of boluses
Duration >12 hours since initiation of epidural analgesia
Initiation of analgesia using an epidural-only technique as compared to combined spinal epidural
Maternal height > 167 cm
Urgency of cesarean delivery

While spinal anesthesia may provide a superior quality of anesthesia compared to epidural anesthesia,[14] the reported increased risk of high or total spinal anesthesia in the setting of preexisting labor epidural infusion is a potential disadvantage of its use for intrapartum CD.[9] However, most reports of high or total spinal anesthesia occurred when a spinal was performed *after* failed epidural conversion and the patient had received bolus doses of epidural LA.[9] In the setting of an urgent or emergent CD, quickly dosing an indwelling epidural catheter may achieve anesthesia faster than providing a new spinal anesthetic. In a study simulating emergency CD, the mean time to spinal anesthesia by expert obstetric anesthesia professionals was just over two minutes compared to one minute 58 seconds for general anesthesia.[14] Kinsella and colleagues proposed the concept of a "rapid sequence spinal" in a case series of category 1 (emergent) CD in which the median interquartile range time to prepare and perform a spinal anesthetic was 2 (2–3 [1–7]) min, and time to develop a satisfactory surgical anesthesia was 4 (3–5 [2–7]) min.[15]

In conclusion, conversion of labor epidural analgesia to epidural surgical anesthesia is associated with a variable and potentially high failure rate. Successful conversion is influenced by multiple factors that may not always be anticipated. Therefore, spinal anesthesia should be considered as a reasonable alternative anesthetic technique for intrapartum CD, even in women with an indwelling labor epidural catheter.

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The author has no conflicts of interest to disclose.

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LETTER TO THE EDITOR:

Medication Error Related to Look-Alike Prefilled Syringes

Around the time of the publication of the letter "'No Read' Errors Related to Prefilled Syringes" in this publication,[1] we experienced a similar incident in our institution. Use of prefilled syringes has been found to have many advantages including convenience, sterility, and safety.[2] In this case, prefilled syringes of epinephrine 0.1 mg/ml and lidocaine 2% were assembled prior to induction of anesthesia and placed on top of the anesthesia cart (Figure 1A and 1B). Both syringes were manufactured by IMS, Limited of South El Monte, CA. For induction, syringes were placed into the intravenous manifold by a beginning anesthesia trainee. The trainee called out what medication was being administered as the trainee administered the drugs. The trainee stated that 100 mg of lidocaine was being administered. Shortly after induction the patient became very hypertensive and tachycardic. When the anesthesia attending looked at the drugs in the manifold, it became apparent that 0.8 mg of epinephrine had been administered instead of lidocaine. Propofol and esmolol were given to counteract the effects of the epinephrine, which resulted in profound hypotension. Low-dose epinephrine was given and a few chest compressions were administered. The patient quickly stabilized and the case proceeded as scheduled. There were no ECG changes and associated cardiac enzymes were negative.

The case was presented to the hospital quality improvement committee and it was determined that the syringes, when assembled, looked very similar and that color coding of the syringes did not meet standards set by the American Society for Testing and Materials (ASTM).[3] In fact, the lidocaine syringe and box have a pink label, which is close to the violet used for vasopressors in ASTM standard labeling (Figure 2). In addition, the epinephrine has a grey/tan label, similar to the grey used in the ASTM standards for local anesthetics (Figure 2). Neither has circumferential color labeling (Figure 1).

As a result of this incident, the following institutional policies were implemented:

1. Epinephrine syringes are not to be assembled until they are needed.
2. Epinephrine is not to be kept on top of the anesthesia cart.
3. Beginner trainees are not to administer induction drugs.

We hope these interventions will reduce the risk of medication error and subsequently improve patient safety.

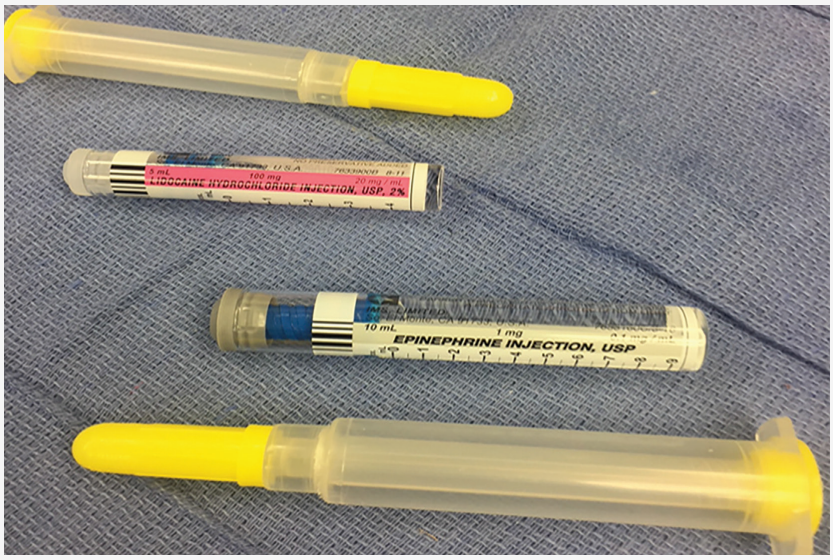

Figure 1A: Depicts the front labeling of the 2% lidocaine and epinephrine 0.1 mg/ml syringes.

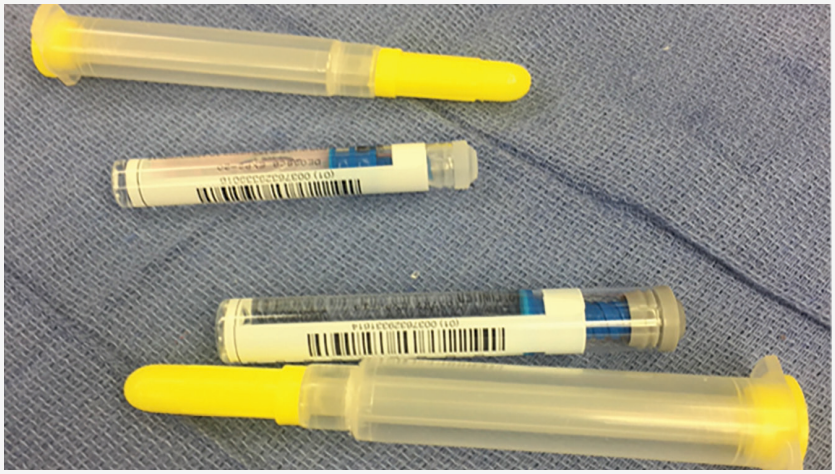

Figure 1B: Depicts the back labeling of the 2% lidocaine and epinephrine 0.1 mg/ml syringes. Note the similarity between the syringes.

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The authors have no conflicts of interest to disclose.

Figure 2: Depicts the packaging boxes of both 2% lidocaine and epinephrine 0.1 mg/ml.

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LETTER TO THE EDITOR:

Single-Use or Preservative-Free Does Not Equate to Sulfite-Free

Preservative-containing solutions are generally avoided for intrathecal administration. However, sodium bisulfites are commonly added to epinephrine-containing solutions to function as an antioxidant and increase the shelf-life for these agents.[1] While much of the data describing adverse events (anaphylactoid reactions, neurotoxicity, and chronic adhesive arachnoiditis/neurologic deficits) related to intrathecal administration of these agents is historical and potentially controversial in nature, it is important to remain vigilant and aware of the impact that medication shortages and shifting suppliers may have on the constitution of many commonly utilized agents.[1-5] In addition, it is important to realize that medications labeled as single-use or preservative-free may contain sulfite preservatives.

It was recently brought to our attention that our supply of single-use epinephrine (Adrenalin®, 1 mg/mL, 1 mL single-use vial, Par Pharmaceutical, Inc., Chestnut Ridge, NY) commonly utilized to prolong neuraxial anesthesia for orthopedic procedures contains sodium bisulfite (Figure 1 – Right). Product vial labeling of "single-dose" epinephrine led to the widespread belief that this equated to "preservative-free." While the vial label makes no mention of its inactive ingredients, the product box does provide a more thorough description of additional agents (Figure 2).[6]

While there were no detectable adverse events related to the intrathecal administration of this preservative-containing agent, this does highlight the importance of continued vigilance with regard to medication supplies and a good working relationship with pharmacy so that they understand the utilization of the medications being administered by anesthesia professionals.

To avoid the issue of preservative-containing epinephrine solutions, preservative-free ampules are now available and clearly labeled in all locations where neuraxial anesthesia is performed (Figure 1 – Left.) It is ultimately incumbent upon anesthesia professionals to ensure that products intended for neuraxial administration are specifically marked "preservative free" or, if labeled as "single-use," are without unwanted preservatives, and collaboration with pharmacy colleagues may facilitate this process.

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Shelly B. Borden, MD is assistant professor, Department of Anesthesiology, University of Wisconsin School of Medicine and Public Health.

Trisha A. Ludwig, PharmD is pharmacy manager, UW Health at The American Center.

Elizabeth Wilson, MD, is assistant professor, Department of Anesthesiology, University of Wisconsin School of Medicine and Public Health.

Dr. Schroeder has no relevant conflicts. Dr. Shroeder is editor of ASRA News *(unpaid), lecturer for Northwest Anesthesia Seminars and* AudioDigest® *(paid), and has an equipment grant for training purposes from Cook Medical. Drs. Borden, Ludwig, and Wilson have no pertinent conflicts of interest.*

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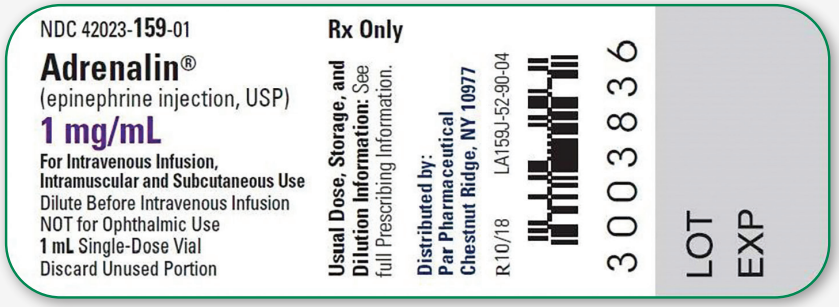
Figure 1: Single-use vial on right of image contains sulfite. Ampule on left of image is preservative-free and without sulfite.



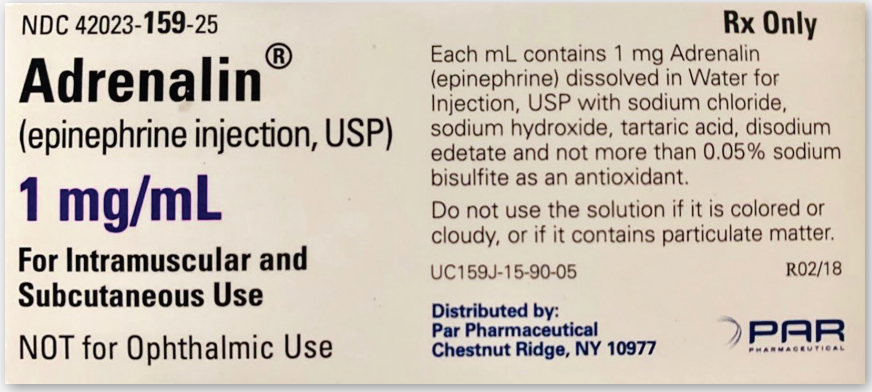


Figure 2: Manufacturing information provided for single-use (sulfite-containing) vials of epinephrine. First image provides information available on vial and second image provides more detailed information available on the product box.

EDITORIAL:

The Call for Standardizing Safer Drug Labeling Methods

by Lauren Lobaugh, MD, and Ronald S. Litman, DO, ML

In the preceding letters, Parr, Schroeder, and colleagues describe medication error events that resulted from look-alike medications and complicated medication labels. These reports evoke the familiar emotions of frustration, empathy, and intolerance, because as anesthesia practice has become increasingly safer throughout the years, we have unintentionally allowed preventable medication errors to remain commonplace. One recent report has estimated that medication errors occur in 1 out of 20 medications administered.[1] This relatively high incidence continues despite the awareness highlighted by the Institute of Medicine's Report *To Err is Human* in 2000.[2]

As anesthesia professionals, we have a responsibility to demand safer medication labeling strategies and are primed to lead this change. As a public health framework to emulate, a unique parallel situation exists for improvements of nutrition labeling on commercially prepared foods to protect individuals. The growing desire of Americans to better understand the components of the food they consume compelled the Food and Drug Administration to implement a regulatory framework for food labeling based on the belief that smarter dietary choices would decrease the leading causes of death (i.e., heart disease, cancers, strokes, and diabetes).[3,4] Ultimately, it was the voice of the American consumer, guided by the health care community and scientific evidence, that resulted in the standardization and simplification of nutrition labeling in the form of a "Nutritional Facts" panel now found on most commercially packaged foods.

Improved clarity in communication through regulation is an example of using data-driven health care policy that is likely to improve health and safety. No one expected standardized nutrition labels to cure heart disease; however, it was important to support consumers in making smart dietary decisions. Similarly, compulsory medication labeling will not entirely prevent anesthesia personnel from making errors, but it will help them proactively recognize when an error may occur. Anesthesia professionals should not have to read between the lines on the drug vial or syringe when practicing in a complex and highly stressful clinical environment. We should be able to confidently select a local anesthetic with epinephrine from our drug tray and know that it is safe to use because we have selected a product with clear labeling that states "For Neuraxial Use Only." The next generation of anesthesia-based electronic records should contain bar-coding modules to decrease medication errors even further.[5]

We thank Parr and Schroeder and their colleagues for sharing these important events that emphasize that unless we advocate for safer systems these errors will not disappear. Like the nutrition labeling initiatives of the 1990s, it is time that we demand change and work with key regulatory stakeholders in the area of public health law[6] to standardize safer drug labeling methods, as well as improve the availability of prefilled syringes to help prevent vial swap, and bar-coding techniques to help prevent syringe swap.

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Dr. Lobaugh has no conflicts as they relate to this article. Dr. Litman serves as medical director for the Institute for Safe Medication Practices.

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LETTER TO THE EDITOR:

Solving Gaps in Blood Pressure Monitoring

I read with interest the letter in the Rapid Response column (*APSF Newsletter* June 2019) concerning questions about gaps in blood pressure monitoring from Dr. Sheron McLean, a faculty member in our department.[1] I am familiar with the issue of blood pressure monitoring gaps, since our multi-institutional study assessing the ability to reduce the incidence of these gaps by utilizing either visual alerts, audible and visual alerts, or no alerts.[2] The study showed that audible alerts did reduce monitoring gaps but the visual alerts alone did not.[2] Subsequently, we found that blood pressure monitoring gaps are a potential patient safety issue since they were associated with an increased incidence of hypotension.[3] Based upon this research, we developed, and have been using, a decision support system with visual and audible alerts that can be programmed for customized alerts. This system (AlertWatch™ Ann Arbor, MI), was commercialized and cleared by the Food and Drug Administration (FDA) as a medical software device.

The name of our company was not indicated in Dr. McLean's letter apparently because it was removed during the editing process "to avoid any appearance of endorsement by APSF."[4] The response from General Electric (GE) published extensive text and multiple screenshots describing how they are trying to approach this problem. This article could be seen as an endorsement for the GE CARESCAPE B-850 monitor. In the spirit of informing anesthesia professionals about methods for enhancing patient safety, I am surprised the Anesthesia Patient Safety Foundation would not reference a system intended to enhance safety, especially in the context of an entire issue on alarm fatigue and patient safety. APSF should publish the editorial policy on content referencing a commercial product to facilitate communication to the anesthesia community yet avoid the possible perception of "endorsing" a specific product, sponsor, or APSF donor.

Kevin Tremper is the Robert B. Sweet Professor and chair of the Department of Anesthesiology, University of Michigan. He is also the founder and equity holder in AlertWatch.

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4. Personal Communication to Sheron McLean from APSF, email dated February 19, 2019.

Editorial Response:

Dear Dr. Tremper,

We want to thank you for your interest in the APSF and understand the concern you have raised in your recent letter. The letter from Dr. McLean was submitted to our Rapid Response (formerly Dear SIRS) column. The history of that column is to receive comments, often disparaging, about technology used in patient care, and publish those comments with the opportunity for a corporate response from the vendor. The goal of the column is to provide a forum to bring patient safety concerns about technology to light while allowing the design work by the company to be clarified, and also to highlight any user issues that may have contributed to a problem. Not infrequently, the identified safety concern influences the product design process by the companies and results in product improvement and/or helps to educate professionals about the proper use of the device. Over the years, this column has been very impactful in part because we have worked hard to manage the corporate sensitivities. In the editorial process, we are cognizant of the potential impact if the *APSF Newsletter* is used as a platform to promote or disparage any particular vendor or technology.

In this particular case, we focused on the concept of blood pressure measurement as a potential patient safety concern and thanks to Dr. McLean, the concept is explored nicely in the *APSF Newsletter*. Not only was her letter critical of the GE design, but given the fact that

AlertWatch™ originated in your department, we were concerned that by mentioning the product by name, her letter would be viewed as an endorsement that could be referenced and used to promote the product. Undoubtedly, you can appreciate the editorial challenges to managing the content in a fashion that informs the readers and provides a forum for companies to highlight the design process yet is neutral with regard to any corporate interests.

Ideally, we would publish an editorial policy that clearly indicates the threshold for mentioning a specific company, but ultimately, the editorial process becomes a matter of judgement. Suffice it to say that the editorial policy is driven to provide a forum for bringing patient safety issues to light without specifically endorsing a particular product or vendor.

Thank you again for taking the time to challenge the editorial process and stimulate us to examine the approach.

Steven Greenberg, MD
Editor-in-chief, Anesthesia Patient Safety Foundation (APSF) Newsletter

Jeffrey Feldman, MD
Chair, APSF Committee on Technology

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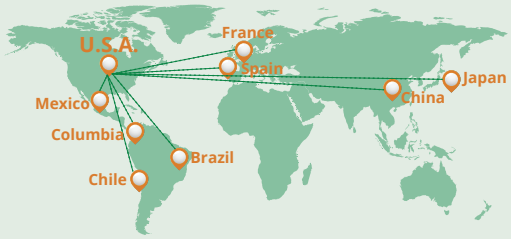

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