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Wearables and Improving Perioperative Patient Safety—Searching for Solutions!

by Megan H. Hicks, MD, and Ashish K. Khanna, MD, MS, FCCP, FCCM, FASA

INTRODUCTION

Surgeons operate on patients with a significant comorbidity burden. Despite this, the intraoperative period is now safer than ever. However, postoperative adverse events are astonishingly common, accounting for approximately 7.7% of all global deaths annually.[1] The most common causes of postoperative mortality in the first 30 days after noncardiac surgery include major bleeding, myocardial injury after noncardiac surgery (MINS), and sepsis, in that order.[2] Importantly, these three entities, taken together, account for about half of all postoperative mortality.[2] Myocardial injury may be underestimated, as it is especially difficult to detect; it is essentially "silent myocardial infarction" with high-sensitivity troponin T (hsTnT) elevation being the only criteria necessary for diagnosis.[3] In the postoperative period, MINS is suggested when the threshold peak hsTnT increases by at least 5 ng/L from the preoperative concentration to at least 20 ng/L or to above 65 ng/L irrespective of baseline concentration.[4] MINS has a strong association with both intraoperative and postoperative hypotension; however, most MINS occurs in the first three postoperative days, which suggests that postoperative hypotension may be a major contributor.[4,5]

In terms of clinical presentation, when one imagines a patient suffering a significant adverse event leading to mortality in the postoperative period, it is most often assumed to be an abrupt catastrophic cardiopulmonary collapse. In actuality, the majority of patients who suffer an in-hospital cardiopulmonary arrest have aberrations in one or more vital signs during the few hours leading up to the event, with a higher risk of mortality with increasing numbers of pre-arrest vital sign abnormalities.[6] At least half of such patients are admitted to wards[6,7] and therefore, monitoring of their vital signs is usually intermittent[8] and these foreboding perturbations often go unnoticed prior to these devastating events. As such, improved ward monitoring of vital signs with wearable devices may be a transformative perioperative patient safety measure with potential to dramatically reduce patient harm.[9,10] While there is no textbook definition, a "wearable device" is generally a noninvasive, autonomous device that continuously monitors patient data using sensors. Challenges remain with evidence building, including return on investment and actual implementation of these measures on a routine basis.

RATIONALE FOR WARD MONITORING

Patients in hospital wards are left under-monitored due to a combination of potential factors, including, but not limited to, staffing shortages, understanding trending vital signs and deterioration on the non-ICU units, lack of adequate monitoring capabilities, and the inability to mitigate the obvious threat of alarm fatigue. In contrast to patients admitted to the ICU, whose nurses oftentimes care for at most two patients and vital signs are measured continually or at least hourly, patients admitted to the ward environment are frequently cared for by nurses who are responsible for many more patients and only receive intermittent vital sign monitoring, every four to twelve hours.[8] While rapid response teams are prevalent, the afferent arm of these medical emergency teams are linked to intermittently measured vital signs. Delays of a mere 15 minutes or more in the recognition of deterioration increase the risk of adverse outcomes.[11] It makes sense that better clinical outcomes after a rapid response may be seen if early warning scores are linked to continuous ward monitoring. A potential benefit of implementation of ward monitoring is early intervention and an overall decrease in rapid response calls.[11] Current ward monitoring standards miss an opportunity for early pattern recognition and intervention in real time, and do not learn from recorded patterns that would help change the way we care for our patients in the future. Many members of the medical community recognize a need for continuous ward monitoring, with nearly all anesthesia professionals in one survey believing that continuous monitoring of blood pressure, heart rate, and pulse oximetry are indicated in at least high-risk patients.[8]

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Continuous Ward Monitoring May Improve Outcomes

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Unfortunately, subjective intermittent vital sign measurements are prone to artifact and inaccuracy due to both imprecise assessments and unrecognized device malposition.[12] Some evidence suggests that heart and respiratory rate are the two vital signs that are most predictive of a future combined outcome of cardiac arrest, intensive care unit transfer, and death.[13] Respiratory rate is a frequent offender for imprecise manual recordings done by bedside providers, while concurrently trending changes measured with automated wearable monitoring show a significant difference in the lead up to a critical event. More recently, machine learning analytics have been developed with age, and continuous heart rate and respiratory rate, which have been found to be predictive of transfer to an ICU and death.[14] As such, intermittent ward monitoring leads to frequent misses of hemodynamic and respiratory vital sign perturbations[15-18] and potentiating reactive rather than proactive patient care interventions.

MISSED DIAGNOSIS OF POSTOPERATIVE HYPOTENSION AND HYPOXEMIA

In addition to changes in respiratory and heart rate, postoperative hypotension may also play a role in postoperative adverse events such as MINS and mortality.[19] It can be common, persistent, profound, and frequently undetected.[15,19,20] For example, about half of all episodes of mean arterial pressures below 65 mmHg are missed with intermittent monitoring on hospital wards.[15] Similarly, postoperative hypoxemia is common, prolonged and profound in both severity and duration. Twenty-one percent of postoperative noncardiac inpatients were found to have ≥10 minutes SpO_2 < 90% *per hour* in patients with clinician-blinded monitoring. More than 90% of desaturation episodes (<90% for a continuous hour) were missed using routine measurements at 4-hour intervals.[18] Unlike postoperative hypotension, the implications of prolonged undetected hypoxemia remain unclear. An important unexplored area is the concurrent trending changes in heart rate, respiratory rate, blood pressure and oxygen saturation, and the implications of such trends on organ system failure on hospital floors. For example, it is appealing to speculate that undetected tachycardia on hospital ward patients would be even more deleterious in the setting of hypotension due to the increased myocardial oxygen demand, however, these relationships have as yet not been investigated.

OPIOID-INDUCED RESPIRATORY DEPRESSION

Opioid-induced respiratory depression is an important perioperative adverse event, especially in the subset of older male patients with heart failure and sleep disordered breathing.[21] About half of all patients in the PRODIGY study suffered at least one episode of opioid-induced respiratory depression that was detected using continuous capnography and oximetry and adjudicated using stringent criteria to separate artifact.[21] Among a cohort of postoperative patients, about one in five suffered from a desaturation to less than 90% each hour, with the majority of these missed by intermittent vital sign monitoring.[16] Approximately 40% of patients suffering an acute respiratory event on the ward will die.[22] In line with this, closed claims data for opioid-induced respiratory depression suggests that about half of these occur within two hours of the last nursing check and almost all are preventable with better monitoring and education.[23]

There is a large and growing cohort of data supporting ward monitoring devices even though most studies examining these devices are primarily observational, retrospective, and before-and-after design studies of insufficient power to really drive dramatic change. These types of data sets help understand real-world utilization and possibly help factor in alarm fatigue and other barriers to adoption. A substantial reduction in the number of rapid response calls, rescue events, and ICU transfers as well as rates of cardiac arrest have been demonstrated after implementation of ward monitoring, including entirely wearable solutions.[24-26] While appropriately powered, prospective interventional randomized trials of monitoring type with a clinical outcome may be ideal, these are yet to be performed, and are logistically challenging, especially if individual patient level randomization and intervention in an average-sized patient ward with numerous patients and limited staffing is considered.

IMPLEMENTATION

At Wake Forest University Medical Center, we implemented continuous ward monitoring using a wireless, wearable solution which captures heart rate, respiratory rate, oxygen saturation, blood pressure, atrial fibrillation, patient mobility, and body temperature every 15 seconds. A study comparing the post implementation data with a pre-implementation historical cohort showed a decrease in rapid response call frequency was statistically significant (189 to 158 per 1000 discharges, P=0.036).[27] This is in line with a historical cohort compared with currently implemented ward monitoring at a large hospital system in the United Kingdom, which reported a substantial reduction in ICU admissions and rapid response calls using the same wireless continuous monitoring technology as ours.[26] Recently, we compared 12,345 patients with intermittent spot-check monitoring in 2018 and 2019 against a propensity-matched cohort of 7,955 postsurgical patients receiving continuous portable monitoring during the same time period and recovering from surgery on different hospital floors at our institution.[28] Patients who received continuous ward monitoring were three-and-a-half times less likely to be transferred to the ICU or to die during index hospitalization compared to those who did not and were less likely to experience heart failure, myocardial infarction, or kidney injury.[28] Interestingly, a ward cluster, randomized, pragmatic, alternative interventions trial from our institution in 2020 and 2021 also demonstrated a significant reduction in the risk of a composite of blood pressure, oxygen saturation, and heart rate changes in favor of continuous monitoring (NCT04574908, clinicaltrials.gov). We also surveyed myocardial injury after noncardiac surgery, and this did not appear to be significantly different in either group.

POSTOPERATIVE MOBILITY AND POSTURE

While traditional vital signs have been monitored on at least an intermittent basis on hospital wards, patient movement is a relatively newer paradigm that is closely linked to the improvement of the postsurgical recovery process. Mobility is, in fact, an often-underappreciated facet of postoperative monitoring in the hospital, while curiously well-tracked using a multitude of tracking devices at home. At Wake Forest, our monitoring solution also includes 3-axis accelerometers positioned on the trunk to identify posture status as upright 90°, upright 45°, supine, lying on one side, walking, and fallen. We examined patient outcomes from a dataset of nearly 9,000 patients recovering from surgery on hospital wards. Data was recorded at 15-second intervals and patients were considered mobilized when their posture was identified as upright 90° and walking posture. Our final confounder-adjusted analysis reported a significant association between each 4-minute increase in mobilization and a composite outcome (hazard ratio [HR], 0.75; 95% CI, 0.67-0.84; $P < .001$) which included myocardial injury, ileus, stroke, venous thromboembolism, pulmonary complications, and all-cause in-hospital mortality.

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Implementation of Continuous Ward Monitoring Remains a Major Challenge

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In addition, there was a reduction in hospital length of stay by 0.12 days (95% CI, 0.09-0.15; *P* < .001) associated with increasing mobility.[29] While unobserved confounding in this data cannot be ruled out, the signal seen here should encourage future interventional trials that bundle mobility-based interventions with continuously monitored traditional vital signs.

WEARABLE WARD MONITORING SYSTEMS

The medical and ambulatory communities have been replete with wearable medical devices since the advent of wireless and compact pulse oximetry, minimally-invasive arrhythmia monitoring, continuous glucose monitoring devices, and wireless insulin infusion and breast pumps. As such, it has been a relatively simple translation to design wearable monitoring devices for the inpatient setting, though most devices struggle with accurate validation data and interventional outcome trials (Table 1).[8] For those that get beyond this stage, implementation on hospital wards remains a challenge.

IMPLEMENTATION CHALLENGES

Despite what appears to be an easily deployable tool with apparent benefit, wearable monitoring devices are fraught with implementation challenges, particularly related to cost and return on investment, security risks, data handling, and technical issues, including concerns regarding artifact and connectivity.[8,10] While upfront costs are significant, cost savings from even minimal reductions in poor patient outcomes are likely to overcome these initial expenditures quite quickly.[21,30] However, this is also an opportunity to perform better cost-effectiveness analyses that model the set-up and annual maintenance of continuous monitoring against the cost of an unwanted ICU admission, an ICU bed that was lost, an extended hospital length of stay, and organ system failure secondary to under-recognized hemodynamic and respiratory changes.

The primary functional hurdle post implementation of these devices remains alarm fatigue due to such a dramatically increased amount of available data. As such, ward monitoring implementation requires concomitant use of risk prediction strategies to determine which patients are most likely to be harmed and thus benefit.[21,31] Further, optimization of these systems may include the creation and implementation of machine learning, pattern detection technology, and artificial intelligence as well as development of minimally invasive advanced cardiac physiologic monitoring modalities. The use of continuous monitoring on hospital units will also necessitate that we partner with our nursing colleagues and scientists who help with research and development of these wearable sensors upfront and before these are sent to the market. Finally, an appropriate and effective efferent intervention system that is protocolized and user-friendly for providers in the non-ICU clinical areas of the hospital is necessary. This may facilitate health care professionals to execute early, appropriate interventions, particularly in those patients that show persistent vital signs trending in the wrong direction.

Table 1. Features of an Ideal Hospital Ward Monitoring System[8]

Evaluation of evidence, stakeholder engagement, and education of personnel before implementation
Noninvasive, portable cardiorespiratory vital signs measurement including mobility and position data
Continuous and modifiable frequency of monitoring
Monitoring display that allows for integrated focused trends, unified signals, and that prevents information overload
Threshold-based alarms connected with rapid response paging systems and early warning scores
Alarm control and delays that can be adjusted at the level of the device and central monitoring station
Automated and high-frequency data flow into device data servers and cloud-based storage
Generates accurate, reliable, and reproducible data
Minimal artifact interference from other monitors
Data flow to other devices (patient monitors, central monitoring platforms, and/or other portable or mobile devices)
Integrated seamlessly with the electronic medical record
Easily extractable data (including waveform data) with accurate time stamps
Layered predictive analytics to guide proactive interventions
AI-based suggested intervention protocols tagged to various combinations of changes in vital signs and alarms

CONCLUSION

In summary, continuous ward monitoring with wearable devices holds significant promise in improving patient safety and outcomes. Implementation challenges persist, but may be overcome with better-conducted research to support a change in current monitoring practices.

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More Research is Welcomed to Further Validate Widespread Adoption of Wearables

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REFERENCES

1. Nepogodiev D, Martin J, Biccard B, et al. Global burden of postoperative death. *Lancet.* 2019;323(10170):401. PMID: 30722955.
2. Spence J, LeManach Y, Chan MTV, et al. Association between complications and death within 30 days after noncardiac surgery. *CMAJ*. 2019;191:E830–837. PMID: 31358597.
3. Writing Committee for the VSI, Devereaux PJ, Biccard BM, et al. Association of postoperative high-sensitivity troponin levels with myocardial injury and 30-day mortality among patients undergoing noncardiac surgery. *JAMA.* 2017;317:1642–1651. PMID: 28444280.
4. Ruetzler K, Khanna AK, Sessler DI. Myocardial injury after noncardiac surgery: preoperative, intraoperative and postoperative aspects, implications, and directions. *Anesth Analg.* 2020;13):173–186. PMID: 31880630.
5. Sessler DI, Khanna AK. Perioperative myocardial injury and the contribution of hypotension. *Intensive Care Med*. 2018;44:811–822. PMID: 29868971.
6. Andersen LW, Berg KM, Chase M, et al. Acute respiratory compromise on inpatient wards in the United States: Incidence, outcomes, and factors associated with in-hospital mortality. *Resuscitation.* 2016;105:123-9. PMID: 27255952.
7. Perman SM, Stanton E, Soar J, et al. Location of in-hospital cardiac arrest in the United States—variability in event rate and outcomes. *J Am Heart Assoc*. 2016;5:e003638. PMID: 27688235.
8. Michard F, Thiele RH, Saugel B, et al. Wireless wearables for postoperative surveillance on surgical wards: a survey of 1158 anaesthesiologists in Western Europe and the USA. *BJA Open*. 2022;23:1:100002. PMID: 37588692.
9. Hemapriya D, Viswanath P, Mithra VM, et al. Wearable medical devices—design challenges and issues. IEEE International Conference on Innovations in Green Energy and Healthcare Technologies (ICIGEHT'17). March 2017. doi: 10.1109/IGEHT.2017.8094096.
10. Khanna AK, Hoppe P, Saugel B. Automated continuous noninvasive ward monitoring: future directions and challenges. *Crit Care*. 2019;23(1):194. doi.10.1186/s13054-019-2485-7.
11. Michard F, Kalkman CJ. Rethinking patient surveillance on hospital wards. *Anesthesiology.* 2021;135:531–540. PMID: 34237129.
12. Badawy J, Nguyen OK, Clark C, et al. Is everyone really breathing 20 times a minute? Assessing epidemiology and variation in recorded respiratory rate in hospitalised adults. *BMJ Qual Saf*. 2017;26:832–836. PMID: 28652259.
13. Churpeck MM, Adhikari R, Edelson DP. The value of vital sign trends for detecting clinical deterioration on the wards. *Resuscitation*. 2016;102:1–5. PMID: 26898412.
14. Akel MA, Carey KA, Winslow CJ, et al. Less is more: Detecting clinical deterioration in the hospital with machine learning using only age, heart rate, and respiratory rate. *Resuscitation*. 2021;168:6–10. PMID: 34437996.
15. Turan A, Chang C, Cohen B, et al. Incidence, severity, and detection of blood pressure perturbations after abdominal surgery: a prospective blinded observational study. *Anesthesiology.* 2019;130:550–559. PMID: 30875354.
16. Saab R, Wu BP, Rivas E, et al. Failure to detect ward hypoxaemia and hypotension: contributions of insufficient assessment frequency and patient arousal during nursing assessments. *Br J Anaesth.* 2021;127(5):760-768. PMID: 34301400.
17. Sun Z, Sessler DI, Dalton JE, et al. Postoperative hypoxemia is common and persistent: a prospective blinded observational study. *Anesth Analg.* 2015;121:709–715. PMID: 26287299.
18. Khanna AK, O'Connell NS, Ahuja S, et al. Incidence, severity and detection of blood pressure and heart rate perturbations in postoperative ward patients after noncardiac surgery. *J Clin Anesth*. 2023;89:111159. PMID: 37295123.
19. Sessler DI, Khanna AK. Perioperative myocardial injury and the contribution of hypotension. *Intensive Care Med.* 2018;44:811–822. PMID: 29868971.
20. Liem VGB, Hoeks SE, Mol KHJM, et al. Postoperative hypotension after noncardiac surgery and the association with myocardial injury. *Anesthesiology*. 2020;133:510–522. PMID: 32487822.
21. Khanna AK, Bergese SD, Jungquist CR, et al. PRediction of Opioid-induced respiratory Depression on Inpatient wards using continuous capnoGraphY and Oximetry: an international prospective, observational trial (PRODIGY). *Anesth Analg*. 2020;131:1012–1024. PMID: 32925318.
22. Morrison LJ, Neumar RW, Zimmerman JL, et al. Strategies for improving survival after in-hospital cardiac arrest in the United States: 2013 consensus recommendations: a consensus statement from the American Heart Association. *Circulation.* 2013;127:1538–1563. PMID: 23479672.
23. Lee LA, Caplan RA, Stephens LS, et al. Postoperative opioid-induced respiratory depression: a closed claims analysis. *Anesthesiology.* 2015;122:659–665. PMID: 25536092.
24. Taenzer AH, Pyke JB, McGrath SP, Blike GT. Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: a before-and-after concurrence study. *Anesthesiology.* 2010;112:282–287. PMID: 20098128.
25. Brown H, Terrence J, Vasquez P, et al. Continuous monitoring in an inpatient medical-surgical unit: a controlled clinical trial. *Am J Med.* 2014;127:226–232. PMID: 24342543.
26. Eddahchouri Y, Peelen RV, Koeneman M, et al. Effect of continuous wireless vital sign monitoring on unplanned ICU admissions and rapid response team calls: a before-and-after study. *Br J Anaesth.* 2022;128:857–863. PMID: 35282866.
27. Weller RS, Foard KL, Harwood TN. Evaluation of a wireless, portable, wearable multi-parameter vital signs monitor in hospitalized neurological and neurosurgical patients. *J Clin Monit Comput.* 2018;32:945–951. PMID: 29214598.
28. Rowland B, Motamedi V, Michard F, et al. Impact of continuous and wireless monitoring of vital signs on clinical outcomes: a propensity matched study in 34,636 surgical ward patients. *Br J Anaesth*. 2023. (accepted for publication)
29. Turan A, Khanna AK, Brooker J, et al. Association between mobilization and composite postoperative complications following major elective surgery. *JAMA Surg.* 2023;158:825–830. PMID: 37256591.
30. Khanna AK, Ahuja S, Weller RS, et al. Postoperative ward monitoring—why and what now? *Best Pract Res Clin Anaesthesiol.* 2019;33:229–245. PMID: 31582102.
31. Greenwald S, Chamoun GF, Chamoun NG, et al. Risk stratification index 3.0, a broad set of models for predicting adverse events during and after hospital admission. *Anesthesiology.* 2022;137:673–686. PMID: 36129680.

Q&A

Post-Alcohol Consumption Cognitive Performance

by Todd Nelson, MD

To the Editor:

For passenger safety and pilot performance, The Federal Aviation Administration (FAA) has several recommendations regarding alcohol consumption for pilots.[1] A few are listed below.

1. As a minimum, adhere to all the guidelines of 14 CFR Part 91.17:
   - 8 hours from "bottle to throttle"
   - Do not fly while under the influence of alcohol
   - Do not fly while using any drug that may adversely affect safety
2. A more conservative approach is to wait 24 hours from the last use of alcohol before flying. This is especially true if intoxication occurred or if you plan to fly Instrument Flight Rules. Cold showers, drinking black coffee, or breathing 100% oxygen cannot speed up the elimination of alcohol from the body.
3. Consider the effects of a hangover. Eight hours from "bottle to throttle" does not mean you are in the best physical condition to fly or that your blood alcohol concentration is below the legal limits.

Further, the FAA guidelines mandate the removal from duties of any employee performing a safety-sensitive function whose breath alcohol concentration is above 0.04 on a required alcohol test or who uses alcohol in a way that violates FAA guidelines. Temporary removal from performing safety-sensitive functions is directed if breath alcohol concentration registers between 0.02–0.039 on a required alcohol test. For reference, in the United States, a standard drink typically contains approximately 14 to 15 grams of alcohol, which is equivalent to about 0.5 to 0.6 fluid ounces. This amount is roughly equivalent to consuming a 12-ounce beer, a 5-ounce glass of wine, or a 1.5-ounce shot of 80-proof liquor. Two standard drinks are sufficient to produce a blood alcohol level of 0.04 in a 180-pound male.[2]

The American Society of Anesthesiologists Guidelines for Occupational Health and Wellness does not appear to address the issue of alcohol intake as it pertains to patient safety and anesthesia professional performance.[3] Following a night of heavy alcohol consumption psychomotor speed, short-term memory, long-term memory, and sustained attention suffer the next day.[4] These deficits in cognitive processing are more pronounced when attention is divided and when there are competing mental demands.[5]

Moreover, the consumption of alcohol is associated with an increased risk of sleep apnea and a decline in sleep quality, both of which can significantly impact cognitive function.[6,7]

Given the detrimental after-effects of alcohol consumption on cognitive performance, anesthesia professionals should seek societal recommendations that address an alcohol abstinence window before engaging in anesthetic care of patients (i.e., time from "glass to mask"). Should on-the-job random alcohol breath tests for anesthesia professionals involved in safety-sensitive patient care functions be implemented in routine practice?

Todd Nelson, MD, is a staff anesthesiologist at Memorial Hospital, Colorado Springs, CO, USA.

The author has no conflicts of interest.

REFERENCES

1. Federal Aviation Administration. Alcohol & flying: a deadly combination. https://www.faa.gov/pilots/safety/pilotsafetybrochures/media/alcohol.pdf Accessed July 30, 2023.
2. Mukamel KJ. Overview of the risks and benefits of alcohol consumption. https://www.uptodate.com/contents/overview-of-the-risks-and-benefits-of-alcohol-consumption?search=blood%20alcohol%20concentration&source=search_result&selectedTitle=4~150&usage_type=default&display_rank=4#H158926803 Accessed July 30, 2023.
3. American Society of Anesthesiologists. https://www.asahq.org/standards-and-practice-parameters/resources-from-asa-committees Accessed July 30, 2023.
4. Gunn C, Mackus M, Griffin C, et al. A systematic review of the next-day effects of heavy alcohol consumption on cognitive performance. *Addiction.* 2018;113:2182–2193. PMID: 30144191.
5. Ayre E, Benson S, Garrisson H, et al. Effects of alcohol hangover on attentional resources during a verbal memory/psychomotor tracking dual attention task. *Psychopharmacology (Berl).* 2022;239:2695–2704. PMID: 35543714.
6. Simou E, Britton J, Leonardi-Bee J. Alcohol and the risk of sleep apnoea: a systematic review and meta-analysis. *Sleep Med.* 2018;42:38–46. PMID: 29458744.
7. Thakkar MM, Sharma R, Sahota P. Alcohol disrupts sleep homeostasis. *Alcohol.* 2015;49:299–310. PMID: 25499829,

More Q&A

In Response To: Post-Alcohol Consumption Cognitive Performance

by Michael G. Fitzsimons, MD

The author, Todd Nelson, MD, is to be commended for raising the issue of performance of anesthesia after consumption of alcohol in this issue of the *APSF Newsletter.*

Alcohol abuse or dependence occurs in 12.9% of male physicians and 21.4% of female physicians and the incidence may be increasing.[1,2] Anesthesia professionals are not immune to alcohol abuse or dependence, but they are not necessarily at higher risk.[2] Anesthesia professionals work in an environment that constantly requires pattern recognition, rapid situational assessment, prompt physical response, and judgment based upon experience and memory. It is incomprehensible that any health care provider can argue that it is acceptable to provide anesthesia care while under the acute effects of alcohol or while legally intoxicated. What is unclear is when performance in a safety-sensitive area can be resumed after consumption of alcoholic beverages. Default to the Federal Aviation Administration (FAA) guidelines to assure patient safety and compliance of anesthesia professionals is a reasonable place to start discussions, but several weaknesses need to be addressed.[3] The guidelines and their development have been discussed in detail in two articles.[4,5]

The rule of eight hours "bottle to throttle" was suggested in 1966 and formalized in 1970.[4] The foundation upon which this rule is grounded is unclear and appears to be arbitrary. The rule is subject to individual compliance and is not based upon the amount of alcohol consumed or whether the individual is still under the influence of alcohol, whether other recreational substances were consumed, or the impact of factors

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In Response To: Post-Alcohol Consumption Cognitive Performance (cont'd)

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such as sleep, just the passing of eight hours of time. It may be assumed that pilots will regulate their alcohol consumption prior to duty to assure that they will not be affected at the eight-hour mark, but the ability to assess impairment is inconsistent. The National Institute on Alcohol Abuse and Alcoholism has defined levels of alcohol use.* Drinking in moderation is considered alcohol consumption of no more than two drinks a day for males and one drink a day for females.[6] Binge drinking is defined as consuming five or more drinks by a male and two or more drinks by a female in two hours. Those who binge drink more than five days a month are classified as heavy drinkers.[7] None of these levels define safety after consumption and the guidelines stress that less alcohol is better for long-term health. Although moderate drinkers can be taught to estimate their blood alcohol concentration (BAC) with a reasonable degree of accuracy, heavy drinkers and alcoholics do not have the same degree of success.[8] The study by Ross and Ross in 1990 revealed that pilots overestimate the amount of alcohol necessary to achieve a certain BAC and underestimate the time of elimination of the alcohol.[9] The rule also assumes that personal impairment is recognized.

The second limitation of the guidelines relates to the established levels of BAC and whether this is impactful under normal circumstances and applies to adoption in a widespread policy. The FAA has established a BAC of 0.04 in a blood or breath alcohol specimen (FAA guidelines). This rule was established in the 1980s after years of resistance based largely upon the notion that only a small number of aviation accidents were associated with alcohol use.[4] This level is lower than the 0.08 level established by states for operation of motor vehicles.[10] Some states have even lower levels for commercial vehicle operators or minors. Operating under higher levels may trigger enhanced penalties. The FAA established level is lower than that defined as legal intoxication for motor vehicle operation and adds a theoretical extra margin of safety. The logistic problem with the FAA BAC requirement is that although commercial pilots are subject to random, reasonable suspicion, post-accident, return to duty, and follow-up drug testing, they are not subject to testing prior to all flight duties as a matter of routine. There are many reports of pilots demonstrating obvious impairment and subsequently being removed from duty. Subtle presentations of impairment may go undetected. Even obvious behaviors consistent with impairment must be reported by an observer for testing to occur. If pilots are like health care professionals, there is a high likelihood that they would not report an impaired colleague, especially if certainty is lacking. Nearly one-third of physicians would not report an impaired medical colleague.[11] Although more anesthesiology departments are instituting drug testing, none have reported their mechanisms or processes to test for acute impairment by alcohol.[12-15] Another challenge specific to breath alcohol testing is that to maintain standards to the level of the Department of Transportation (DOT), individuals must maintain certification as a Breath Alcohol Technician (BAT) or Screening Test Technician (STT).[16] This requirement may limit an institution's ability to perform tests or require the use of the more invasive blood alcohol testing.

The third limitation of the FAA guidelines relates to the notion that even if eight hours have passed since the last consumption of alcohol, and the BAC is less than 0.04, then it is assumed that performance has returned to a level equal to that prior to any alcohol consumption. This current guidance suggests to "consider the effects of hangover," a recommendation which is purely subjective and up to the discretion of the individual. Hangover is defined as a combination of negative mental and physical symptoms that persist into the day after heavy alcohol consumption even though the blood alcohol concentration approaches zero.[17] Symptoms may include fatigue, nausea, headache, weakness, and sound sensitivity.[18] Several different scales have been suggested for estimating hangover effects including the Hangover Symptoms Scale (HSS), the Acute Hangover Scale (AHS), and the Alcohol Hangover Severity Scale (AHSS). These scales generally underestimate hangover severity, bringing into question their value.[18] Howland et al. determined that 76% of individuals who consumed to a level of intoxication reported mild to moderate hangover.[19] Verster has suggested updating the definition of hangover by removing the criteria of "heavy alcohol consumption" based on data that show hangover can occur at levels far below that meeting legal intoxication.[20]

Numerous studies have examined the impact alcohol consumption the prior evening has on performance of daily activities (e.g., driving) the following day. Many of these studies have addressed performance when the BAC is near or at zero. Alford et al. compared simulated driving performance before alcohol consumption and then on the day after consumption.[21] On the day after consumption, half of the participants had a BAC of 0% (zero alcohol group) and half had residual alcohol (0.01–0.08). Individuals with hangover, but zero BAC had similar impairment of many simulated driving variables including response times, excursions from lane, and time off the road. The conclusion of the study was that whether residual alcohol was present or not, the pattern of impairment was similar in patients with hangover.[21] The study also revealed that individuals are not always aware of their level of impairment. The amount of alcohol consumed was not reported. Scholey et al. studied the impact of hangover on cognitive performance.[22] The study evaluated executive performance after a night of heavy alcohol consumption (average number of drinks 13.5).

[1]Levels are defined as grams of alcohol per deciliter of blood or grams of alcohol per 210 liters of breath (Code of Federal Regulations).

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More Q&A

In Response To: Post-Alcohol Consumption Cognitive Performance (cont'd)

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Cognitive function and working memory were impaired during hangover and were associated with the previous night's BAC alcohol level. McKinney and Coyle revaluated memory and psychomotor performance when alcohol levels were zero or very near zero after a normal night of alcohol consumption.[23] The average alcohol consumption during a normal night of drinking was more than ten units (drinks) the night prior to testing. Both performance measures were impaired at 9:00 AM the next morning despite the zero or very near zero alcohol levels.[23] The study by Ayre et al. mentioned by the author Nelson in this issue of the *APSF Newsletter*, noted cognitive function impairment during hangover when participants consumed more than eight drinks the evening prior to testing.[24] Interpretation of studies regarding the impact of alcohol on performance must be made with caution due to design variances including amount, frequency of consumption, timing in relation to assessment, gender, differences in metabolism, binge drinking versus social drinking, and concurrence of dependence or abuse.[25] Additionally, other factors such as the impact of sleep disturbance associated with alcohol use should be considered.[26] More sleep disturbances such as number of night awakenings, duration of night awakenings, total sleep time, and poorer sleep quality were associated with alcohol consumption and resulted in higher hangover severity as well as poorer cognitive performance the day afterwards.

CONCLUSIONS AND RECOMMENDATIONS

Alcohol levels below legal intoxication and the residual condition of "hangover" have a negative impact on performance. Although guidelines exist for individuals in safety-sensitive positions such as aviation, they have not been formalized in the specialty of anesthesiology. Application of current FAA guidelines to anesthesiology ignores weaknesses of those guidelines including an arbitrary time from "glass to mask" in the eloquent words of Nelson, the subjective nature of hangover, reliance on self-policing to initiate alcohol testing, and logistic limitations of alcohol testing.

Anesthesia professional societies should take the recommendations of Nelson and others as a challenge to develop guidelines for the performance of anesthesia after the use of recreational substances beginning with alcohol, but ultimately including other recreational substances. Such guidelines should address time from "glass to mask," the role of substance screening including pre-placement, under conditions of reasonable suspicion for impairment, and after a significant critical event when a provider is suspected of compromise. Practicing anesthesia personnel and trainees in residency and fellowships should undergo required education on the impact of these substances on our performance and include behaviors, which indicate impairment by recreational or controlled substances. Routes to obtain confidential personal care for individuals with substance use disorders should be outlined. Mechanisms to report impairment by colleagues should be clear.

Substances primarily utilized for recreation such as alcohol impact our ability to perform the core responsibilities of our critical role as stewards of safety. It is imperative that education include the unpredictable effects residual recreational substances have on performance. It is our responsibility to develop policy regarding the use of these substances as well as design systems which enhance our ability to assure objective oversight.

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REFERENCES

1. Oreskovich MR, Shanafelt T, Dyrbye LN, et al. The prevalence of substance use disorders in American physicians. *Am J Addict.* 2015;24:30–38. doi: 10.1111/ajad.12173. PMID: 25823633.
2. Wilson J, Tanuseputro P, Myran DT, et al. Characterization of problematic alcohol use among physicians: a systematic review. *JAMA Netw Open.* 2022;5:e2244679. PMID: 36484992.
3. Federal Aviation Admiinistration. Alcohol & flying: a deadly combination. https://www.faa.gov/pilots/safety/pilotsafety-brochures/media/alcohol.pdf Accessed December 13, 2023.
4. Schofield DU. Knowing when to say when: federal regulation of alcohol consumption by air pilots, *J Air L & Com.* 1992;937:937–979. https://scholar.smu.edu/cgi/viewcontent.cgi?article=1963&context=jalc
5. Modell JG, Mountz JM. Drinking and flying—the problem of alcohol use by pilots. *N Engl J Med.* 1990;323(7):455-461. PMID: 2197554.
6. National Institute on Alcohol Abuse and Alcoholism. Acohol's effects on health. https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/moderate-binge-drinking Accessed July 7, 2023.
7. Substance Abuse and Mental Health Services Administration. Substance use disorders. https://mm.nh.gov/media/dhhs-trainings/sud-training/presentation_content/external_files/Substance%20Use%20Disorders%20_%20SAMHSA.pdf Accessed July 7, 2023.
8. Aston ER, Liguori A. Self-estimation of blood alcohol concentration: a review. *Addict Behav.* 2013;38: 1944–1951. PMID: 23380489.
9. Ross SM, Ross LE. Pilots' knowledge of blood alcohol levels and the 0.04% blood alcohol concentration rule. *Aviat Space Environ Med.* 1990;61:412–4`7. PMID: 2350310.
10. World Population Review. BAC limit by state 2023. https://worldpopulationreview.com/state-rankings/bac-limit-by-state Accessed July 7, 2023.
11. DesRoches CM, Rao SR, Fromson JA, et al. Physicians' perceptions, preparedness for reporting, and experiences related to impaired and incompetent colleagues. *JAMA.* 2010;304:187–193. doi: 10.1001/jama.2010.921. PMID: 20628132.
12. Fitzsimons MG, Baker KH, Lowenstein E, Zapol WM. Random drug testing to reduce the incidence of addiction in anesthesia residents: preliminary results from one program. *Anesth Analg.* 2008;107:650–655. PMID: 18633044.
13. Fitzsimons MG, Baker K, Malhotra R, et al. Reducing the incidence of substance use disorders in anesthesiology residents: 13 years of comprehensive urine drug screening. *Anesthesiology.* 2018:129:821–828. PMID: 30020101.
14. Tetzlaff J, Popa D. A strategy to prevent substance abuse in an academic anesthesiology department. *J Clin Anesth.* 2010;22:143–150. PMID: 20304360.
15. Rice MJ, Grek SB, Swift MD, et al. The need for mandatory random drug testing in anesthesia providers. *Anesth Analg.* 2017;124:1712–1716. PMID: 28207591.
16. U.S. Department of Transportation. How to become a breath alcohol technician and screening test technician. https://www.transportation.gov/partners/drug-and-alcohol-testing/how-become-breath-alcohol-technician-and-screening-test-technician Accessed July 7, 2023.
17. Van Schrojenstein Lantman M, van de Loo AJ, Mackus M, et al. Development of a definition for the alcohol hangover: consumer descriptions and expert consensus. *Curr Drug Abuse Rev.* 2016;9:148–154. PMID: 28215179.
18. Verster JC, van de Loo AJAE, Benson S, et al. The assessment of overall hangover severity. *J Clin Med.* 2020;9:786. PMID: 32183161.
19. Howland J, Rohsenow DJ, Allensworth-Davies D, et al. The incidence and severity of hangover the morning after moderate alcohol intoxication. *Addiction.* 2008;103:758–765. PMID: 18412754.
20. Verster JC, Scholey A, van de Loo AJAE, et al. Updating the definition of the alcohol hangover. *J Clin Med.* 2020;9:823. PMID: 32197381.
21. Alford C, Broom C, Carver H, et al. The impact of alcohol hangover on simulated driving performance during a 'commute to work'-zero and residual alcohol effects compared. *J Clin Med.* 2020;9:1435. PMID: 32408588.
22. Scholey A, Benson S, Kaufman J, et al. Effects of alcohol hangover on cognitive performance: findings from a field/internet mixed methodology study. *J Clin Med.* 2019;8:440. PMID: 30935081.
23. McKinney A, Coyle K. Next day effects of a normal night's drinking on memory and psychomotor performance. *Alcohol Alcoholism.* 2004;39:509–513. PMID: 15477234.
24. Ayre E, Benson S, Garrisson H, et al. Effects of alcohol hangover on attentional resources during a verbal memory/psychomotor tracking dual attention task. *Psychopharmacology (Berl).* 2022;239:2695–2704. PMID: 35543714 .
25. Thørrisen MM, Bonsaksen T, Hashemi N, et al. Association between alcohol consumption and impaired work performance (presenteeism): a systematic review. *BMJ Open.* 2019;9:e029184. doi: 10.1136/bmjopen-2019-029184.
26. Ayre E, Scholey A, White D, et al. The relationship between alcohol hangover severity, sleep and cognitive performance; a naturalistic study. *J Clin Med.* 2021;10:5691. PMID: 34884392.

2023 President's Report: The Continued Quest To Fulfill Our Vision *"That No One Shall Be Harmed By Anesthesia Care"*

by Dan Cole, MD

Recent data continues to confirm the epidemic of preventable harm in American health care. In 2022 the U.S. Department of Health and Human Services Office of Inspector General released a report titled "Adverse Events in Hospitals: A Quarter of Medicare Patients Experienced Harm in October 2018."[1] In 2023, Bates et al, reported on a survey of hospitals in Massachusetts that, "Adverse events were identified in nearly one in four admissions," with adverse drug events accounting for 39.0% of all events, and surgical procedural events a close second at 30.4%.[2] Clearly, we have work to do in the perioperative space.

The Anesthesia Patient Safety Foundation (APSF) approaches the challenge of preventable harm by creating collaborative relationships. Since inception, the APSF has included anesthesia professionals, leaders from industry, regulatory agencies, other health care specialties and providers, and medicolegal and insurance companies to achieve a vision "that no one shall be harmed by anesthesia care." The APSF participates in enhancing these partnerships to resolve patient safety issues that can have devastating impacts on patients, their families, and their health care providers. In the past few years, we have broadened our relationships to includes partners such as the Patient Safety Movement Foundation, the Institute for Healthcare Improvement, the National Quality Forum, the Sepsis Alliance, and the Institute for Safe Medication Practices, to name a few.

While the APSF has been laser-focused on our vision *"that no one shall be harmed by anesthesia care,"* we understand that like the strands of a strong rope we should not disentangle safety from quality. The primary goal of quality health care is to ensure that patients receive the best possible care, achieving optimal outcomes, while meeting or exceeding their personal health goals. Health care and our patients do not get to quality outcomes without safety. Our vision should be entrenched throughout the experiences of the patient during the entire perioperative process, and beyond. In short, we aspire to a system without preventable harm, returning patients to their baseline or an improved state of physical, cognitive, and psychological health.

OUR ACTIVITIES

The APSF serves as a strong advocate for perioperative safety, and we continue to work the levers of action by which we turn ideas into action, and action into results. They include research, education, our *Newsletter,* other communication vehicles (e.g., social media), collaboration with other stakeholders in patient safety, and advocacy. With limited resources, we will continue to strategically exercise these levers to make continued progress in the fight against preventable harm. Let me highlight just a few of our many activities:

Daniel J. Cole, MD, Current APSF President

- *Establishment of perioperative patient safety priorities.* The APSF seeks broad input and established a list of the top ten perioperative patient safety priorities. These may be viewed at https://www.apsf.org/patient-safety-priorities/. In general, APSF's primary activities and initiatives are focused on these priority issues, which include:
  1. Culture of Safety
  2. Teamwork
  3. Clinical Deterioration
  4. Nonoperating Room Anesthesia
  5. Perioperative Brain Health
  6. Opioid-Related Harm
  7. Medication Safety
  8. Infectious Diseases
  9. Clinician Safety
  10. Airway Management.
- *Consensus Conferences:* Each year, the APSF hosts a Stoelting Consensus Conference oriented towards one of the primary priority issues. These conferences bring together patient safety advocates, anesthesia and surgical professionals, and industry and regulatory leaders to address specific topics. Examples of past conferences can be found at https://www.apsf.org/past-apsf-consensus-conferences-and-recommendations//. The 2023 conference was titled "Emerging Medical Technologies—A Patient Safety Perspective on Wearables, Big Data, and Remote Care."

  Emerging medical technologies encompass a very diverse group of medical devices and software tools that are having an increasing impact on patient care and health care providers. Some are already in use, others are just on the horizon, but rapidly headed for adoption. Examples of these emerging technologies include:

  - Wearable devices
  - New approaches to noninvasive patient monitoring
  - Closed-loop control of medical devices
  - Big data tools—Artificial Intelligence including machine learning, predictive analytics
  - Remote Medicine—telehealth, remote control of medical devices.

  While all of these technologies may improve patient care, they are not without cost and potential risk. The goal of the Stoelting Conference 2023 was to critically examine a group of emerging technologies from the perspective of perioperative patient safety thought leaders and create recommendations that will be published.

  - A manuscript with recommendations from our 2022 Stoelting Conference (Crucial Patient Safety Issues in Office-Based and Non-Operating Room Anesthesia [NORA]) has recently been published in *Anesthesia & Analgesia* as well as in the October 2023 issue of the *APSF Newsletter*.
  - In November of 2022, we also held a consensus conference on perioperative hemodynamic instability. Hemodynamic instability occurs with high frequency in the perioperative period, can lead to end-organ hypoperfusion, and is associated with a range of adverse events. Yet, there are no specific recommendations to guide clinicians in identifying risks, best monitoring, specific patient thresholds for intervention, and administering effective and timely interventions. The results of the conference will be published soon and were presented at a late-breaking panel at the recent annual meeting of the American Society of Anesthesiologists. The interest among participants during the panel session was clearly palpable as there was standing room only.
  - Our Committee on Technology under the leadership of Jeff Feldman, MD, has created a technology education initiative, which can

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be found on the APSF website. Two learning activities are currently available free-of-charge, and include 1) Low-Flow Anesthesia, and 2) Quantitative Neuromuscular Monitoring. More are in the planning stage.

We have a deeply committed group of volunteers who I am confident will rise to the perioperative health care challenges over the next decade, and the solutions that patient safety engender. We rely on your financial support to achieve our goals, and we will use our resources wisely to ensure that anesthesiology remains a leader in perioperative safety to the benefit of our patients and providers. Sometimes it is best to resist change, sometimes to align with change, but we at the APSF will be proactive to continue our work to fulfill our vision "that no one shall be harmed by anesthesia care." It is indeed a sacred trust that we have with our patients and our goal is to further the foundation of trust on which our specialty has been built.

Dan Cole, MD, is professor of clinical anesthesiology in the Department of Anesthesiology and Perioperative Medicine, David Geffen School of Medicine, University of California at Los Angeles. He is also the current president of the Anesthesia Patient Safety Foundation.

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REFERENCES

1. HHS. U.S. Department of Health and Human Services Office of Inspector General. https://oig.hhs.gov/oei/reports/OEI-06-18-00400.pdf. Accessed December 13, 2023.
2. Bates DW, Levine DM, Salmasian H, et al. The safety of inpatient healthcare. *N Engl J Med.* 2023;388:142–153. PMID: 36630622.

APSF Newsletter Podcast

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The APSF now offers you the opportunity to learn about anesthesia patient safety on the go with the Anesthesia Patient Safety Podcast. The weekly APSF podcast is intended for anyone with an interest in perioperative patient safety. Tune in to learn more about recent *APSF Newsletter* articles with exclusive contributions from the authors and episodes focused on answering questions from our readers related to patient safety concerns, medical devices, and technology. In addition, special shows that highlight important COVID-19 information on airway management, ventilators, personal protective equipment, drug information, and elective surgery recommendations are available. The mission of the APSF includes being a leading voice for anesthesia patient safety around the world. You can find additional information in the show notes that accompany each episode at apsf.org. If you have suggestions for future episodes, please email us at podcast@APSF.org. You can also find the Anesthesia Patient Safety Podcast on Apple Podcasts or Spotify or anywhere that you listen to podcasts. Visit us at APSF.org/podcast and at @APSForg on Twitter, Facebook, and Instagram.

Allison Bechtel, MD
APSF Podcast Director

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Safety Considerations in Peripheral Nerve Blocks

by Christina Ratto, MD; Joseph Szokol, MD, JD, MBA; and Paul Lee, MD, MS

INTRODUCTION

Peripheral nerve blocks (PNB) are safe and effective alternatives or supplements to general anesthesia. They may improve pain control both during and after surgery, thus avoiding many of the side effects of systemic opioids. PNBs may also lead to improved patient satisfaction, decreased resource utilization, and may be better for the environment by decreasing usage of anesthetic gases and other medications.

The use of PNB has increased over time. One study using the National Anesthesia Clinical Outcomes Registry analyzed data from 12,911,056 outpatient surgeries between 2010 and 2015 and found a marked increase in overall PNB.[1] With the growing use of peripheral nerve blocks in the United States, we want to examine safety issues surrounding the procedures. Specifically, we will examine the safety of nerve blocks as it relates to nerve injury, recognition, and treatment of local anesthetic systemic toxicity (LAST), and appropriate health care professional performance of timeouts to avoid wrong-sided blocks.

USING ULTRASOUND-GUIDED PERIPHERAL NERVE BLOCKS TO ENHANCE PATIENT SAFETY

Ultrasound-guided PNBs have rapidly become the preferred approach among many anesthesia professionals. The use of ultrasound guidance when compared to peripheral nerve stimulation may lead to significantly improved block success, decreased need for rescue analgesia, decreased pain during performance of the block, and lower rates of vascular and pleural puncture. While there is no convincing evidence that ultrasound-guided regional anesthesia reduces the risk of pneumothorax for certain blocks such as paravertebral and supraclavicular blocks, the ability to visualize the pleura may provide confidence that the pleural space has not been violated.[2]

It has been suggested that the risk of nerve injury would be further reduced by utilizing ultrasound to directly visualize the needle and target nerve. However, the existing literature generally does not support the argument that ultrasound-guided blocks reduce the incidence of postoperative neurologic symptoms as compared with other techniques such as peripheral nerve stimulation. The primary source of PNB-mediated neurologic injury is likely mechanical injury to the fascicle and/or injection of local anesthetic into a fascicle causing myelin and axonal degeneration. Fortunately, most neurologic symptoms after PNB are transient. The incidence of long-term nerve injury reported from the 3 largest registries is 4 per 10,000 peripheral nerve blocks, which is similar to the historic incidence associated with peripheral nerve stimulation guided blocks.[2] Part of this lack of difference may be due to the quality of the ultrasound equipment and the skill of the proceduralist in identifying the intended nerve. Operators may not adequately visualize the needle tip and misinterpret surrounding artifacts. Needle movement and/or hydrodissection may not ensure lack of needle to nerve contact or vascular injection of local anesthetics. In another registry, the incidence of adverse events across all peripheral regional anesthetics was 1.8 per 1,000 blocks for postoperative neurologic symptoms lasting longer than 5 days, but only 0.9 per 1,000 blocks for postoperative neurologic symptoms lasting longer than 6 months.[3] It is worth noting that patients with preexisting neuropathy may be at an increased risk of postoperative neurologic dysfunction. Avoidance of intraneural injection is of paramount importance to patient safety.[4]

Conversely, the use of ultrasound does significantly reduce the risk of LAST. A recent study provided strong evidence that the use of ultrasound may play a part in decreasing the incidence of LAST.[5] Ultrasound guidance allows for real-time guidance of the needle to avoid vascular injury and subsequent intravascular injection of local anesthetic. While the use of ultrasound minimizes the incidence of LAST (2.7 per 10,000 cases), strict attention must still be directed to this possibility and providers should be ever vigilant for its occurrence.[6]

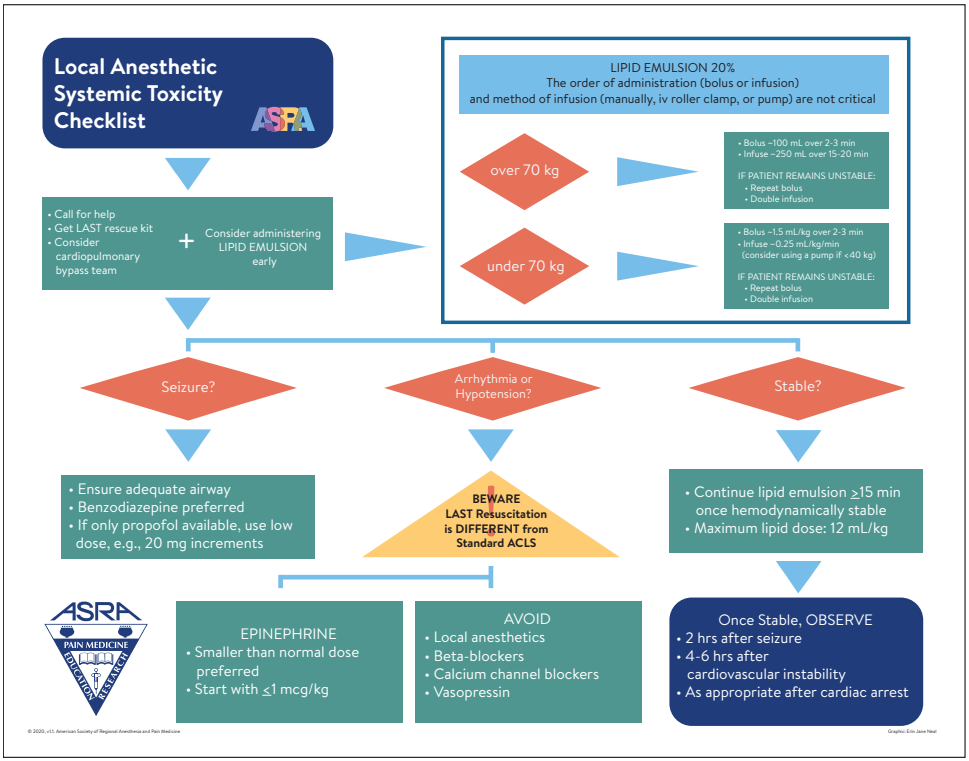

Figure 1. Local Anesthetic Systemic Toxicity Checklist.

Used with the permission of the American Society of Regional Anesthesia and Pain Medicine.

LOCAL ANESTHETIC SYSTEMIC TOXICITY

In 1998, Weinberg and colleagues published the first case report suggesting that an infusion of a soybean oil emulsion, which was normally used for total parenteral nutrition solution, could prevent (by pretreatment) or reverse cardiac arrest caused by bupivacaine overdose in the intact, anesthetized rat.[7] It was almost two decades later that a LAST report was published concerning a patient undergoing a PNB for shoulder surgery, who subsequently developed cardiac arrest. The patient failed to respond to standard resuscitative efforts for approximately 20 minutes, but achieved normal vital signs shortly after receiving a 100 ml bolus of lipid emulsion. The patient had a complete recovery with no neurologic deficits or cardiovascular sequelae.[8]

The American Society of Regional Anesthesia and Pain Medicine in 2010 published its LAST checklist, which has undergone revisions in 2012, 2017, and most recently in 2020.[9] (Figure 1). The checklist was revised most

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Wrong-Sided Blocks are "Never Events" That Still Occur

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recently due to simulation and user feedback that highlighted the failure to emphasize the differences between LAST resuscitation efforts and Advanced Cardiac Life Support (ACLS)-guided resuscitation. Animal studies have demonstrated some of the standard medications used for ACLS, such as code dose epinephrine and vasopressin, worsen outcomes in LAST.[10,11] When simulation subjects chose to use both LAST and ACLS checklists, the resulting confusion and missteps led to delayed and sometimes wrong treatment. Admonitions were placed at the top of previous checklists, but these did not eliminate the placed errors. The 2020 redesign was purposed to incorporate a standard triangular caution sign to highlight the differences between LAST and ACLS resuscitation. The 2020 update also simplified lipid emulsion dosing for patients over 70 kg to a single 100 ml bolus followed by an infusion rather than employing a weight-based calculation.[9]

THE RISK OF PERIPHERAL NERVE BLOCKS UNDER SEDATION

It has been a quarter of a century since a case report brought to everyone's attention the risk of placing a thoracic epidural in a patient while under general anesthesia.[12] The patient suffered a spinal cord injury after four attempts at epidural placement. However, there is scant literature in the adult population that provides guidance as to the safety or risk of placing regional blocks in patients under general anesthesia. In the pediatric population, placing regional blocks in anesthetized patients is considered safe. This comes from data from the Pediatric Regional Anesthesia Network, a multi-institutional research consortium which created a registry of more than 50,000 regional anesthetic blocks in children under 18 years of age.[13] Conversely, in adult patients, based on no rigorous scientific evidence, the primary practice is placing regional anesthetics in patients prior to induction of general anesthesia. Sedation may improve the safety and success of block placement and lead to greater patient satisfaction by enhancing the operating conditions for the anesthesia professionals performing the block.[14] Additional studies are needed to determine the true risk and benefit of placing PNBs under general anesthesia in adults.

PREVENTION OF WRONG-SIDED BLOCKS

Wrong-sided procedures are considered "Never Events," but still occur at a rate of 7.5 per 10,000 procedures.[15] The term "Never Event" was first introduced in 2001 by Ken Kizer, MD, former CEO of the National Quality Forum (NQF), in reference to egregious medical errors that should never happen.[16] Over time, the term's use has been extended to designate adverse events that are unambiguous, serious, and usually preventable. Since the initial Never Event list was developed in 2002, it has been revised multiple times over the years and now comprises 29 "serious reportable events" grouped into 7 categories.[17]

There are certain characteristics identified in most wrong-sided blocks (Table 1). Prior to starting the nerve block, visual confirmation of the correct procedure location is performed by both the patient and nurse using institution-specific standards, which can include placing a wristband marked with the word "yes" on the side corresponding to the surgery or marked clearly by the surgeon or provider performing the procedure. Involving the patient in the process prior to receiving sedation or anesthesia leads to decreased error and may enhance patient satisfaction as patients may feel they are active participants in the process and gain confidence in their providers.[14]

Table 1: Factors that Contribute to Wrong-Sided Blocks[15]

Characteristics of Wrong-Sided Blocks
• Failure to verify site preoperatively
• Failure to mark area adequately by the surgeon
• Rushed, inadequate, or absent anesthesia timeout
• Distractions
• Patient position changes
• Scheduling changes
• Poor communication

The clinician placing the regional anesthetic block should discuss the operative/invasive procedure with the patient before administering anesthesia/moderate sedation. The patient should verbalize agreement of the correct procedure and surgical site, and the discussion and patient verbalization should be documented on the consent form. Communication barriers (e.g., sight and hearing impairments, a non-English-speaking patient, as well as the patient's emotional status) should be addressed by all providers so that the patient is able to fully participate in preoperative discussions. Measures taken to address communication barriers should be documented in the medical record.

All relevant documentation including the consent form, history of present illnesses, and diagnostic data should be verified by the preprocedural nurse/procedural team. If there are any discrepancies or uncertainties, the preprocedural nurse/procedural team should call the surgeon for clarification prior to starting the procedure.

Immediately prior to performing the peripheral nerve block, the proceduralist should engage in the "Universal Protocol" and take a preprocedural "timeout" (Figure 2). "Timeout" must be performed immediately prior to incision or starting the procedure. The "timeout" process should be conducted in the location where the procedure will be done and should involve the immediate members of the procedural team, including the individual performing the procedure, the circulating nurse, and other active participants who will be participating in the procedure from the beginning.

At a minimum the following should be done before performing a regional block:

When the anesthesia professional is about to begin the regional anesthesia block, they should confirm the site is marked by the individual performing the block using the same method as described above. This has been our practice, but other institutions may have different protocols in place.

CONCLUSION

In summary, regional anesthesia is a safe supplement or alternative to general anesthesia that can improve patient satisfaction and decrease opioid usage along with its side effects. While nerve blocks are already quite safe, it is essential to ensure maximum safety while delivering excellent care. As the utilization of regional anesthesia continues to grow, it is imperative for us to perform regional anesthesia blocks as safely as possible by considering ultrasound guidance when available, understanding LAST recognition and resuscitation, and executing proper pre-procedural checklists to avoid wrong-sided blocks.

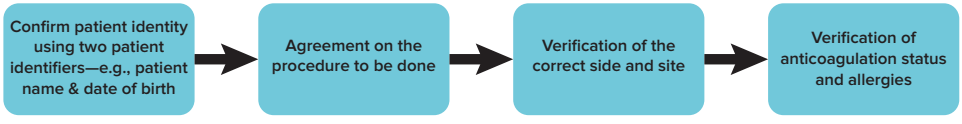

Figure 2. Workflow for Timeout Procedure for Performing a Peripheral Nerve Block.

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Peripheral Nerve Blocks, (cont'd)

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REFERENCES

1. Gabriel RA, Ilfeld BM. Use of regional anesthesia for outpatient surgery within the United States: a prevalence study using a nationwide database. *Anesth Analg.* 2018;126:2078–84. PMID: 28922231.
2. Neal JM, Brull R, Horn JL, et al. The Second American Society of Regional Anesthesia and Pain Medicine evidence-based medicine assessment of ultrasound-guided regional anesthesia: executive summary. *Reg Anesth Pain Med.* 2016;41:181–194. PMID: 26695878.
3. Sites BD, MD, Taenzer AH, Herrick MD. Incidence of local anesthetic systemic toxicity and postoperative neurologic symptoms associated with 12,668 ultrasound-guided nerve blocks an analysis from a prospective clinical registry. *Reg Anesth Pain Med.* 2012;37:478–482. PMID: 22705953.
4. Brull R, McCartney C, Chan V. El-Beheiry H. Neurological complications after regional anesthesia: contemporary estimates of risk. *Anesth Analg.* 2007;104:965–975. PMID: 17377115.
5. Barrington MJ, Kluger R. Ultrasound guidance reduces the risk of local anesthetic systemic toxicity following peripheral nerve blockade. *Reg Anesth Pain Med.* 2013; 38:289-99. PMID: 23788067.
6. El-Boghdadly K, Pawa A, Chin KJ. Local anesthetic systemic toxicity: current perspectives. *Local Reg Anesth.* 2018;11:35–44. Published online 2018 Aug 8. PMID: 30122981.
7. Weinberg GL, VadeBoncouer T, Ramaraju GA, et al. Pretreatment or resuscitation with a lipid infusion shifts the dose-response to bupivacaine-induced asystole in rats. *Anesthesiology.* 1998;88:1071–1075. PMID: 9579517.
8. Rosenblatt MA, Abel M, Fischer GW, et al. Successful use of a 20% lipid emulsion to resuscitate a patient after a presumed bupivacaine-related cardiac arrest. *Anesthesiology.* 2006;105:217–218. PMID: 16810015.
9. Neal JM, Neal EJ, Weinberg GL. American Society of Regional Anesthesia and Pain Medicine local anesthetic systemic toxicity checklist: 2020 version. *Reg Anesth Pain Med.* 2021;46:81–82. PMID: 33148630.
10. Hiller DB, Di Gregorio G, Ripper R, et al. Epinephrine impairs lipid resuscitation from bupivacaine overdose. *Anesthesiology.* 2009;111:498–505. PMID: 19704251.
11. Di Gregorio G, Schwartz D, Ripper R, et al. Lipid emulsion is superior to vasopressin in a rodent model of resuscitation from toxin-induced cardiac arrest. *Crit Care Med.* 2009;37:993–999. PMID: 19237909.
12. Bromage PR, Benumof JL. Paraplegia following intracord injection during attempted epidural anesthesia under general anesthesia. *Reg Anesth Pain Med.* 1998;23:104–107. PMID: 9552788.
13. Taenzer AH, Walker BJ, Bosenberg AT, et al. Asleep versus awake: does it matter? Pediatric regional block complications by patient state: a report from the Pediatric Regional Anesthesia Network. *Reg Anesth Pain Med.* 2014;39: 279–283. PMID: 24918334.
14. Kubulus C, Schmitt KC, Albert N, et al. Awake, sedated or anaesthetised for regional anaesthesia block placements? A retrospective registry analysis of acute complications and patient satisfaction in adults. *Eur J Anaesthl.* 2016;33:715–724. PMID: 27355866.
15. Barrington MJ, Uda Y, Pattullo SJ, Sites BD. Wrong-site regional anesthesia: review and recommendations for prevention? *Curr Opin Anesthesiol.* 2015;28:670–684. PMID: 26539787.
16. Kizer KW, Stegun MB. Serious reportable adverse events in health care. In: Henriksen K, Battles JB, Marks ES, et al., eds. Advances in patient safety: from research to implementation (volume 4: programs, tools, and products). *Advances in Patient Safety.* Rockville, 2005:339–352.
17. Agency for Healthcare Research and Quality. Patient Safety Network. Never events.https://psnet.ahrq.gov/primer/never-events Accessed December 13, 2023.

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Vision

The vision of the Anesthesia Patient Safety Foundation is to ensure that no one shall be harmed by anesthesia care.

& Mission

The APSF's mission is to improve the safety of patients during anesthesia care by:

- *Identifying safety initiatives and creating recommendations to implement directly and with partner organizations*
- *Being a leading voice for anesthesia patient safety worldwide*
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APSF 2023 Pierce Memorial Lecture Relates Anesthesia Monitoring and Technology to Improved Clinical Behaviors and Outcomes

by John H. Eichhorn, MD

APSF's annual Pierce Memorial lecture this year, titled "Integrating Behavior and Technology for Anesthesia Patient Safety," was delivered October 14, 2023, during the ASA Annual Meeting in San Francisco.

Ellison C. "Jeep" Pierce, Jr., MD, the inspirational founding President of the APSF (Figure 1), first considered anesthesia patient safety as a junior attending when he was assigned to give a lecture on "anesthesia accidents." The topic later became a consuming passion, fueled in part by the tragic death of a friend's daughter from an unrecognized accidental esophageal intubation during an anesthetic for dental surgery. As Chief of Anesthesia at New England Deaconess/Harvard, he collected accident case reports from all over the country and often lamented the significant number of deaths from esophageal intubations.

A 1982 television exposé/documentary, "The Deep Sleep: 6000 Will Die or Suffer Brain Damage,"[1] detailing catastrophic anesthesia accidents, attracted great public attention. This coincided with E.C. Pierce's impending American Society of Anesthesiologists (ASA) presidency and gave him the opportunity to initiate attention and projects on patient safety within the ASA. Awareness of anesthetic mishaps in England stimulated E.C. Pierce, MD, along with Jeff Cooper, PhD, and Richard Kitz, MD, both from Mass General/Harvard to convene in Boston in 1984 the "International Conference on Preventable Anesthesia Mortality and Morbidity," immediately after which the APSF was conceived—with the intent of involving physicians, CRNAs, as well as relevant corporate and regulatory entities—completely independent of the bureaucratic inhibitions of government and large organizations. Based on my prior experience as a newspaper reporter and editor, E.C. Pierce, MD, asked me to create and edit the *APSF Newsletter*, which was and is still the largest circulation anesthesia publication in the world. A 2010 special issue recounts the history of the first 25 years of the APSF.[2]

Coincidentally at the same time, the captive company providing malpractice insurance to all Harvard faculty physicians and hospitals came to the nine Harvard hospital Chiefs of Anesthesia with the concern that anesthesia claims were excessive: anesthesiologists were 3% of the faculty, but generated 12% of the insurance company payout.[3] To investigate and address this problem, the Harvard Risk Management Committee was created. I was named Chair of that committee, because of an episode the previous year in which I directed the investigation and remediation of a catastrophic oxygen pipeline accident at an Army hospital in Alabama. The committee studied in great detail all the Harvard anesthesia malpractice claims from the creation of the insurance company in 1976 through 1984 and realized that most of the catastrophic accidents involved unrecognized issues with patient ventilation. The Harvard Standards for intraoperative monitoring[4] were created—not guidelines or recommendations, but mandatory standards of care, so that the medical-legal implication of ignoring them was perfectly clear. After some convincing, these standards were adopted at Harvard on July 1, 1985. The last catastrophic accident that would have been prevented by safety monitoring of that era in the Harvard system occurred the following month. Importantly, while the behavior of continuous monitoring of ventilation and circulation were required as core principles of this "safety monitoring," the technologies of capnography and pulse oximetry were only mentioned as possible methods. These technologies did not become mandatory standards until several years later when the profession in general recognized their enormous value in extending the human senses, thus providing much earlier warning of untoward developments (such as an esophageal intubation) and allowing for more timely diagnoses and institution of corrective treatment. Demonstrating the dramatic efficacy of safety monitoring in virtually eliminating intraoperative catastrophic anesthesia accidents was not amenable to the classic statistically significant *p* value of less than 0.05 seen in randomized prospective controlled trials. However, great success was clear as malpractice insurance premiums for Harvard anesthesiologists decreased by 66% from 1986–1991.Large reductions in premiums could only come from substantial decreases in the number and severity of anesthesia accidents. Further, a retrospective analysis[5] of the catastrophic accidents that provoked the monitoring standards in the first place showed that application of the principles of safety monitoring would have prevented those patient-injury events.

Figure 1: Ellison C. (Jeep) Pierce, Jr., MD (1929–2011): Chairman, New England Deaconess Hospital; ASA President; founding President, Anesthesia Patient Safety Foundation.

STANDARDS SPREAD

The Harvard monitoring standards inspired the expanded ASA Standards for Basic Intraoperative Monitoring[6] (essentially every anesthesia record today, paper or electronic, has a check box for "ASA monitors applied"), which, in turn, led to the creation by an independent group of what became the much-expanded World Federated Societies of Anesthesia International Standards, first adopted in 1992, with multiple updates in the years since.[7] Careful appreciation of all the standards over the years reveals that, as important as the monitoring devices and technologies are, it is the behavior of the anesthesia professionals interpreting and reacting to the generated signals that is the final common pathway for maintaining anesthesia patient safety.

Current intraoperative monitoring practices are prescribed by the ASA Standards and, also, the 2023 ASA Practice Parameter on monitoring and antagonism of neuromuscular blockade,[8] which strongly recommends quantitative rather than qualitative monitoring of ulnar nerve train-of-four count. Brain monitoring is covered by an ASA "Practice Advisory," but the APSF published revised recommendations[9] for (among other things) awareness prevention using processed EEG. Use of video laryngoscopes for all intubations is not yet addressed, but significant published research favors this, and it may become a recommendation or even a de facto standard of care in the future.

DISTRACTION DANGER

A dangerous misperception about patient safety may exist among anesthesia professionals because now there are far fewer catastrophic intraoperative patient injuries from lack

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The Next Frontier of Safety Technology Has Begun

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of monitoring than in the 1970s. This remarkable success, considering that what we do is inherently dangerous, can lead to complacency and a relaxation of vigilance, which is, after all, the ASA motto. Distractions have always existed, but today the issue is computers, tablets, and cell phones in the operating room, and the anesthesia professional being on social media, or surfing the internet, shopping on Amazon or E-Bay, gaming, texting, or even talking on the phone. Debate has occurred and opinions can differ, but it is undeniable that if a patient-injury event occurs when anesthesia personnel are voluntarily distracted, as testified to by others in the operating room at the time, the legal liability could be dramatic.[10] One possibly related idea is whether there could be an eventual role for continuous high-resolution multi-angle audio-video recording of the monitors of all the activity in the operating room. Highly accurate technology exists,[11] but the costs and legal implications likely would influence this new integration of cutting-edge technology with human behavior.

ADDITIONAL TECHNOLOGY ADVANCES

Advanced technology applications are integrating with direct bedside intensive care unit (ICU) management at the University of Pennsylvania, where a remote monitoring system, with two-way audiovisual connections, covers more than 450 ICU beds from one central location, is integrated with the electronic health record, and can provide early-warning alerts.[12] A fascinating speculative corollary is whether, one day, such a system might be applicable also to anesthesia care.

"Smart" alarms are a logical step in integrating technology and clinician behavior during anesthetics in the operating room. Safety monitoring is intended to provide the earliest possible warning of abnormal or untoward signals from multiple simultaneous measurements and, thus, maximize time for appropriate response to prevent danger/injury. The original 1988 idea of smart alarms[13] was to pull all the monitoring signals and alarms into one display. Much evolution, research, development, and testing has occurred since then, the most dramatic of which has been developed by researchers from the University of Michigan, where the "Alert Watch® OR" system with its multiple iterations provides a reactive decision support system with a graphical human-machine interface that was inspired by the multifunction primary flight display used by pilots in modern aviation. It not only alerts anesthesia professionals to abnormalities, but it can also suggest a cause and confirmatory testing (Figure 2). An extensive report[14] concluded that, so far, the system improved process measures, but not postoperative clinical outcomes.

SMARTER ALARMS AND AI

"Smarter" alarms are a bridge toward the application of artificial intelligence to anesthesia care. They enhance the technology-behavior interface by introducing machine learning and predictive analytics. Multiple studies have demonstrated programs that automatically analyze arterial line waveforms and predict hypotension during an anesthetic, 5–15 minutes in advance. Of course, it is the clinician's response that determines the value of the warning. A step closer to artificial intelligence is a system that preoperatively considers all patient characteristics and parameters to predict hypotension

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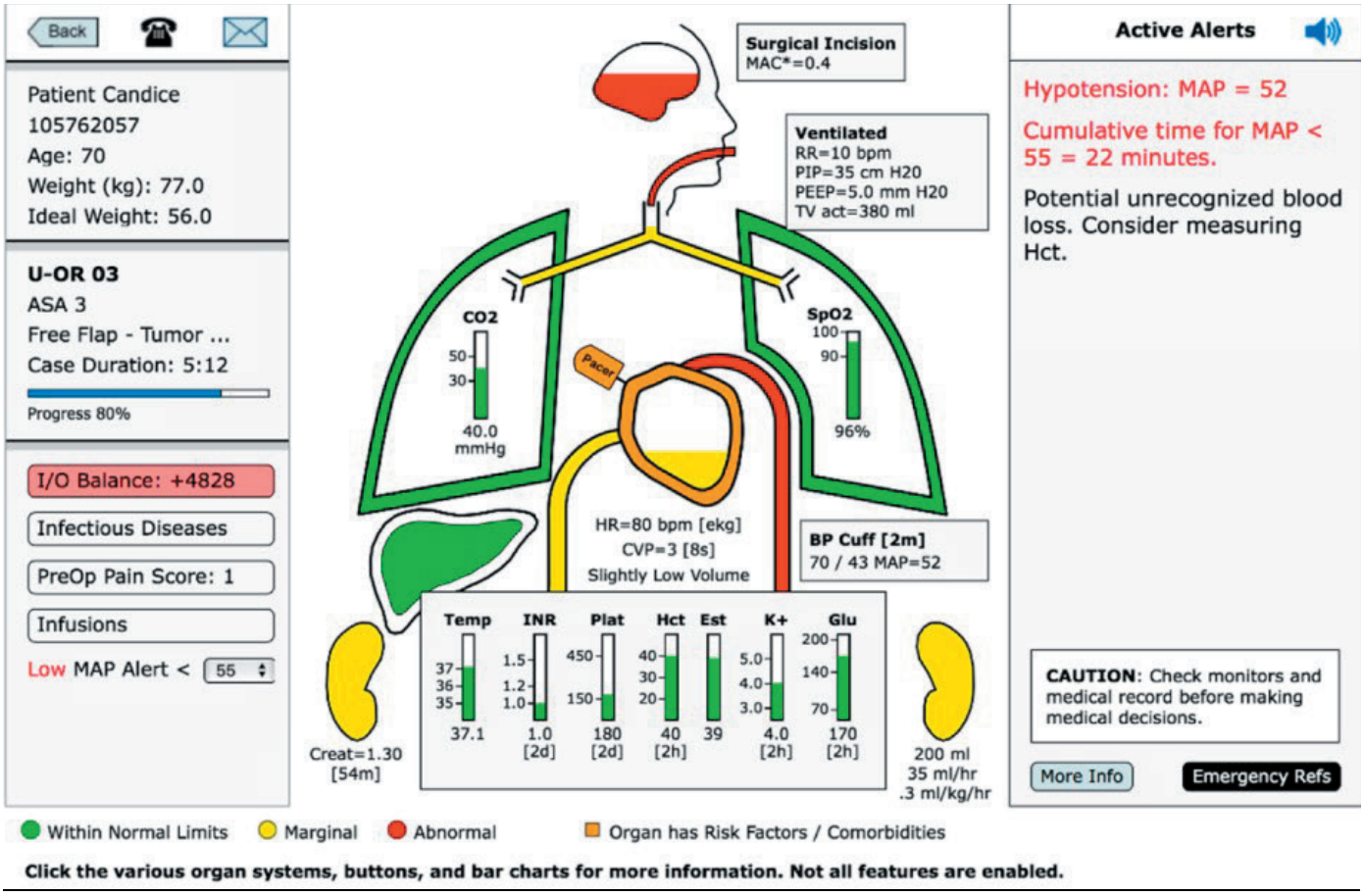

Figure 2. Prototype sample monitor/alert/decision support screen from "Alert-Watch OR."[18]

Smarter Alarms May Enhance the Technology-Behavior Interface

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following the induction of general anesthesia. Retrospective analysis showed this system to be 72% accurate, which the researchers considered "modest performance."[15]

True AI (and maybe the robots of the future directed by it) is not here yet, but it is a popular topic.[16] The potential appears limitless. A system developed at Michigan is being studied which considers all factors for a patient, predicts risks of adverse outcomes, weighs the potential "burden" of each, considers potential actions to mitigate each, and then calculates which action leads to the least overall burden, thus rendering a judgment and recommendation.[15] Predictions for expanding AI to the entirety of perioperative medicine are offered in a remarkable recent article,[17] with a fascinating illustration (Figure 3 on next page).

So far, technology cannot replace the human behavior it must elicit. The intraoperative pattern is always the same—the earliest possible alert to untoward developments allows maximum time for corrective diagnosis and response. Implementation of AI is essentially an analogy to the adoption of "safety monitoring" strategy in the late 1980s (particularly with its vast extension of human senses by the sensitivity/accuracy of capnography and pulse oximetry)—which led to the virtual elimination of intraoperative anesthesia catastrophes. Practice improvements from AI will not be as obvious or dramatic when compared to the implementation of the original safety monitoring standards, but may become the standard of care. This is excellent, but, as Jeep Pierce, the APSF inspirational founding leader who is honored through this lectureship, reminded us: we must be ever "vigilant" (the ASA motto), because there will always be human error.

John H. Eichhorn, MD, the 2023 APSF Pierce Memorial lecturer, was the founding editor and publisher of the APSF Newsletter. *Living in San Jose, CA, as a retired professor of anesthesiology, he continues to serve on the APSF Editorial Board.*

The author has no conflicts of interest.

REFERENCES

1. Janice Tomlin (producer): The Deep Sleep: 6,000 will die or suffer brain damage, WLS-TV Chicago, 20/20. April 22, 1982
2. Eichhorn JH. The APSF at 25: pioneering success in safety, but challenges remain. *APSF Newsletter* 2010;25:21-24,35–39. PMID: 22253277. Accessed December 14, 2023.
3. Eichhorn JH. The history of anesthesia patient safety. In: Ball C, Bacon D, Featherstone P (eds,) Broad horizons—the history of anesthesia beyond the operating room. International Anesthesiology Clinics. 2018;56:56-93.
4. Eichhorn JH, Cooper JB, Cullen DJ, et al. Standards for patient monitoring during anesthesia at Harvard Medical School. *JAMA.* 1986;256:1017–1020. PMID: 3735628.
5. Eichhorn JH. Prevention of intraoperative anesthesia accidents and related severe injury through safety monitoring. *Anesthesiol.* 1989;70:572–577. PMID: 2929993.
6. American Society of Anesthesiologists. Standards for Basic Anesthetic Monitoring. (last amended October 20, 2010) (original approval: October 21, 1986) (https://www.asahq.org/standards-and-practice-parameters/standards-for-basic-anesthetic-monitoring).
7. Merry AF, Cooper JB, Soyannwo O, et al. International standards for a safe practice of anesthesia. *Can J Anesth.* 2010;57:1027–1034. PMID: 20857254.
8. ASA Task Force on Neuromuscular Blockade. 2023 American Society of Anesthesiologists practice guidelines for monitoring and antagonism of neuromuscular blockade. *Anesthesiol* 2023;138:13–41. PMID: 36520073.
9. Committee on Technology. APSF-endorsed statement on revising recommendations for patient monitoring during anesthesia. *APSF Newsletter.* 2022;37:7–8. (https://www.apsf.org/article/apsf-endorsed-statement-on-revising-recommendations-for-patient-monitoring-during-anesthesia/#:~:text=Quantitative%20neuromuscular%20blockade%20monitoring%20has,neuromuscular%20blocking%20agent%20is%20used.) Accessed November 30, 2023.
10. Thomas BJ. Distractions in the operating room: an anesthesia professional's liability? *APSF Newsletter.* 2017;31:59–61. (https://www.apsf.org/article/distractions-in-the-operating-room-an-anesthesia-professionals-liability/) Accessed November 30, 2023.
11. Michaelsen, K. Cameras in the OR: reimaging patient safety. *ASA Monitor.* 2023;37:38. doi: 10.1097/01.ASM.0000949632.42292.92
12. Scott, M. "The Tele-ICU – Now and in the Future." APSF Stoelting Conference, Las Vegas, NV; September 7, 2023. (www.apsf.org)
13. Watt RC, Miller KE, Navabi MJ, et al. An approach to "smart alarms" in anesthesia monitoring. *Anesthesiol.* 1988;89:A241. doi: 10.1097/00000542-198809010-00240
14. Kheterpal S, Shanks A, Tremper K. Impact of a novel multiparameter decision support system on intraoperative processes of care and postoperative outcomes. *Anesthesiol.* 2018;128:272–282. PMID: 29337743.
15. Mathis M. "Machine learning & predictive analytics." APSF Stoelting Conference, Las Vegas, NV; September 6, 2023. (https://www.apsf.org/event/apsf-stoelting-conference-2023/). Accessed December 8, 2023.
16. Kennedy S. "Exploring the Role of AI in Anesthesiology." Health IT Analytics, July 20, 2023. (www.https://healthitanalytics.com/features/exploring-the-role-of-artificial-intelligence-in-anesthesiology)
17. Maheshwari K, et al. Artificial intelligence for perioperative medicine: perioperative intelligence. *Anesth Analg.* 2023;136:637–45. PMID: 35203086.
18. Tremper KK, Mace JJ, Gombert JM. et al. Design of a novel multifunction decision support display for anesthesia care: AlertWatch® OR. *BMC Anesthesiol.* 2018;18:16. PMID: 29402220.
19. Nathan N. Perioperative artificial intelligence: infographic. *Anesth Analg.* 2023;136:636. PMID: 36928148.

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Implementation of Artificial Intelligence is Analogous to Safety Monitoring in 1980s

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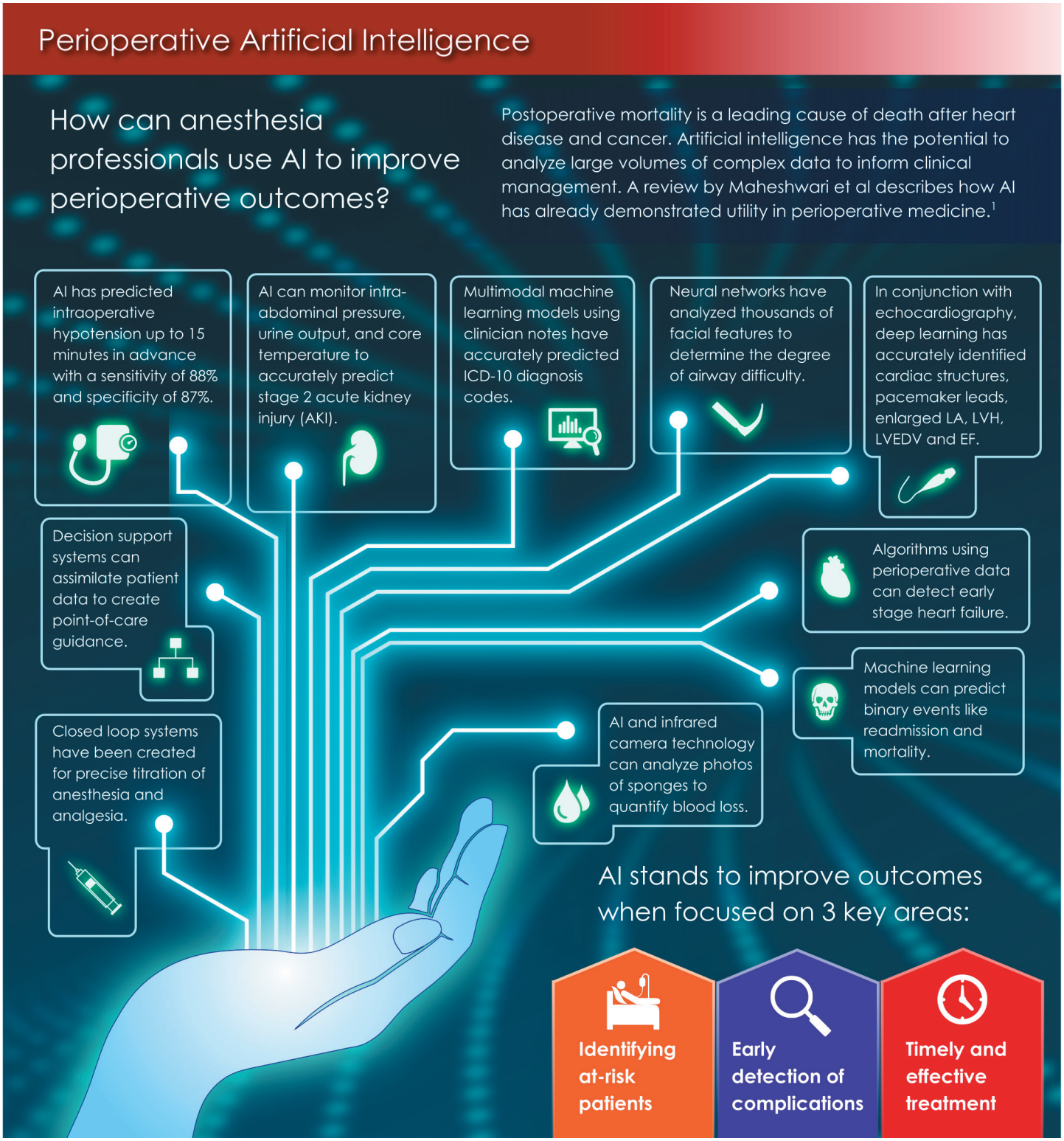

Figure 3. Perioperative artificial intelligence application models.[19] Permission for use and modification granted from *Anesthesia & Analgesia*. Nathan N. Perioperative artificial intelligence: infographic. *Anesth Analg.* 2023;136:636.

RAPID Response
to questions from readers

Innovative Technology, Persistent Risk: Electrical Injury from an Automated Quantitative Neuromuscular Blockade Monitoring (QNMT) Device

by Gregory A. Chinn, MD, PhD; Stefan G. Simon, MD; Andrew T. Gray, MD, PhD; Julin F. Tang, MD; John C. Markley, MD, PhD

INTRODUCTION

Quantitative neuromuscular blockade monitoring (QNMT) is strongly recommended by the ASA[1] and APSF[2] and can be accomplished with several commercially available devices. The basic principle is that a low voltage stimulus to the ulnar nerve, delivered by paired electrodes, will elicit a motor response in the adductor pollicis to move the thumb. The strength of the response is influenced by the degree of neuromuscular blockade and can be quantified. One QNMT method utilizes an accelerometer attached to the thumb which senses acceleration as a surrogate for the strength of the response. Under normal circumstances, no voltage is being directly delivered to the thumb, but the accelerometer positioned at the thumb requires an electrical supply.

CASE REPORT

A 43-year-old male underwent a 2-hour uncomplicated revision colostomy under endotracheal general anesthesia with neuromuscular monitoring by QNMT (Philips IntelliVue NMT, Andover, MA).[3] On postoperative day (POD) 2, the anesthesia service was consulted to evaluate a blister on the patient's thumb, with concern that it might be related to a monitoring device. The patient reported that he noticed the blister in the PACU, but did not report it until POD 2. On exam he had a 1-cm blister on his ventral thumb, as well as a region of skin breakdown over his ipsilateral ventral ulnar forearm (Figure 1A). After identifying the operating room where the procedure had taken place, the QNMT monitor was inspected and found to have exposed wires from a breakdown in the insulation in a place that matched the position of the blister when the device was applied (Figure 1B). The patient was informed of the complication, a hand service consultation was placed, and the device was taken out of service (along with 3 other similarly damaged devices that were subsequently identified). The injury was minor and resolved with topical silver sulfadiazine (Silvadene®) ointment applications twice daily. The patient was appreciative that the anesthesia team had taken his complaints seriously and was relieved to have an answer to his complaint.

DISCUSSION

Descriptions of injury from monitoring devices[4] or specifically nerve stimulators are numerous.[5-7] There has also been a safety bulletin for this device.[8] However, with correct usage and uncompromised device integrity, the chance of shock or burn should be very low. The manufacturer of the specific device in this incident offers an attachment which correctly positions the device without direct skin contact which could be considered a convenience and additional safety feature if used. In this case, the damaged cable was not recognized by providers, and because of the way the device can be placed in several orientations, it was only by chance that this complication did not occur with use in other patients (the accelerometer is cubical and can be attached with any of four sides to the patient's thumb and in this case, the wire contacted the skin directly.) We believe the skin contact with the wire where the insulation had broken down allowed electrical current to flow from that site to the ground electrode at the site of ulnar nerve stimulation. The burn resulted from high energy dissipation in the form of heat as the current passed through the skin.[9,10] The anesthesia record did not indicate the frequency of stimulation, but was likely between 1-5 minutes as is typical in our practice.

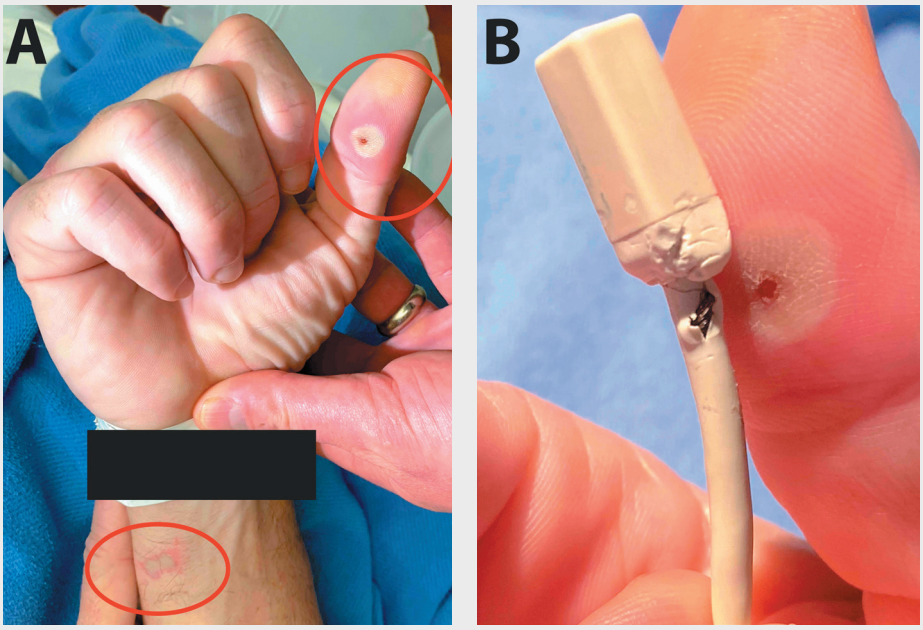

Figure 1: A. Injury to patient's thumb and forearm after two hours of surgery with NMT monitoring using a damaged cable. B. Image of the damaged device in the proper orientation with exposed wire at the site of patient's injury.

In response to this event, we made a number of changes at our institution. First, we removed all cables in use with any signs of insulation damage and returned them to the manufacturer for close inspection, including the specific cable that was used in this case report. We opened a dialogue with the manufacturer to discuss the specifics of the case and the resolution. The case was presented at our Morbidity and Mortality Conference, which included an education session about proper use for all anesthesia professionals stressing the importance of inspection of every device attached to patients prior to use. We also educated our anesthesia technicians who assist with room-turnover and processing of equipment. They now inspect the cables while cleaning according to manufacturer instructions and will remove equipment with any signs of damage. Finally, we have acquired the manufacturer specific hand-adapter for our QNMT device and are waiting for final approval on its use from our institution.

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RAPID Response
to questions from readers

Electrical Injury With Use of a Neuromuscular Monitor

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This case is an important reminder to inspect all devices that are attached to patients, especially those that are automated and hidden from plain view (i.e., tucked arms, drapes, etc.). While there is no guideline for interval of device evaluations, we suggest all devices be inspected for intact insulation at the time of application, prior to placement.

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Gregory Chinn, MD, PhD, Stefan Simon, MD, Julin Tang, MD, and John Markley, MD, have no conflicts of interest. Andrew Gray, MD, received equipment support from Rivanna Medical (Charlottesville, VA).

REFERENCES

1. Thilen SR, Weigel WA, Todd MM, et al. 2023 American Society of Anesthesiologists practice guidelines for monitoring and antagonism of neuromuscular blockade: a report by the American Society of Anesthesiologists Task Force on Neuromuscular Blockade. *Anesthesiology*. 2023;138:13–41. PMID: 36520073.
2. Caruso L, Lampotang S, Gravenstein N. Patient safety and quantitative neuromuscular transmission monitoring in 2022. *APSF Newsletter.* 2022;37:66. https://www.apsf.org/article/patient-safety-and-quantitative-neuromuscular-transmission-monitoring-in-2022/#:~:text=In%20fall%20of%202022%2C%20the,anesthetics%20with%20neuromuscular%20blockade%2C%20and Accessed November 30, 2023.
3. Dubois V, Fostier G, Dutrieux M, et al. Philips Intellivue NMT module: precision and performance improvements to meet the clinical requirements of neuromuscular block management. *J Clin Monit Comput.* 2020;34:111–116. PMID: 30806937.
4. Bruner John M R. Common abuses and failures of electrical equipment. *Anesth Analg.* 1972;51: 810–826. https://journals.lww.com/anesthesia-analgesia/citation/1972/09000/common_abuses_and_failures_of_electrical_equipment.39.aspx.
5. Cooper JB, DeCesare R, D'Ambra MN. An engineering critical incident: direct current burn from a neuromuscular stimulator. *Anesthesiology*. 1990;73:168–172. PMID: 2360724.
6. Gray AT. Excessive voltage output? *Anesth Analg*. 2001;93:515–516. doi: 10.1213/00000539-200108000-00055
7. Hadzic A, Vloka J. Peripheral nerve stimulators for regional anesthesia can generate excessive voltage output with poor ground connection. *Anesth Analg.* 2000;91:1306. doi: 10.1213/00000539-200011000-00049
8. Health and Human Services. URGENT - Medical Device Recall Philips IntelliVue Neuromuscular Transmission Patient Cable 989803174581. https://www.hsa.gov.sg/docs/default-source/announcements/field-safety-notices/hsa-6004101-026-17-09_45-fsn_redacted.pdf. Accessed December 15, 2023.
9. Kouwenhoven WB. Electrical accidents. *T Am Inst Elec Eng*. 1937;56:1077–1079. doi: 10.1109/T-AIEE.1937.5057695
10. Arnoldo BD, Purdue GF. The diagnosis and management of electrical injuries. *Hand Clin.* 2009;25:469–479. PMID: 19801121

Philips Response to APSF Newsletter Query—Re: NMT Cable Issue

Philips has received the report of the patient event related to the PhilipsIntelliVue Neuromuscular Transmission (NMT) Patient Cables 989803174581. At this time, we continue to review this report in accordance with the Philips Quality Management System and regulatory compliance requirements.

Regarding the incident report, we feel that it may benefit from inclusion of information from primary source documents such as the instructions for use (IFU) of the IntelliVue NMT Cable, which aligns with the recommendations the authors provide in the Discussion section of the manuscript.

For example, the device IFU indicates in a number of places the potential for an electrical shock hazard and potential for burns in case of use of a damaged cable. The IFU also stipulates that a visual inspection should be performed before every use—and to refrain from using a cable if it shows any signs of damage or if it has exceeded its use-by date (Figure 2).

See "Electrical Injury," Next Page

INSPECTING THE EQUIPMENT AND ACCESSORIES

Perform a visual inspection before every use, and in accordance with your hospital's policy. With the monitor switched off:

1. Examine unit exteriors for cleanliness and general physical condition. Make sure that the housings are not cracked or broken, that everything is present, that there are no spilled liquids and that there are no signs of abuse.
2. Inspect all accessories (cables, transducers, sensors and so forth). If any show signs of damage, or the use-by date has been exceeded, do not use.
3. Switch the monitor on and make sure the backlight is bright enough. Check that screen is at its full brightness. If the brightness is not adequate, contact your service personnel or your supplier.
4. If the Multi-Measurement Module and Measurement Extensions are mounted on the monitor, make sure that they are locked into place and do not slide out without releasing the locking mechanism.

WARNING

Electrial Shock Hazard: Do not open the monitor or measurement device. Contact with exposed electrical components may cause electrical shock. Always turn off and remove power before cleaning the sensor, monitor, or measurement device. Do not use a damaged sensor or one with exposed electrical contacts. Refer servicing to qualified service personnel.

Figure 2: Device Instructions for Use. Permission to reuse Device Instructions for Use information from Phillips.

RAPID Response
to questions from readers

Electrical Injury With Use of a Neuromuscular Monitor

From "Electrical Injury," Preceding Page

Furthermore, in 2017, Philips issued a voluntary field safety notice for NMT Cables manufactured between 2012 and 2017, regarding the potential for electrical shock hazard, and also enhanced the electrical insulation for the component. The following information was also added to the IFU at that time (Figure 3):

Additionally, the "Care and Cleaning" chapter of the IFU contains a general point that "After cleaning and disinfection, check the equipment carefully. Do not use if you see signs of deterioration or damage."

Also worthy of note is that Philips recommends the use of the Philips NMT Hand Adapter (989803199211) to improve the measurement and to facilitate the application of the NMT sensor (Figure 4). The NMT hand adapter provides a secure fixation point for the NMT patient cable acceleration sensor without the need for applying it with adhesive tape.

Please let us know if we may provide further information or support, and we will be sure to follow up.

Lorenzo Quinzio, MD
Product Marketing Lead,
Measurement Solutions
Hospital Patient Monitoring
Royal Philips

The author has no conflicts of interest other than being an employee at Philips.

Chapter: Monitoring NMT - Additional Information

MX400-800 and MX750/ MX850 only

WARNING

Inspect the NMT cable for damage prior to and during monitoring. Using a damaged NMT cable on a patient could cause burns.

Figure 3: Device Instructions for Use on using damaged NMT cables. Permission to reuse Device Instructions for Use information from Phillips.

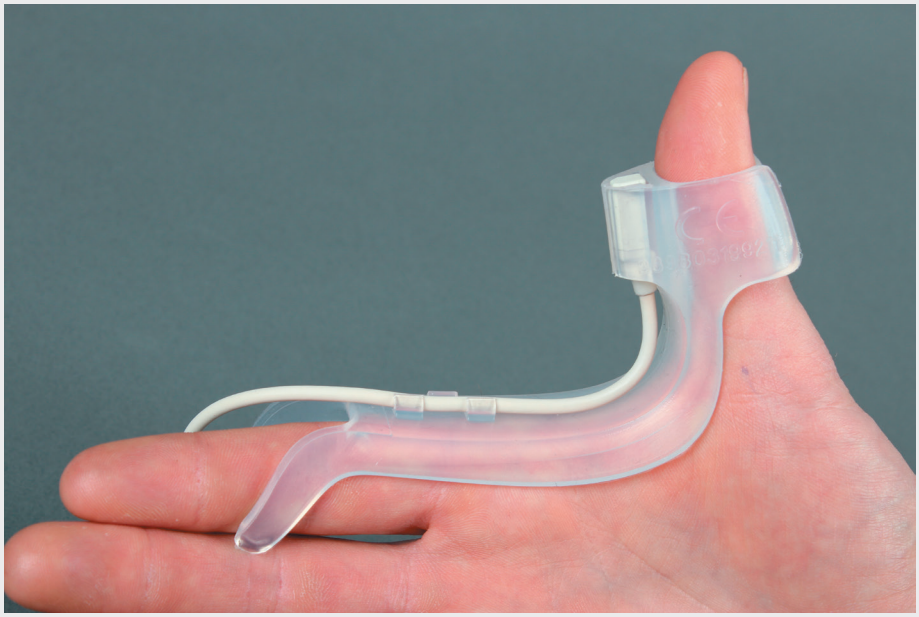

Figure 4: Philips NMT Hand Adapter (989803199211) .

APSF Awards 2024 Grant Recipients

Yan Xiao, PhD

The APSF grant program supports and advances anesthesia patient safety culture, knowledge, and learning, a part of the APSF mission. The program has played an essential role in establishing and enhancing careers of many health care professionals in conducting safety research and education. Since 1987, ASPF has supported more than 130 anesthesia professionals and other researchers with more than $14 million in funding.

The 2023–2024 APSF investigator-initiated grant program received 29 letters of intent from 20 organizations in the United States and Canada. The Scientific Evaluation Committee scored and discussed these letters, with the assistance of external statistical reviews. The top five scoring letters were invited to submit full proposals. Five full proposals were received and were discussed via a hybrid meeting on October 14, 2023. Two proposals were recommended for funding to the APSF Executive Committee and Board of Directors, and both received unanimous support. This year's recipients are Garrett Burnett, MD, from Icahn School of Medicine at Mount Sinai and Matteo Parotto, MD, PhD, from the University Health Network, Toronto General Hospital. They provided the following description of their proposed work.

Garrett Burnett, MD

Assistant Professor of Anesthesiology, Perioperative & Pain Medicine, Icahn School of Medicine at Mount Sinai

Dr. Burnett's project is entitled ***"Pulse Oximetry Accuracy and Skin Pigmentation in Congenital Heart Disease: A Prospective Observational Study."***

Background: Pulse oximetry (SpO_2) has been an essential perioperative monitor for noninvasively estimating arterial oxygen saturation (SaO_2). The incorporation of pulse oximetry into routine care has coincided with a significant reduction in anesthesia-related fatalities.[1] Recent retrospective studies have demonstrated discrepancies between measured pulse oximeter values and measured arterial oxygen saturation in patients self-identifying as Black or Hispanic.[2] These findings have demonstrated elevated rates of occult hypoxemia (i.e., SpO_2 ≥92% despite SaO_2≤88%) in non-White patients and linked occult hypoxemia to increased mortality and changes in treatment.[3-5] These previous retrospective studies have utilized self-identified race/ethnicity as a surrogate marker for skin pigmentation, but this may not be an accurate metric for skin pigmentation because a wide variety of skin pigmentations can be observed within a given racial or ethnic group. While several small prospective studies have investigated this discrepancy outside the clinical setting, all have utilized color-matching techniques (i.e., Fitzpatrick Scale) to quantify skin pigmentation.[6] Color-matching represents a more objective measure of skin pigmentation when compared to self-identified race/ethnicity, but its utility is limited by factors such as ambient lighting and variability in practitioner interpretation. Further, commonly used color-matching techniques (i.e., Fitzpatrick scale) were not developed to evaluate skin pigmentation. Color spectrophotometry (CS) represents an objective method for skin pigmentation measurement and overcomes the limitations of color-matching.[7] It is imperative that the relationship between pulse oximeter accuracy and CS-measured skin pigmentation be determined in order to improve equity in pulse oximeter function across all patients.

Aims: This study aims to evaluate the relationship between pulse oximeter accuracy and CS-measured skin pigmentation in pediatric patients with congenital heart disease having cardiac surgery. Accuracy will be tested using United States Food & Drug Administration guidelines (Accuracy Root Mean Square, Mean Bias, and Bland-Altman analysis). As a secondary aim, the correlation between pulse oximetry accuracy with CS-measured skin pigmentation, self-reported race/ethnicity, and measures using Fitzpatrick scale will be assessed. As a final secondary aim, we will evaluate the relationship of occult hypoxemia undetected by pulse oximetry with CS-measured skin pigmentation.

Implications: This project addresses the APSF's priority on Clinical Deterioration by working to improve a commonly utilized perioperative monitor for patients of all races and ethnicities. Pulse oximetry is utilized for all patients throughout the perioperative period. Inaccuracies in pulse oximetry may have impacts on patient outcomes and treatments. Determining the relationship between pulse oximetry and CS-measured skin pigmentation works towards the goal of making pulse oximetry equitable for all patients. Results from this study will potentially improve pulse oximeter accuracy in the congenital heart disease population and inform future studies evaluating this relationship in the more general population as a whole.

REFERENCES

1. Kiani J. How pulse oximetry influenced medicine and how its evolutiion will influence medicine. *APSF Article Between Issues.* June 2021. https://www.apsf.org/article/how-pulse-oximetry-influenced-medicine-and-how-its-evolution-will-influence-medicine/ Accessed November 30, 2023.
2. Burnett GW, Stannard B, Wax DB, et al. Self-reported race/ethnicity and intraoperative occult hypoxemia: a retrospective cohort study. *Anesthesiology.* 2022;136:688–696. PMID: 35231085.
3. Henry NR, Hanson AC, Schulte PJ, et al. Disparities in hypoxemia detection by pulse oximetry across self-identified racial groups and associations with clinical outcomes. *Crit Care Med.* 2022;50:204–211. PMID: 35100193.
4. Wong AKI, Charpignon M, Kim H, et al. Analysis of discrepancies between pulse oximetry and arterial oxygen saturation measurements by race and ethnicity and association with organ dysfunction and mortality. *JAMA Netw Open.* 2021;4. PMID: 34730820.
5. Fawzy A, Wu TD, Wang K, et al. Racial and ethnic discrepancy in pulse oximetry and delayed identification of treatment eligibility among patients with COVID-19. *JAMA Intern Med.* 2022;182:730–738. PMID: 35639368.
6. Foglia EE, Whyte RK, Chaudhary A, et al. The effect of skin pigmentation on the accuracy of pulse oximetry in infants with hypoxemia. *J Pediatr.* 2017;182:375–377.e2. PMID: 27939107.
7. Ly BCK, Dyer EB, Feig JL, et al. Research techniques made simple: cutaneous colorimetry: a reliable techique for objective skin color measurement. *J Invest Dermatol.* 2020;140(1):3-12.e1. doi 10.1016/j.jid.2019.11.003.

Funding: $149,999 (January 1, 2024–December 31, 2025). The grant was designated as the APSF/Medtronic Research Award.

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2024 Grant Recipients (cont'd)

From "Grant Recipients," Preceding Page

Matteo Parotto, MD, PhD

Associate Professor, Anesthesia & Pain Management, University Health Network, Toronto General Hospital

Dr. Parotto's project is entitled: ***"EXtubation-related complications—an international observational study To Understand the impact and BEst practices in the operating room and intensive care unit—the EXTUBE study."***

Background: Globally, over 200 million people each year require extubation. While routinely performed, extubation is a skilled and potentially high-risk procedure that should be performed only when physiologic, pharmacologic, and contextual conditions are optimal.[1] Complications at this stage of patient care can result in decreased oxygen delivery to the brain and body, sometimes leading to serious adverse events such as cardiac arrest, brain damage, or death. Indeed, one quarter of airway complications that result in death or brain death occur at the time of extubation.[2] Despite the frequency of extubation and the potential for life-threatening complications, we lack systematic data on the rate and circumstances under which these severe complications occur. The limited data indicate 10–30% of extubations may lead to severe complications, depending on the population and outcome definition.[2-4] However, the certainty of these estimates is severely limited because they are based on studies that are small, mostly single-center, based on clinician recall, only capture a small portion of extubation complications (e.g., malpractice claims), or do not reflect current clinical practice. In addition, most lack a denominator and exclude successful extubations, making estimates of actual complication rates and risk factors impossible. Promisingly, a recent focus on intubation complications, risk factors, and best-practices has decreased intubation complications by up to 26%,[5] suggesting that a similar program of research focusing on extubation could have a comparable impact on patient safety and outcomes. As a result, there have been calls for a large, systematic study to identify risks of extubation complications and effective extubation techniques, fitting with the APSF priority in Airway Management difficulties. In particular, high-quality baseline data on complication rates are needed to evaluate future interventions and clinical practice guidelines. There has been no large study of extubation techniques or adherence to guidelines; so procedural factors associated with complications must be elucidated. While adherence to clinical practice guidelines has not been formally evaluated, surveys show nonadherence to some best practices and considerable variation in practice, and data from audits and medicolegal claims show that lack of adherence to best practices is frequently at the root cause of severe adverse extubation outcomes with half of the complications deemed preventable.[2-4] Therefore, data on the frequency and nature of extubation complications, patient and procedural risk factors for complications, and guideline adherence rates are needed before these preventable events can be addressed.

Aims: Our primary question is "What is the incidence of severe extubation complications within 60 minutes after extubation in adults who have undergone mechanical ventilation for general anesthesia or critical illness?" Severe complications will be measured by i) Severe hypoxemia (SpO_2 < 80% for >5 minutes); ii) Unplanned noninvasive ventilation; iii) Cardiac arrest; iv) Need for airway management (reintubation, insertion of a supraglottic airway, bag-mask ventilation). Our secondary questions are: 1) "What is the incidence of mild extubation complications?"; 2) "What are patient- and procedure-related risk factors for extubation complications?"; 3) "Is there an association between extubation complications and outcomes until hospital discharge?"; 4) "What is the rate of adherence to extubation clinical practice guidelines?"

Implications: EXTUBE will establish the burden of extubation complications and the extent to which they are preventable, which could guide future interventions and guideline updates. This information will directly contribute to the advancement of the APSF priority in Airway Management difficulties, skills, and equipment, moving the field forward in improving patient safety in this fundamental area of care.

REFERENCES

1. Parotto M, Ellard L. Extubation following anesthesia. *UpToDate;* 2022. https://www.uptodate.com/contents/extubation-following-anesthesia Accessed November 30, 2023.
2. Joffe AM, Aziz MF, Posner KL, et al. Management of difficult tracheal intubation: a closed claims analysis. *Anesthesiology.* 2019;13:818–829. PMID: 31584884.
3. Cook TM, Woodall N, Frerk C. 4th National Audit Project of The Royal College of Anaesthetists and The Difficult Airway Society: major complications of airway management in the United Kingdom Report and Findings. 2011. PMID: 21447488.
4. Crosby ET, Duggan LV, Finestone PJ, et al. Anesthesiology airway-related medicolegal cases from the Canadian Medical Protection Association. *Can J Anaesth*. 2021;68:183–195. PMID: 33200320.
5. Pedersen TH, Ueltschi F, Hornshaw T, et al. Optimisation of airway management strategies: a prospective before-and-after study on events related to airway management. *Br J Aneasth*. 2021;127:798–806. PMID: 34535275.

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Yan Xiao, PhD, is a professor at the University of Texas at Arlington College of Nursing and Health Innovation, and the chair of the APSF's Scientific Evaluation Committee.

The author has no conflicts of interest.

Collectively Intelligent Anesthesia Care Teams

by D. Matthew Sherrer, MD, MBA, FASA, FAACD; Melissa Mines Ramsey, DNP, CRNA; and Kesha Thurston, DNP, MSHQS, CRNA

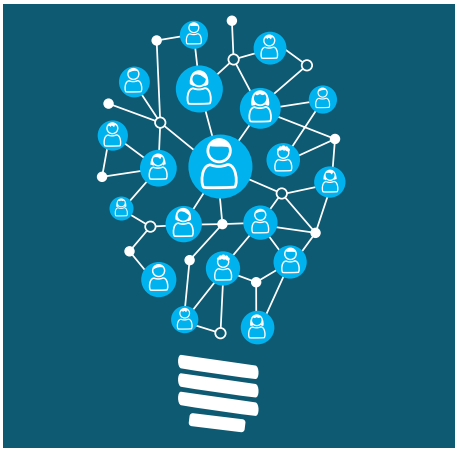
INTRODUCTION

On August 6th, 1997, Guam fire department dispatchers began receiving calls about a fire on a hillside that turned out to be the tragic crash of Korean Air flight 801. Despite efforts by rescuers and emergency personnel, 228 passengers and crew lost their lives in what was later described as a "controlled flight into terrain."[1] The events surrounding the crash of Korean Flight 801 have been extensively studied, with obvious contributing factors including fatigue, inadequate crew training, and failing monitors and warning systems. However, what still perplexes investigators is the *communication* of the flight crew. News reporter Bernadette Sterne recalls attending a public hearing about the flight a few months after the crash. According to Sterne, "The copilot knew that the pilot was too low. The copilot was trying to tell him, and the pilot was getting mad at him because, you know, he felt it wasn't his place to question his authority. And then they crashed."

Further analysis reveals that the copilot recognized the dire nature of the situation early on, as evidenced by his repeated comments about the rainy weather and the plane's warning systems. However, he did not speak up definitively to the captain, with the command of "let's make a missed approach," until six seconds before impact—six seconds before his own death. The captain reacted too slowly to pull the plane to safety. While we will never know why the copilot did not speak up sooner, it has been postulated that a cultural tradition of deference to authority and elders may have contributed. If the copilot had taken control of the plane when he finally spoke up, there was likely enough time to steer clear of the hillside and save the lives of the passengers and crew. Had the pilot and copilot functioned as a collectively intelligent team, the crash could have potentially been avoided.[2]

COMMUNICATION AND TEAMWORK IN HEALTH CARE

While we would like to believe that communication in health care is better than in the aviation example, statistics indicate there is ample room for improvement. According to the Joint Commission, communication failures account for up to 80% of serious medical errors,[3] with teamwork, communication, and human factors identified as the top three causes of sentinel events.[4] A recent study reported that medical error is the third leading cause of death in the US, behind only cancer and heart disease.[5] While some may argue that claim is inflated, the potential follow-up study stating that medical error has been eliminated has yet to be written.



Improvements in teamwork and communication have been shown to not only improve patient outcomes,[6,7] but can also enhance the mental health of health care workers. For example, residents who viewed their work groups as cohesive displayed less stress and were more satisfied with their jobs than colleagues in less cohesive work groups.[8] Further, team-building is one of the most useful organizational interventions to improve morale and productivity in the workplace and to ensure the mental and physical health of employees.[9] So surely then, anesthesia professionals need to dedicate significant time and energy intentionally educating and training on teamwork and communication.

In the perioperative space, a prior APSF article pointed to role ambiguity, stereotyping, and microaggressions among anesthesia professionals as being a threat to both patient safety and wellness.[10] With ongoing provider shortages threatening our practice models and pushing the remaining workforce to exhaustion and burnout,[11] there is barely a moment for a lunch break, much less a class or simulation session on teamwork and communication. Although teams can "improve clinical care because they can aggregate and apply a greater amount and variety of knowledge in order to…solve problems…and execute tasks more effectively and efficiently than any individual working alone,"[12] synergy in our perioperative teamwork is extraordinarily hard to achieve. Every second that we don't speak up, that we don't bring relevant information to the table, is a threat to the safety of our patients and to our own well-being.

HUMAN PERFORMANCE IN SMALL GROUPS

Communication and teamwork in health care, especially in the high-stakes environment of the operating room, are critical to patient safety. In the United States, most anesthetics are delivered in some iteration of an anesthesia care team model. If anesthesia professionals champion evidence-based clinical practice, then it follows logically that we should continue to examine the literature related to team performance in small groups. Moreover, we should educate and collectively train ourselves on those topics. To that end, let us now examine various bodies of knowledge on small group performance in search of themes and similarities.

COLLECTIVE INTELLIGENCE

In 2010, Anita Woolley, PhD, and her team at Carnegie Mellon University published a landmark study on "collective intelligence" in small group performance.[13] The study applied the methods used in foundational psychological studies on general intelligence to groups of two to five members. The team discovered the collective intelligence of a group was a property of the group itself and not just the individuals in it. In other words, the average or maximum intelligence of the team members did not significantly contribute to the collective intelligence of the team. This begs the question, then, if smart teams are not simply teams of smart people, what contributes to a collectively intelligent team?

Woolley's team found that three primary factors contributed to collective intelligence: 1) the average social sensitivity of team members, 2) the number of females in the group (likely directly correlated with social sensitivity) and 3) a negative correlation with variance in speaking turns.[13] Teams with socially sensitive team members who equally distribute participation in conversation, valuing the input of *all* team members over a hierarchical communication structure may function most effectively.

Amy Edmondson, PhD, has coined the term "teaming" for teamwork in dynamic environments. In contrast to stable teams, teaming involves working with a shifting mix of collaborators on a range of projects in fast-paced environments where the time between problem identification and solution application is rapidly shrinking.[14] This descriptor might seem appropriate for anesthesia professionals, who may work with different team members every day,

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Intelligent Teamwork Can Help to Benefit Patients and Providers

From "Collective Intelligence," Preceding Page

providing a variety of anesthetic techniques to an increasingly less-healthy and aging patient population. Teaming requires quickly identifying what collaborators know and what they bring to the table so that tasks with no known solution can be accomplished in short order. As such, Edmondson lists curiosity and empathy as identifying characteristics of a teaming culture. Curiosity drives us to find out what our team members bring to the table and what they can add to the team, while empathy allows us to see another's perspective, which is critical to effective collaboration under pressure.[14] Sharing the conversation, valuing the input of all team members, and being socially sensitive to other team members' perspectives contribute to effective group performance.

Similarly, Roger Schwarz, PhD, postulated that a mutual learning model is critical for helping teams develop the trust required to work through difficult challenges.[15] The mutual learning model has core values of compassion and curiosity, in contrast to the unilateral control model, where one person dominates the conversation as a superior under the assumption that they understand the problem, and others do not. Under the mutual learning model, differences are seen as opportunities for learning. Each team member may see things that others do not, and by sharing all relevant information, asking genuine questions, stating interests instead of positions, and jointly designing next steps, trust is increased, conflict and defensiveness are reduced, and solutions are achieved more rapidly and in a way that is more satisfying to team members.[15]

THE PATH FORWARD

The Anesthesia Care Team Optimization Committee (ACTOC) at The University of Alabama Birmingham (UAB) has recognized the importance of understanding collective intelligence, teaming, and the mutual learning model and has applied these models to its anesthesia care teams. Under the guidance of a consulting psychologist facilitator and using Schwarz's mutual learning model as a framework, UAB Medicine CRNAs and UAB Heersink School of Medicine physician anesthesiologists collaborated to overcome tensions in the operating room and improve the performance of team members, with the goal of delivering world-class care to patients. Emphasizing the importance of the committee, initial group members included the department chair and executive vice chair, division directors, hospital nursing leaders, CRNA managers, and C-suite executives alike. Further, front line anesthesiologists and nurse anesthetists elected to participate in initial meetings were chosen based on the characteristics of civility, inquiry, openness, and the ability to visualize a world where both groups succeed. Both sides acknowledged that patient care was paramount and that workplace tension negatively impacted patient care while contributing to unwellness and job dissatisfaction. The team recognized that each member brought a unique perspective and skill set to the team that, if harnessed appropriately, could allow for synergy in patient care.

After airing grievances and identifying common goals, the team crafted shared vision and mission statements. The effort was then expanded by establishing clinical, teamwork, education, and scholarship task forces, each consisting of seven to ten front line anesthesiologists and CRNAs. To date, these task forces have produced new perioperative communication tools, publications on overcoming anesthesia interprofessional conflict, "lunch and learn" education sessions on clinical topics, and shared journal clubs and social events. ACTOC leaders also regularly present at continuous quality improvement meetings with updates on ACTOC initiatives as well as with invited outside expert presentations on topics such as teamwork and leadership, conflict management, well-being and burnout, and organizational behavior.

Comments from initial surveys indicate that the "temperature" in the operating room has shifted toward warmer and more rewarding interactions. More recent survey responses included comments like "peace in coming to work," "mutual appreciation stronger," and "improvement in collaboration." The guidance of UAB ACTOC has allowed team members to voice opportunities, challenges, and successes in a safe space, and ACTOC leaders receive input from team members regularly to identify areas of success and growth opportunities. The palpable change in culture has led to requests for consultation by ACTOC liaisons both by nursing leadership within the perioperative space, and by obstetric, perinatal, and emergency medicine colleagues facing similar teamwork challenges. Next steps for ACTOC include IRB approved studies related to CRNA and anesthesiologist perceptions of their ACTOC experience, a formalized curriculum centered around high-performing collaborative teamwork, further expansion of ACTOC principles to multiple UAB-associated community hospitals, and ongoing interprofessional expansion to other colleagues, specialties, and departments within the institution.

CONCLUSION

Advances in evidence, knowledge, technology, and techniques continue to bolster the safety of anesthesia practice. External circumstances, however, continue to place pressure on the very practitioners whose skills and knowledge are required to deliver safe anesthesia at the patient's bedside. With the collaborative support of and guidance from the UAB ACTOC, our team has shown that civility in the workplace and an understanding and practice of collectively intelligent teamwork can thrive, benefitting patients and providers alike.

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The authors have no conflicts of interest.

REFERENCES

1. Dulla NS, Stephens J, Dana Williams. Recalling the crash of KAL Flight #801. Pacific Daily News; 2022. https://www.guampdn.com/news/25-years-later-remembering-kal-flight-801/article_8fced502-120f-11ed-b113-e3f11d784345.html. Accessed April 6, 2023.
2. Gladwell M. Outliers: The story of success. London: Penguin Books, 2009.
3. Joint Commission. Sentinel event data: root causes by event type 2004–2015. www.jointcommission.org. Accessed April 6, 2023.
4. Joint Commission. Sentinel event statistics released for 2015. https://info.jcrinc.com/rs/494-MTZ-066/images/Sentinel39.pdf. Accessed April 6, 2023.
5. Makary MA, Daniel M. Medical error—the third leading cause of death in the US. *BMJ.* 2016;35:i2139. PMID: 27143499.
6. Horak BJ, Pauig J, Keidan B, Kerns J. Patient safety: a case study in team building and interdisciplinary collaboration. *J Healthc Qual.* 2004;26:6–13. PMID: 15060954.
7. Gittell JH, Fairfield KM, Bierbaum B, et al. Impact of relational coordination on quality of care, postoperative pain and functioning, and length of stay: a nine-hospital study of surgical patients. *Med Care.* 2000;38:807–819. PMID: 10929993
8. Heyworth J, Witley TW, Allison EJ, Revicki DA. Predictors of work satisfaction among SHOs during accident and emergency medicine training. *Arch Emerg Med.* 1993;10:279–288. PMID: 8110316
9. Guzzo RA, Shea GP. Group performance and intergroup relations. In: Dunnette MD, Hough LM, eds. Handbook of Industrial and Organizational Psychology. Palo Alto, CA: Consulting Psychologists Press. 1992:269–313.
10. Anesthesia Patient Safety Foundation Newsletter. Culture of safety: the multidisciplinary anesthesia professional relationship. Available at: https://www.apsf.org/article/culture-of-safety-the-multidisciplinary-anesthesia-professional-relationship/. Accessed June 23, 2022.
11. Medac Anesthesia Business Partners. Anesthesia manpower update. Available at: https://www.medac.com/anesthesia-manpower-update/. Accessed June 23, 2022.
12. Larson JR. In search of synergy in small group performance. New York: Psychology Press, 2010.
13. Woolley AW, Chabris CF, Pentland A, et al. Evidence for a collective intelligence factor in the performance of human groups. *Science.* 2010;330:686–688. doi: 10.1126/science.1193147
14. Edmondson, AC. (2013) The three pillars of a teaming culture. Harvard Business Review (online article). https://hbr.org/2013/12/the-three-pillars-of-a-teaming-culture. Accessed April 6, 2023.
15. Schwarz, RM. Smart leader, smarter teams: how you and your team get unstuck to get results. San Francisco: Jossey Bass, 2013.

Keeping Pace: 2023 Update on the Perioperative Management of Cardiovascular Implantable Electronic Devices (CIEDs)

by Drew Disque, MD; Ashley P. Oliver, MD, MA; and Jacques P. Neelankavil, MD

Cardiovascular Implantable Electronic Device (CIED) technology continues to evolve and the global population of individuals with CIEDs is expanding. We present a focused update to the perioperative management of CIEDs since our last publication in 2020.

LEADLESS CIEDS

In our previous article in 2020, we introduced the Medtronic Micra™ leadless single-chamber ventricular pacemaker.[1] This device is inserted via the femoral vein and implanted in the right ventricular endocardium. The interest in leadless devices is driven by vascular access challenges in some patients, such as those with end-stage renal disease and multiple previous hemodialysis lines, and those with congenital heart disease with abnormal vascular anatomy. In addition, transvenous CIEDs are susceptible to infection and lead fracture. In 2023, Medtronic received approval from the Food and Drug Administration (FDA) for its newest Micra pacemakers, with two different models: the Micra AV2 and the Micra VR2. Similar to the original Micra, the Micra VR2 is intended only for ventricular sensing and pacing for patients who have atrioventricular (AV) block or atrial fibrillation. The Micra AV2 is indicated for patients with AV block, but unlike the VR2, it can provide atrial sensing and synchronous ventricular pacing. The Micra AV2 uses an accelerometer to sense the atrium and is able to pace in a VDD mode (Table 1). The key point for anesthesia professionals is that the Medtronic Micra models are not responsive to magnet application. If the patient requires asynchronous (VOO) pacing due to a risk for electromagnetic interference, the pacemaker must be reprogrammed with the programmer device.

Table 1: Generic pacemaker codes from the North American Society of Pacing and Electrophysiology and British Pacing and Electrophysiology Group.[2] Position refers to letter position in the pacemaker code (e.g., DDD, DOO, etc.).

Position	I	II	III	IV	V
	Chamber Paced	Chamber Sensed	Response to Sensing	Rate Modulation	Multisite Pacing
	O = None A = Atrium V = Ventricle D = Dual (atrium + ventricle)	O = None A = Atrium V = Ventricle D = Dual (atrium + ventricle)	O = None T = Triggered I = Inhibited D = Dual (atrium + ventricle)	O = None R = Rate modulation	O = None A = Atrium V = Ventricle D = Dual (atrium + ventricle)

The Abbott AVEIR™ VR, also a leadless device, was FDA-approved in 2022. The AVEIR VR has similar capabilities as the Micra; however, the AVEIR VR cannot perform AV sequential pacing (VDD) like the Micra AV. The AVEIR DR system, which was recently approved by the FDA, can perform dual chamber pacing. One advantage of the AVEIR devices is that they do respond to magnet placement. The magnet must be placed directly over the heart, and it will change the pacing mode to VOO at 100 beats per minute for five beats. If the battery is depleted, the magnet rate will then decrease to less than 100 depending on remaining battery life. Since the magnet response can be programmed off, anesthesia professionals should confirm magnet response prior to the start of the procedure by applying a magnet and observing the initial magnet rate of 100 for five beats.

MRI-CONDITIONAL DEVICES

CIED technology has evolved to include devices that are magnetic resonance (MR) conditional. This refers to a device that can be safely utilized in the MRI environment under specific conditions. CIEDs that do not meet MR conditional criteria are labeled MR nonconditional. There is the potential for patient morbidity and even mortality in the MRI environment related to

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Table 2: General Recommendations for Perioperative CIED Management

Intervention	Implantable defibrillator in the pacemaker-dependent patient	Implantable defibrillator in the non-pacemaker-dependent patient	Pacemaker-dependent patient	Non-pacemaker-dependent patient
	Patients with defibrillators undergoing procedures where EMI could occur and with suspended anti-tachytherapy should be in monitored environments with defibrillation equipment readily available.		Patients with pacemakers undergoing procedures where EMI could occur should have temporary pacing options readily available.	
Procedure above the umbilicus which may generate EMI	Apply external defibrillator pads and deactivate ICD anti-tachytherapy. If clinically indicated, asynchronous pacing mode may be applied. Ensure reactivation of anti-tachytherapy and permanent pacing settings before patient is discharged.	Apply external defibrillator pads and deactivate anti-tachytherapy. Ensure reactivation of anti-tachytherapy before patient is discharged.	Turn off rate response feature and program to asynchronous pacing mode. Consider increasing lower rate limit if clinically indicated. Ensure restoration to permanent settings before patient is discharged.	Monitor during surgery to ensure adequate intrinsic rate. Reprogram the device if a higher heart rate is physiologically desirable.
Procedure below the umbilicus which may generate EMI	Preemptive reprogramming not required. Ensure magnet or programmer is available. Utilize standard or invasive monitors as clinically indicated.			

EMI: electromagnetic interference; ICD: implantable cardiac defibrillator.

Update on CIEDs (cont'd)

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CIED complications including generator movement, tissue heating, electromagnetic interference, and device reset. The practice advisory from the American Society of Anesthesiologists (ASA) from 2020 recommends that MR conditional devices should be interrogated prior to MRI and programmed to the magnetic resonance imaging mode.[3] The device should be placed in an asynchronous pacing mode for pacemaker-dependent patients with suspension of anti-tachycardia therapy. Finally, the CIED should be interrogated after the MRI. The recommendations for MR nonconditional CIEDs are similar with respect to asynchronous pacing for pacemaker-dependent patients with suspension of anti-tachycardia therapy. The Heart Rhythm Society (HRS) 2017 guidelines also recommend that for MR nonconditional CIEDs, one should consider programming to non-pacing modes (e.g., ODO) or inhibiting modes (e.g., DDI) for patients that are not pacemaker -dependent.[4] The HRS also states that it is reasonable for MR nonconditional CIEDs to have an MRI if there are no fractured, epicardial, or abandoned leads and MRI is the best diagnostic test to answer the clinical question. Perioperative guidelines for CIED care in the MRI environment also include EKG and pulse oximetry monitoring,

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Table 3: Clinical Pearls for Perioperative CIED Management in Particular Contexts.

Clinical context	Implantable defibrillator in the pacemaker-dependent patient	Implantable defibrillator in the non-pacemaker-dependent patient	Pacemaker-dependent patient	Non-pacemaker-dependent patient
Cardiac surgery	Apply external defibrillator pads and deactivate anti-tachytherapy. Reprogram to appropriate rate in asynchronous pacing mode. Ensure reactivation of anti-tachytherapy before patient is discharged.	Apply external defibrillator pads and deactivate anti-tachytherapy. Ensure reactivation of anti-tachytherapy before patient is discharged.	Turn off rate response feature and program to asynchronous pacing mode. Consider increasing lower rate limit if clinically indicated. Ensure restoration to permanent settings before patient is discharged.	Monitor during procedure to ensure adequate intrinsic rate; reprogram the device if a higher heart rate is physiologically desirable.
Electroconvulsive therapy (ECT)	Deactivate anti-tachytherapy for procedure and reactivate at case conclusion.		Preemptive reprogramming not required. Utilize standard or invasive monitors as clinically indicated.	
Endoscopy	Most endoscopy procedures do not use monopolar electrocautery or an argon beam; therefore, no modifications are necessary to the CIED for these cases. If monopolar electrocautery will be used, follow the recommendations for surgery above the umbilicus.		If monopolar electrocautery or argon beam is used, follow recommendations for surgery above the umbilicus.	Preemptive reprogramming not required. Utilize standard or invasive monitors as clinically indicated.
Lithotripsy	Apply external defibrillator pads and deactivate anti-tachytherapy for procedure and reactivate at case conclusion. Avoid focusing lithotripsy beam near generator.		Preemptive reprogramming not required. Utilize standard or invasive monitors as clinically indicated. Avoid focusing lithotripsy beam near generator.	
Magnetic Resonance Imaging (MRI)	For MRI conditional devices: program to MRI mode to suspend anti-tachycardia function. Reprogram to appropriate rate in asynchronous pacing mode. Deactivate MRI mode before patient is discharged. For MRI nonconditional devices: suspend anti-tachycardia therapy, reprogram to appropriate rate in asynchronous pacing mode. Ensure restoration of permanent settings before patient is discharged	For MRI conditional devices: program to MRI mode to suspend anti-tachycardia function. Deactivate MRI mode at case conclusion. For MRI nonconditional devices: suspend anti-tachycardia therapy. Ensure restoration of permanent settings before patient is discharged.	For MRI conditional devices, program to MRI mode to initiate asynchronous pacing for pacemaker-dependent patients. Ensure restoration of permanent settings before patient is discharged.	For MRI conditional devices, monitor to ensure adequate intrinsic rate during scan. Reprogram the device if a higher heart rate is physiologically desirable. Ensure restoration of permanent settings before patient is discharged.
	To utilize programmer or external defibrillator, patient will need to be moved outside of the immediate vicinity of the MRI machine.			
Ophthalmological surgery	It is common to use bipolar electrocautery; therefore, there is minimal risk of EMI with the CIED. If monopolar electrocautery will be used, follow recommendations for surgery above the umbilicus.			
Radiofrequency Ablation (RFA)	If RFA is planned superior to the umbilicus, follow recommendations for surgery above the umbilicus. Keep current pathway (electrode tip to current return pad) as far away from generator and leads as possible.			

CIED: cardiovascular implantable electronic device; MRI: magnetic resonance imaging; EMI: electromagnetic interference

Ongoing Education to Manage CIEDs is Paramount

From "Update on CIEDs," Preceding Page

personnel able to perform advanced cardiovascular life support (ACLS), external defibrillator immediately available outside zone 4, and personnel able to program CIED available as defined by institutional protocol.[5]

ALTERNATIVE PACING SITES

Anesthesia professionals might encounter CIEDs that are aimed to provide cardiac physiologic pacing (CPP). CPP is any form of pacing that restores or preserves ventricular synchrony. CPP is further divided into conduction system pacing such as His bundle pacing, left bundle branch pacing, or cardiac resynchronization therapy (CRT). CRT is achieved with biventricular (BiV) pacing using a coronary sinus branch or epicardial left ventricular lead. The goal of CPP is to reduce heart failure that may be seen in patients who require a significant amount of ventricular pacing. Patients who require substantial ventricular pacing may develop pacing-induced cardiomyopathy. Patients who have His bundle pacing or left bundle branch pacing should be managed similarly to patients with traditional dual chamber pacemakers in the perioperative period.

UPDATES IN THE LITERATURE

Since the 2020 update to the original article, further guidelines from the British Heart Rhythm Society have been published in 2022 in *Anaesthesia*.[1,6,7] Additionally, the European Heart Rhythm Association in conjunction with the Heart Rhythm Society, Latin American Heart Rhythm Society, and Asian Pacific Heart Rhythm Society published a comprehensive consensus statement regarding the prevention and management of procedural EMI in patients with CIEDs (Table 2).[8] Strengths of these articles include the discussion of common procedural contexts that have not before been broadly discussed, such as eye surgery, electroconvulsive therapy, and dental work, as well as more nuanced discussions of CIED management in clinical contexts like MRI scanning and therapeutic radiation for malignancy (Table 3).

Key recommendations of these papers reiterate that electromagnetic interference, most often in the form of monopolar electrocautery above the umbilicus, may continue to pose a threat to patient safety by inhibiting pacing in the pacemaker-dependent patient, inappropriate cardiac defibrillator shocks, or device resets. The anesthesia professional at the time of procedure must be equipped with essential information (Table 4) to support the patient with a CIED through the periprocedural period. It is imperative the anesthesia team understand the response to a CIED to magnet application.

Although some academic centers have a dedicated perioperative CIED team,[5] managing cardiac devices is within the scope of practice of perioperative providers.[9] Thankfully, there exist guidelines and consensus statements to help steer perioperative management of these devices. Smartphone-based apps such as Pacemaker-ID and Device Detector may aid providers by being able to correctly identify CIEDs via chest x-ray. Especially as technology continues to evolve, ongoing education in the management of these devices is essential.

Table 4: Essential information to be communicated to the perioperative team by the CIED specialty or electrophysiology team

1	Indication for device placement
2	Device type, manufacturer and model
3	Date of last device interrogation* **Guidelines recommend ICD or cardiac resynchronization devices to be interrogated every 6 months, pacemakers to be interrogated every 12 months in the absence of clinical changes or concern for performance*
4	Battery longevity
5	Any leads placed or replaced within the last 3 months
6	Whether patient is pacemaker dependent
7	Current program settings
8	Device response to magnet placement
9	Whether any alerts have been placed on device, i.e., any recalls or manufacturing issues
10	Last pacing thresholds
11	Individual perioperative recommendations or prescriptions based on patient information, device characteristics, and surgical factors
12	Device location (pre-pectoral region, vs. lateral chest wall, vs. abdomen)

ICD: implantable cardiac defibrillator

Used with permission from Neelankavil JP, Thompson A, Mahajan A. Managing cardiovascular implantable electronic devices (CIEDs) during perioperative care. *APSF Newsletter.* 2013:2;29–35.

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REFERENCES

1. Neelankavil JP, Thompson A, Mahajan A. Change of pace: an update on the perioperative management of cardiovascular implantable electronic devices (CIEDs). *APSF Newsletter.* 2020:35;92–93. https://www.apsf.org/article/change-of-pace-an-update-on-the-perioperative-management-of-cardiovascular-implantable-electronic-devices-cieds/ Accessed December 5, 2023.
2. Bernstein AD, Daubert JC, Fletcher RD, et al. The revised NASPE/BPEG generic code for antibradycardia, adaptive-rate, and multisite pacing. North American Society of Pacing and Electrophysiology/British Pacing and Electrophysiology Group. *Pacing Clin Electrophysiol.* 2002;25:260–264. PMID: 11916002.
3. Practice advisory for the perioperative management of patients with cardiac implantable electronic devices: pacemakers and implantable cardioverter–defibrillators 2020: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Management of Patients with Cardiac Implantable Electronic Devices. *Anesthesiology.* 2020;132:225–252. PMID: 21245737.
4. Indik J, Gimbel JR, Abe H, et al. 2017 HRS expert consensus statement on magnetic resonance imaging and radiation exposure in patients with cardiovascular implantable electronic devices. *Heart Rhythm.* 2017;e97-e153. PMID: 28502708
5. Streckenbach S, Lai Y, Bas H,, et al. Starting an anesthesia-based perioperative device management service: a practical guide to training anesthesiologists. *J Cardiothor Vasc An.* 2021;35:1006–1017. PMID: 33341343.
6. Neelankavil JP, Thompson A, Mahajan A. Managing cardiovascular implantable electronic devices (CIEDs) during perioperative care. *APSF Newsletter.* 2013:28;29–35 https://www.apsf.org/article/managing-cardiovascular-implantable-electronic-devices-cieds-during-perioperative-care/ Accessed December 5, 2023.
7. Thomas H, Plummer C, Wright IJ, et al. Guidelines for the peri-operative management of people with cardiac implantable electronic devices: guidelines from the British Heart Rhythm Society. *Anaesthesia.* 2022;77:808–817. PMID: 35429334
8. Stühlinger, M, Burri H, Vernooy K, et al. EHRA consensus on prevention and management of interference due to medical procedures in patients with cardiac implantable electronic devices: For the European Heart Rhythm Association (EHRA), Heart Rhythm Society (HRS), Latin America Heart Rhythm Society (LAHRS), Asian Pacific Heart Rhythm Society (APHRS). *Europace.* 2022;24:1512–1537. PMID: 36228183
9. Song P, Rooke GA. Fundamental electrophysiology principles related to perioperative management of cardiovascular implantable electronic devices. *J Cardiothor Vasc An.* 2023.Oct 6:S1053-0770(23)00800-5. PMID: 37940457

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Three Quarters of Preventable Patient Harm Stems from Situation Awareness Breakdowns: Recognizing and Addressing the Core Issue

by David W. Tscholl, MD; Cynthia A. Hunn, MD; and Greta Gasciauskaite, MD

BACKGROUND

The principles of Situation Awareness (SA) originated in aviation psychology, a field that bears similarities to medicine in its daily challenges of dealing with complex, dynamic, and often unforeseen situations. David Gaba, MD, an anesthesiologist at Stanford University and former member of the Board of Directors of the APSF recognized this connection nearly 30 years ago and introduced the concept of SA to the field of anesthesiology.[1] Two decades later, SA experienced a resurgence through the combined efforts of its originator, Mica Endsley, PhD, an engineer,[2] and an anesthesiologist, Christian Schulz, MD.[3] With this contribution, we aim to bring the concept into focus once again and highlight its critical importance for patient safety, as errors in SA often underlie patient harm.[4,5]

SITUATION AWARENESS

SA is a three-tiered concept that involves a cyclical sequence of perceiving individual elements of information from the environment (SA Level 1), comprehending their collective meaning (SA Level 2), and finally projecting the meaning of that comprehension into the immediate future (SA Level 3). Only when the relevant information is perceived can its importance be understood and then used to predict where the situation may lead. In other words, SA serves as the foundation of our decision-making ability by constructing a mental model of a given situation and its near future, enabling us to predict the consequences of our actions. Our capacity to build SA is positively influenced by our experience, knowledge, and training. Conversely, factors like fatigue, excessive workload, and system complexity have a negative impact on it (Figure 1).[6]

Figure 1 illustrates that effective SA can lead to improved patient safety. To demonstrate this notion, consider an example from anesthesia practice: a care provider initially observes gradual drops in blood pressure, then an increase in the volume of blood in the suction canisters, and an increasingly nervous surgeon (SA Level I). Only then can they understand that this is likely a bleeding situation (SA Level II) and anticipate that, depending on the severity, assistance will be required (SA Level III). A decision can now be made to pick up the phone and call for help, thus initiating the next steps. Over time, the cycle must continuously repeat so that the specialist can adapt to new challenges and optimize patient safety. By reducing the effort required to build SA, caregivers can make patient safety decisions faster and with less workload.

Figure 1 is based on Endsley's model of situation awareness,[2] adapted by the authors to demonstrate the impact of situation awareness on patient safety. At least three quarters of errors in medicine, much like in aviation, are human errors, or ultimately situation awareness errors.

SITUATION AWARENESS: SIMILARITIES AMONG MEDICAL AND AVIATION ERROR

The World Health Organization states *"First, do no harm"* as the most fundamental principle

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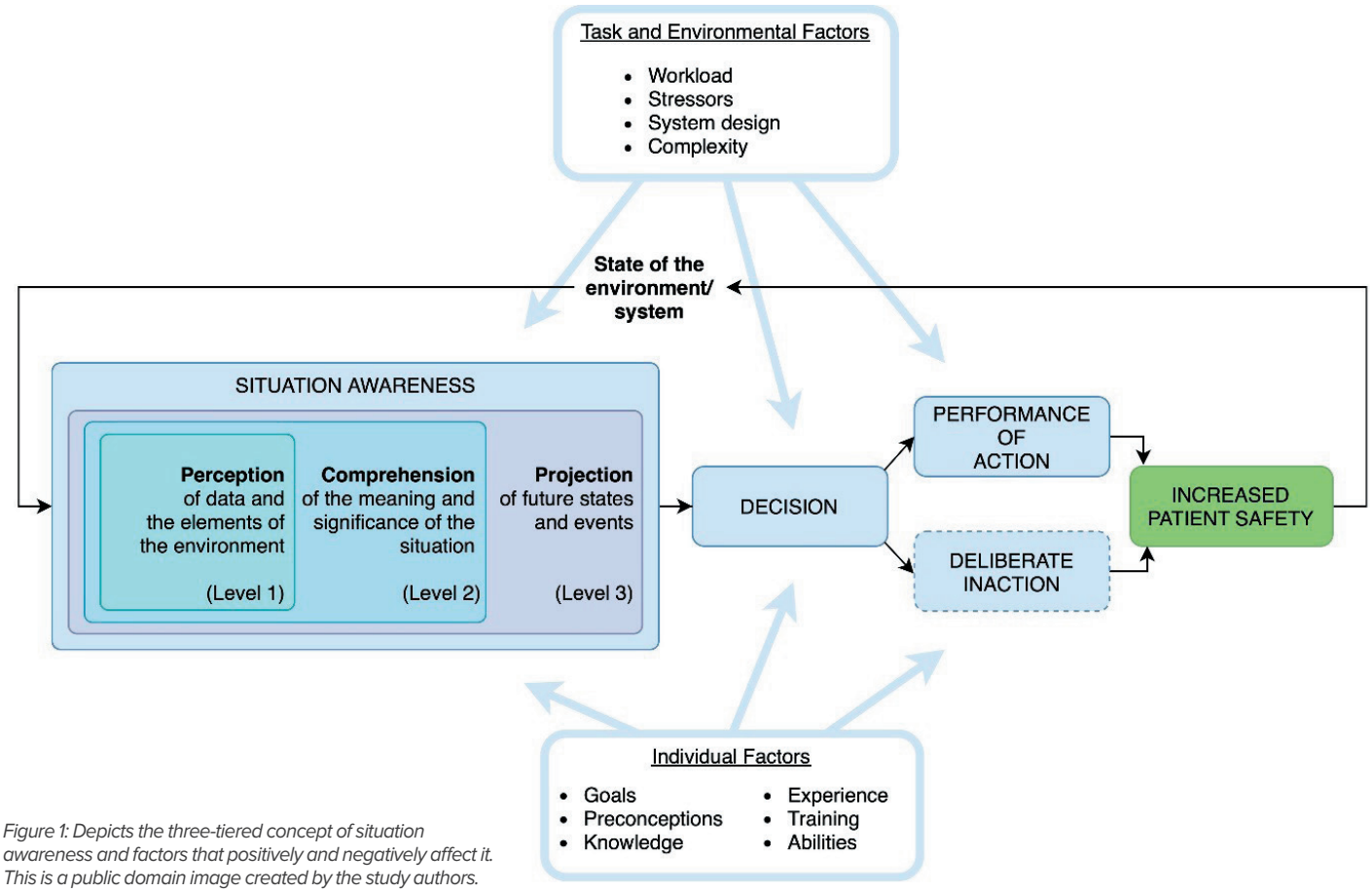

Figure 1: Depicts the three-tiered concept of situation awareness and factors that positively and negatively affect it. This is a public domain image created by the study authors.

Situation Awareness is Root Cause of Many Safety-Related Adverse Events

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of health care.[7] Nevertheless, approximately one in ten patients experience adverse events in health care settings, with over 50% of harm deemed preventable.[8,9] Typical adverse incidents that may lead to preventable harm to patients include medication errors, unsafe surgical practices (such as performance of non-routine procedures by inexperienced surgeons, wrong-site surgery, retained surgical instruments, or anesthesia-related errors), health care-associated infections, and incorrect diagnoses.[7] Based on analyses of malpractice claims and critical incident reporting system cases, Schulz et al. found that three quarters or more of all errors in anesthesiology and intensive care can be attributed to deficiencies in SA.[3,10]

AVIATION AND SITUATION AWARENESS

In aviation, a parallel challenge exists, with approximately 80–85% of accidents attributed to SA problems.[11] In fact, the three worst U.S. airline accidents in the last two decades—Asiana Airlines Flight 214 in San Francisco,[12] Colgan Air Flight 3407 in Buffalo, NY,[13] and Comair Flight 5191 in Lexington, KY[14]—were all attributed to SA errors. In the 1930s, decades before the term SA was coined, the aviation industry recognized that machines had become too complex for humans to operate them safely without checklists and has since achieved its current high safety standards by improving technology and training, implementing the use of standard operating procedures such as checklists, and increasing awareness to optimize SA.[15]

In medicine, Schulz et al. identified that the most common types of errors were Level I errors, in which the individuals failed to perceive information available to them in their environment, such as when a caregiver fails to notice a change in blood pressure because he or she is preoccupied with setting respiratory parameters. Misinterpretation of perceived information and incorrect projection of the situation into the near future were the second and third most common subtypes of errors.[4,10] The top ten patient safety priorities listed by the Anesthesia Patient Safety Foundation are of paramount importance.[16] As we address these priorities, it is essential to view them through the lens of SA optimization in order to maximize patient safety at its core.

WHAT CAN WE DO TO IMPROVE SITUATION AWARENESS AND PATIENT SAFETY?

To answer this central question, we need to consider the primary purpose of SA design: to efficiently transfer goal-relevant information to the decision-makers, enabling them to make informed and timely therapeutic decisions with minimal cognitive effort. In the book *Designing for Situation Awareness*, Mica Endsley, PhD, specifies eight points to consider when focusing on systems optimized for SA.[6] When applied to health care, these include, but are not limited to, organizing and displaying relevant information around the care provider's main goals to facilitate perception and understanding of the most important data, such as through the use of checklists or intuitive visualization techniques. In order for users to make efficient decisions while maintaining a comprehensive understanding of complex situations, critical cues must be easily identifiable through salient signals that attract our attention, such as through changes in color, form, or frequency. This can be accomplished by utilizing our innate parallel processing abilities and optimizing information delivery in accordance with the principles of human visual information processing. In addition, the implementation of novel technologies based on predictive algorithms can directly support level 3 SA projections.

We hope that these principles, when implemented in medicine, can help achieve the goal of the World Health Organization's Global Patient Safety Action Plan: "to achieve the maximum possible reduction in avoidable harm due to unsafe health care globally".[7] The focus of safety design efforts should be to optimize SA from all angles by considering the task, environmental, and individual factors outlined in Figure 1.

Comparing SA in medicine and aviation, a person would need daily anesthesia for 548 years to encounter the 1:200,000 mortality risk estimated for a healthy patient,[17] while flying daily for 25,000 years to face a fatal plane crash, as per the International Air Transport Association Safety Performance Report of 2023.[18] Although these mortality events are uncommon, lack of SA leads to a much higher number of nonlethal critical incidents. It is important to address inadequate SA, as it is the root cause of most patient safety issues and can be improved through the application of SA-oriented design.

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REFERENCES

1. Gaba DM, Howard SK, Small SD. Situation awareness in anesthesiology. *Human Factors*. 1995;37:20–31. PMID: 7790008.
2. Endsley MR. Toward a theory of situation awareness in dynamic systems. *Human Factors.* 1995;37:32–64. doi: 10.1518/001872095779049543
3. Schulz CM, Endsley MR, Kochs EF, et al. Situation awareness in anesthesia: concept and research. *Anesthesiology.* 2013;118:729–742. PMID: 23291626.
4. Schulz CM, Burden A, Posner KL, et al. Frequency and type of situational awareness errors contributing to death and brain damage: a closed claims analysis. *Anesthesiology.* 2017;127:326–337. PMID: 28459735
5. Schulz CM, Krautheim V, Hackemann A, et al. Situation awareness errors in anesthesia and critical care in 200 cases of a critical incident reporting system. *BMC Anesthesiol.* 2016;16:4. PMID: 26772179.
6. Endsley MR. Designing for situation awareness: an approach to user-centered design. 2nd ed. CRC Press Inc. Boca Raton, FL, USA; 2011.
7. World Health Organization. Patient safety. https://www.who.int/news-room/fact-sheets/detail/patient-safety#:~:text=Around%201%20in%20every%2010,from%20unsafe%20care%20(1). Accessed November 12, 2023.
8. Slawomirski L, Klazinga N. The economics of patient safety: from analysis to action. Organisation for Economic Co-operation and Development. https://www.oecd.org/health/health-systems/Economics-of-Patient-Safety-October-2020.pdf. Accessed November 12, 2023.
9. Panagioti M, Khan K, Keers RN, et al. Prevalence, severity, and nature of preventable patient harm across medical care settings: systematic review and meta-analysis. *BMJ.* 2019;366:l4185. PMID: 31315828.
10. Schulz CM, Krautheim V, Hackemann A, et al. Situation awareness errors in anesthesia and critical care in 200 cases of a critical incident reporting system. *BMC Anesthesiol.* 2016;16:4. PMID: 26772179.
11. Jones DG, Endsley MR. Sources of situation awareness errors in aviation. *Aviat Space Environ Med.* 1996;67:507–512. PMID: 8827130.
12. Board NTS. Descent below visual glidepath and impact with seawall, Asiana Airlines Flight 214, Boeing 777-200ER, HL7742, San Francisco, California July 6, 2013. 2014. https://www.ntsb.gov/investigations/accidentreports/reports/aar1401.pdf. Accessed November 15, 2023.
13. Board NTS. Loss of control on approach, Colgan Air, Inc., Operating as Continental connection flight 3407, Bombardier DHC-8-400, N200WQ, Clarence Center, New York, February 12, 2009. 2010. https://www.ntsb.gov/investigations/accidentreports/reports/aar1001.pdf. Accessed November 15, 2023.
14. Board NTS. Attempted takeoff from wrong runway, Comair Flight 5191, Bombardier CL-600-2B19, N431CA, Lexington, Kentucky, August 27, 2006. 2007. https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR0705.pdf. Accessed November 14, 2023.
15. University of Calgary IVP Services| Environment HaS. Safety Moment. Use of checklists as an administrative control. https://www.ucalgary.ca/risk/sites/default/files/teams/13/EHS_SM__Use_of_Checklists_as_an_Administrative_Control.pdf. Accessed November 13, 2023
16. Greenberg S. The APSF revisits its top 10 patient safety priorities. *APSF Newsletter.* 2021;36:48,53. https://www.apsf.org/article/the-apsf-revisits-its-top-10-patient-safety-priorities/#:~:text=New%20additions%20to%20the%20current,%2D19)%2C%20including%20patient%20management Accessed November 30, 2023.
17. Essentials CCH. How safe is anesthesia? 5 common concerns. https://health.clevelandclinic.org/safe-anesthesia-5-things-know. Accessed November 14, 2023.
18. IATA. IATA releases 2022 airline safety performance. https://www.iata.org/en/pressroom/2023-releases/2023-03-07-01/. Accessed November 13, 2023.

If Looks Could Kill: Anesthetic Implications of Cosmetic Enhancements

by Melissa Byrne, DO, MPH, FASA, and Danielle Saab, MD

INTRODUCTION

Nonsurgical cosmetic enhancements such as neurotoxins, eyelash extensions, gel manicures, or permanent jewelry, have grown exponentially in popularity over the last several years. Whether individuals seek to alter their appearance to achieve a more youthful image, enhance self-esteem, or experience the latest social media trend, these procedures have become increasingly safer, more accessible, socially acceptable, and affordable.

Regrettably, many of these cosmetic enhancements can significantly impact anesthetic technique and delivery. This article highlights popular cosmetic enhancements that may have under-recognized anesthetic implications whilst providing suggestions to improve patient safety by (1) promoting conversations with patients about the associated risks and (2) outlining steps that can minimize patient harm (Table 1).

Table 1. Potential Cosmetic Safety Risks and Authors' Proposed Risk Mitigation Strategies

Safety Risk	Description	Potential Source of Harm	Risk Mitigation Strategies
Neurotoxins	Blocks release of acetylcholine from the neuromuscular junction leading to flaccid muscle paralysis commonly in facial muscles	Impairs monitoring of paralysis and may lead to false interpretation of degree of neuromuscular blockade	Routine use of ulnar nerve stimulation is recommended[7] Obtain a complete and accurate history of cosmetic procedures preoperatively
Eyelash Extensions	Adhesion of semi-permanent, artificial lash fibers to base of natural eye lashes can lead to lagophthalmos (incomplete closure of the eye)	Corneal exposure/ dryness/injury Microbial infection Blepharitis	Remove prior to surgery/ procedure Soft, oval pad across the eyelid Tape horizontally (preferred) or vertically from brow to zygomatic arch Apply ocular lubricants Intraoperative eye checks Re-assess with head or neck position changes
Oral and Facial Piercings	Mouth, tongue and nose piercings (metal or radiolucent materials)	Tongue injury/ laceration Infection Burn risk Piercing dislodgement Nerve injury/pressure necrosis Aspiration	Remove prior to surgery/ procedure
Permanent Jewelry	Custom-fit solid gold or silver bracelets, anklets, or necklaces requiring an expert welder	Site burn Edema causing compressive injury Item dislodgement	Remove prior to surgery/ procedure Taping may reduce risk of item loss When able, employ use of bipolar instead of monopolar electrosurgery Can be removed urgently by cutting the chain at the small ring (aiming to maintain chain integrity)
Nail Polish and Gel Manicures	Green and blue nail polish may falsely indicate desaturation; gel-based manicures may lead to over-estimation of oxygen saturation	Misinterpretation of pulse oximetry findings may lead to unnecessary interventions or delayed detection of hypoxemia	Routinely request removal prior to surgery Consider rotating pulse oximetry probe ninety degrees to avoid painted nail bed Consider alternative locations of pulse oximetry probe (i.e., ear or nose)

NEUROTOXINS AND PERIPHERAL NERVE STIMULATOR MONITORING

Overall trends in the use of minimally invasive cosmetic procedures have significantly gained in popularity since the pre-pandemic era with the return to mask-free environments. According to the American Society of Plastic Surgeons, neuromodulator injections are the most popular minimally invasive procedure with over 8.7 million procedures performed in 2022—an increase of over 70% from 2019.[1] Botulinum toxin, a neurotoxin produced by the bacterium *Clostridium botulinum*, produces flaccid muscle paralysis by blocking the release of acetylcholine at the neuromuscular junction; it is used for the treatment of hyperfunctional facial lines resulting from repeated contractions most commonly in facial muscles such as orbicularis oculi, procerus, corrugator supercilii, and frontalis. Commonly known by their brand names (BOTOX Cosmetic®/AbbVie Inc, North Chicago, IL; Dysport®/Galderma Laboratories, L.P. Dallas, TX; Xeomin®/Bocouture, Merz North America, Inc., Raleigh, NC; Jeuveau®/Evolus, Inc., Newport Beach, CA; and Daxxify®/Revance Therapeutics, Inc., Nashville, TN), these neurotoxins have been of increased interest, driven by the desire for personalized beauty, economic feasibility, and accessibility.

There are few case reports documenting monitoring-related complications secondary to neurotoxin use. In 2006, a case report was published describing a 35-year-old woman presenting for elective laparoscopic surgery given rocuronium with no train-of-four, double-burst, or tetanic stimulation patterns noted on her forehead one hour after induction though forceful and fade-free muscle contractions were provoked at the ulnar nerve.[2] A year later, a case report of a 72-year-old man scheduled for an urgent exploratory laparotomy described that upon surgical closure of the fascia, the surgeon stated the patient's muscles were not relaxed despite 0/4 twitches noted using a peripheral nerve stimulator at the orbicularis oculi muscles bilaterally.[3] Placement of the nerve stimulator over the ulnar nerve noted recovery of the train-of-four. In both case reports, postoperative patient interviews confirmed a history of botulinum toxin injections to the upper facial muscles in the weeks prior to surgery.

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Safety Concerns for Cosmetic Enhancements

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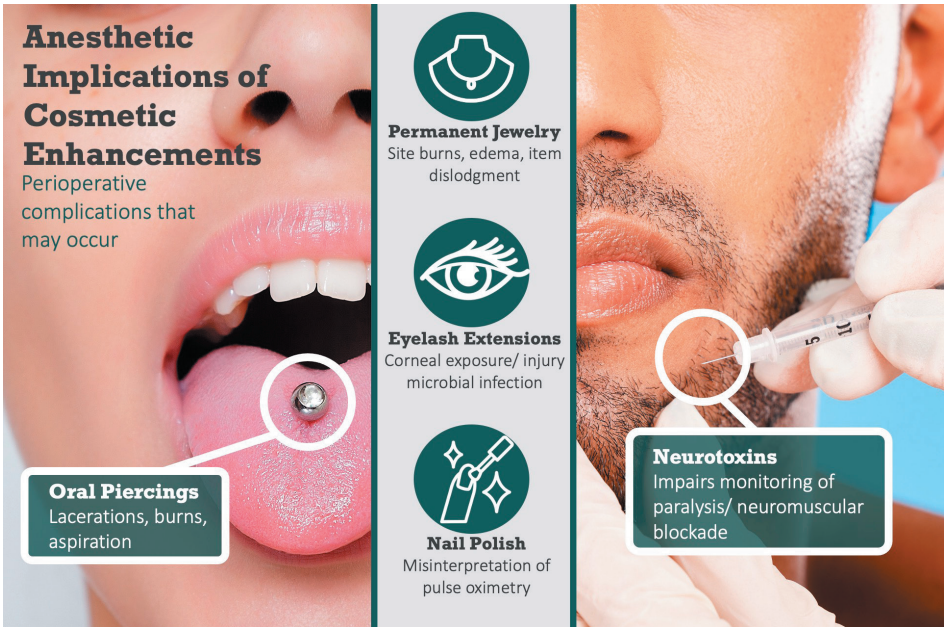
Similar case reports have continued to be published in isolation. One report described an urgent intra-abdominal procedure with surgical concerns voiced about degree of paralysis, and the patient was noted to be breathing while on the ventilator.[4] Another described a 46-year-old woman presenting for Cesarean delivery under general anesthesia for HELLP syndrome who was given succinylcholine to facilitate intubation; absence of train-of-four pattern was noted 25 minutes later at the orbicularis oculi, but full recovery then confirmed with ulnar nerve stimulation, highlighting the risk of encountering cosmetic neurotoxin use in the aging pregnant population.[5] Another report detailed a 61-year-old woman whose postoperative course was complicated by multi-organ system failure requiring mechanical ventilatory support.[6] Adequate neuromuscular blockade with cisatracurium was assumed via facial nerve stimulation; however, patient-ventilator dyssynchrony prompted moving the peripheral nerve stimulator to the ulnar nerve, whereby muscle twitches indicated inadequate paralysis.

Notably, each report proffers sensible advice given the increasingly common use of cosmetic neurotoxins. First, all authors suggested the routine use of the ulnar nerve stimulation for neuromuscular monitoring—a recommendation now strongly supported in the 2023 American Society of Anesthesiologist Practice Guidelines for Monitoring and Antagonism of Neuromuscular Blockade.[7] Second, most authors recommended obtaining a complete and accurate history including the use of cosmetic procedures prior to the administration of paralytic agents. As the prevalence of cosmetic procedures continues to rise, all patients, regardless of age, gender, or youthful appearance, should be queried preoperatively.

EYELASH EXTENSIONS AND CORNEAL INJURY

Eyelash extensions, which involve the adhesion of semipermanent, artificial lash fibers to the base of each individual natural lash via glue with the hopes of obtaining fuller, longer lashes, are also increasing in popularity. Adverse effects following eyelash extensions include dry eyes, burning sensations, lid swelling, and pain following their application. Of particular interest to the anesthesia professional, these extensions can cause lagophthalmos, or incomplete closure of the eye during sleep, which can lead to increased corneal exposure and dryness, collection of bacteria under the lash bed causing microbial infection, and constraints to physical hygiene and cleansing of the lid which can lead to infection and blepharitis.[8] Corneal



injury is cited to be the most common ophthalmic complication during the perioperative period, specifically for patients undergoing general anesthesia.[9] Corneal abrasions and exposure keratopathies are secondary to inadequate closure of the eyelids during anesthesia, and the lagophthalmos caused by eyelash extensions can exacerbate these complications. Furthermore, misdirection of lashes falling into the eye can also increase the risk of corneal injury.

Ideally, eyelashes should be removed prior to surgery. When eyelashes cannot be removed, an increased risk of corneal abrasions, infection, and inadvertent removal of lashes should be disclosed. Intraoperatively, a soft, oval eye pad can be placed across the eyelid with tape placed in a horizontal (preferred) or vertical manner from brow to zygomatic arch, which may avoid direct adhesive contact to the eyelashes, causing unintentional removal. Ocular lubricants can also be used to help prevent dehydration. Vigilance during intraoperative eye checks is paramount, particularly if head or neck positioning changes occur.

ORAL AND FACIAL PIERCINGS AND AIRWAY COMPROMISE

There are numerous potential and actual hazards of mouth, tongue, and nose piercings including unintentional dislodgement, airway obstruction, or reactivity including a published case report of a missing nose stud that was eventually found near the patient's head but had the potential to have been displaced into the airway.[10] More concerning, another case report described a case of laryngospasm caused by oropharyngeal bleeding secondary to a tear adjacent to a tongue stud.[11]

A thorough preoperative assessment of the presence and type of foreign bodies should include piercings. Theoretical and documented risks of these piercings include tongue injury and laceration, infection, bleeding, dental injury, piercing dislodgement, nerve injury, aspiration, pressure necrosis injury, and death. Recognize that while patients may agree to remove metal studs after these risks are detailed, there has been a trend to replace a metal stud with a radiolucent bar to maintain the hole patency—potentially posing a challenge to see or locate should it become displaced.[12] Additionally, while the notion of utilizing neuraxial or regional techniques (such as in the case of laboring parturients or orthopedic procedures) to avoid general anesthesia may seem to pose less of a risk, the need to emergently convert to a general anesthetic is always possible and may potentiate the risks associated with *in situ* jewelry.[13-15]

PERMANENT JEWELRY AND BURN RISKS

Electrocautery use in the operating room requires a return plate for the electrosurgical unit, serving as a low-resistance pathway for the energy to return safely to the apparatus. In the rare case that the pad is not adhered appropriately, dislodged, or has dried electrolyte gel, patient jewelry or piercings could act as a return pathway and cause a burn.[16] While many perioperative protocols require the removal of metal jewelry prior to surgeries using electrocautery, little is known about the risk of burns to patients,

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Preoperative Assessment of Cosmetic Enhancements May Improve Patient Safety

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though the risk is thought to be relatively small.[17,18] The Association of Perioperative Registered Nurses recommends removing metal piercings if they are between the active electrode (i.e., Bovie tip) and the grounding pad[19] Removal of jewelry is a reliable method to eliminate the risk, but may not always be possible. Taping jewelry, believed to insulate metal jewelry from contacting other electroconductive material, has not been proven to affect the risk of site burns though may reduce the risk of losing the personal item.[16]

Permanent jewelry is a recent trend gaining popularity due in part to social media platforms. Though a relatively niche service, permanent jewelry entails a custom-fit solid gold or silver bracelet, anklet, or necklace and requires an expert welder to "zap" (refers to the flash you see when a jewelry piece is welded) the two ends together. These delicate chains can be accessorized with mini charms such as natural gemstones, diamonds, or gold drops and often have sentimental value to the wearer.

Permanent jewelry can be removed by carefully cutting the chain with scissors at the small ring that connects the two ends of the chain to maintain the integrity of the chain, such that it can be re-welded should the user so desire. Ideally, permanent jewelry should be removed prior to scheduled surgery and included in preoperative instructions. If jewelry cannot be removed, potential adverse events (including burn, edema causing compressive injury, or item dislodgement) should be disclosed to the patient and documented. When possible, alternative technologies (i.e., bipolar instead of monopolar electrosurgery) should be employed, and care should be taken to prevent contact between the patient and metal objects. Postoperatively, all jewelry sites should be assessed for evidence of injury.

NAIL POLISH, GEL MANICURES, AND PULSE OXIMETRY

Pulse oximetry helps to measure functional oxygen saturation in arterial blood by examining the difference in absorbance at two wavelengths, 660 and 940 nm. Any factors that increase the difference in absorbance between the two wavelengths will cause the pulse oximeter to falsely indicate desaturation. Spectrophotometric evidence yields that both green and blue nail polish increase absorbance at 660 nm as compared to 940 nm and can "trick" the sensor into indicating desaturation, which could lead to unnecessary interventions in the operating room.[20] More recently, gel-based manicures have gained favor by extending the life of a manicure, utilizing polymerized acrylate monomers that decrease chipping and scratching. These types of manicures can result in a statistically significant increase from baseline SpO_2 readings, most notably with orange and light blue colors, suggesting that nail polish could result in an anesthesia professional's overestimation of the actual oxygen saturation subsequently delaying or even failing to detect hypoxemia altogether.[21] As such, it may be prudent to routinely request polish removal prior to surgery. In the event patients are unable to comply with this request, alternative pulse oximetry probe locations or even simply turning the probe 90 degrees so as to avoid the painted nail bed may be warranted (Figure 1).

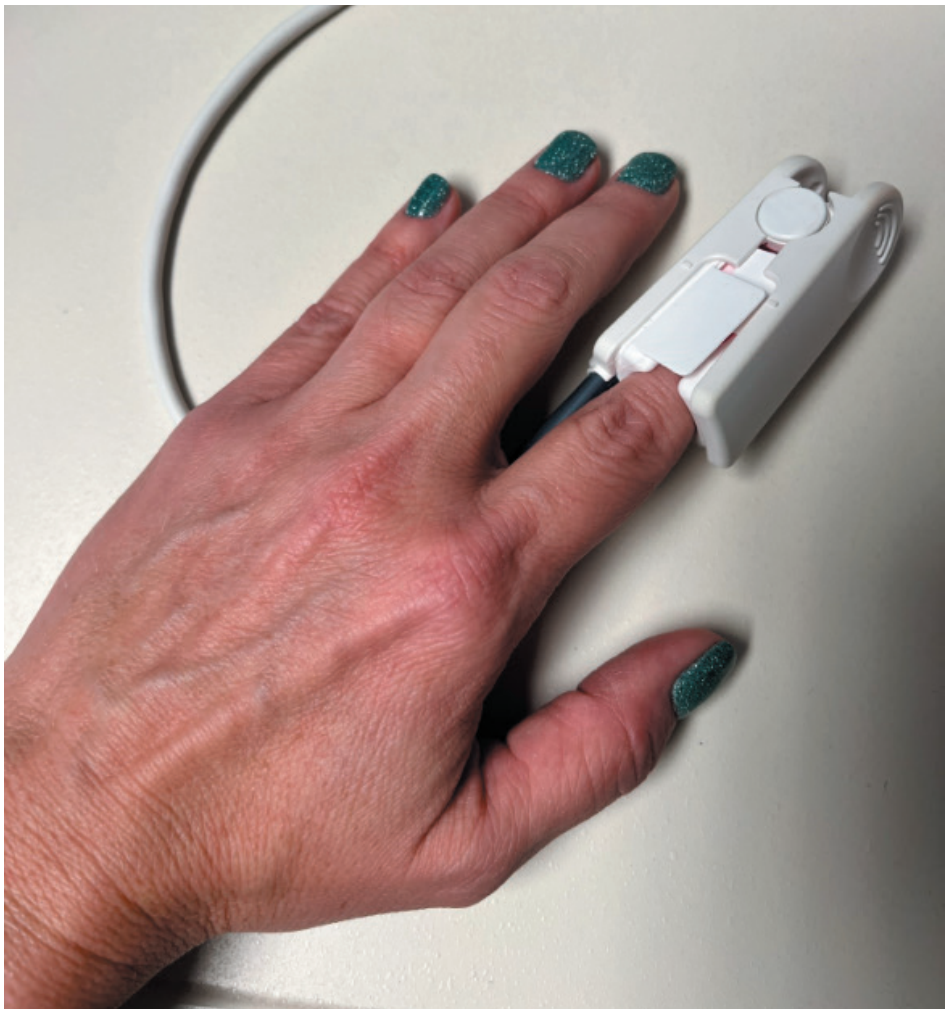

Figure 1. Alternative placement of a pulse oximetry probe on the finger with 90-degree rotation to avoid green nail polish interference.

FACILITATING DISCLOSURE

Cosmetic enhancements can affect the planning and execution of anesthetic delivery both inside and outside of the operating room. The risks these procedures pose to patients should be formally discussed in the informed consent process.

Anesthesia professionals may not be comfortable broaching these topics or feel inadequately suited to ask questions regarding cosmetic enhancements in the preoperative setting, but there are resources to help clinicians discuss sensitive topics with patients. The goal is to improve communication by decreasing patient and physician anxiety, thereby increasing the accuracy and specificity of patient self-reporting.[22] Three essential factors affect the reliability and validity of self-report:

1. The clinician's own anxiety may result in avoidance of inquiry about these topics. Recognizing the anesthetic implications of these cosmetic procedures is vital to understanding and identifying any potential safety concerns.

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2. The patient's anxiety about disclosing, particularly in the perioperative setting without established patient-physician relationships or due to family member presence, may prohibit disclosure. While patients have become more transparent and comfortable with disclosing personal information, it may be beneficial to include the potential liabilities associated with these cosmetic enhancements on informed consent, which the patient can read privately. The perioperative setting can be particularly challenging to navigate these discussions with time-pressure demands, elevated noise levels, and little-to-no privacy.
3. The "how" of asking questions, including reconsidering the wording, order, and form of questions, can affect the accuracy of obtained information. Where many health care professionals have been trained to ask open-ended questions in medical history-taking, it is ideal to ask more closed-ended questions, such as "Have you had any recent cosmetic procedures?" or "Do you have any nail polish, jewelry, or metal studs?" Be sure to ask for specific facts about neurotoxins, the location of piercings, etc.

CONCLUSION

Anesthesia professionals should be knowledgeable of the implications of non-surgical cosmetic procedures. Performing a thorough yet sensitive preoperative assessment, offering informed disclosure of potential adverse events, and promoting vigilance throughout the perioperative environment mitigates the risks from cosmetic procedures and thereby reinforces the anesthesia professional's role as the advocate for patient safety.

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REFERENCES

1. Plastic surgery statistics. American Society of Plastic Surgeons. https://www.plasticsurgery.org/news/plastic-surgery-statistics. Accessed October 30, 2023.
2. Ward SJ, Harrop-Griffiths W. Botox injections and monitoring neuromuscular blockade. *Anaesthesia*. 2006;61:726. PMID: 16792640.
3. Miller L, Neustein S. Neuromuscular blockade monitoring complicated by the unknown preoperative cosmetic use of botulinum toxin. *Anesthesiology*. 2006;105:862. doi: 10.1097/00000542-200610000-00049
4. Cross C. Botox injections and monitoring neuromuscular blockade—a reminder. *Anaesthesia*. 2016;71:732. PMID: 27159003.
5. Kuczkowski, K. Botox and obstetric anesthesia: is there cause for concern? 11AP1-1. *Eur J Anaesth*. 2007;24:139. https://journals.lww.com/ejanaesthesiology/citation/2007/06001/botox_and_obstetric_anesthesia__is_there_cause_for.518.aspx. Accessed December 15, 2023.
6. Le NK, Liauw D, Siddiqui SZ, Donohue KM. Assessment of neuromuscular function in patients with prior cosmetic procedures: a case report. *Eplasty*. 2019;19:e20. eCollection 2019. PMID: 31885763.
7. Thilen SR, Weigel WA, Todd MM, et al. 2023 American Society of Anesthesiologists practice guidelines for monitoring and antagonism of neuromuscular blockade: a report by the American Society of Anesthesiologists Task Force on neuromuscular blockade. *Anesthesiology.* 2023;138:13–41. PMID: 36520073.
8. Masud M, Moshirfar M, Shah TJ, et al. Eyelid cosmetic enhancements and their associated ocular adverse effects. *Med Hypothesis Discov Innov Ophthalmol.* 2019;8:96–103. PMID: 31263720.
9. A case report from the anesthesia incident reporting system. *ASA Newsletter.* 2014;78:44–45. https://pubs.asahq.org/monitor/article/80/7/44/3270/Case-Report-From-the-Anesthesia-Incident-Reporting. Accessed October 15, 2023.
10. Girgis Y. Hypoxia caused by body piercing. *Anaesthesia.* 2000;55:413. PMID: 10781175.
11. Wise H. Hypoxia caused by body piercing. *Anaesthesia.* 1999;54:1129. PMID: 10540120.
12. Pandit JJ. Potential hazards of radiolucent body art in the tongue. *Anesth Analg*. 2000;91:1564–1565. PMID: 11094027.
13. Mandabach MG, McCann DA, Thompson GE. Tongue rings: just say no. *Anesthesiology.* 1998;89:1279–1280 PMID: 9822025.
14. Rapid response: anaesthetic concerns in patients with pierced tongues. *BMJ.* 1999;319:1627. doi: 10.1136/bmj.319.7225.1627.
15. Kuczkowski KM, Benumof JL. Tongue piercing and obstetric anesthesia: is there cause for concern? *J Clin Anesth.* 2002;14:447–448. PMID: 12393114.
16. Body piercing and electrocautery risks. *Anesthesia Patient Safety Foundation.* https://www.apsf.org/article/body-piercing-and-electrocautery-risks/. Accessed October 30, 2023.
17. Blumenstein N, Wickemeyer J, Rubenfeld A. Bringing to light the risk of burns from retained metal jewelry piercings during electrosurgery—torching the myth. *JAMA Surg.* 2022;157:455–456. PMID: 35234844.
18. Deml MC, Goost H, Schyma C, et al. Thermic effect on metal body piercing by electrosurgery: an *ex vivo* study on pig skin and bovine liver. *Technol Health Care*. 2018;26:239–247. PMID: 29286941.
19. Guideline quick view: electrosurgical safety. *AORN J.* 2020;112:430–434. doi: 10.1002/aorn.13421
20. Coté CJ, Goldstein EA, Fuchsman WH, Hoaglin DC. The effect of nail polish on pulse oximetry. *Anesth Analg.* 1988;67:683–686. PMID: 3382042.
21. Yek JLJ, Abdullah HR, Goh JPS, Chan YW. The effects of gel-based manicure on pulse oximetry. *Singapore Med J.* 2019;60:432–435. PMID: 30854571.
22. McBride R. Talking to patients about sensitive topics: communication and screening techniques for increasing the reliability of patient self-report. *MedEdPORTAL*. 2012;8:9089. doi: 10.15766/mep_2374-8265.9089

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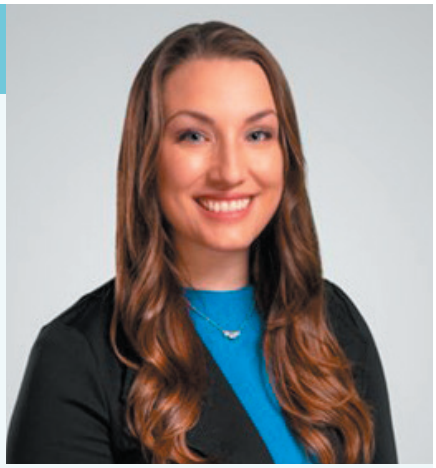
The APSF is eager to connect with patient safety enthusiasts across the internet on our social media platforms. Over the past year, we have made a concerted effort to grow our audience and identify the best content for our community. We've seen increases in followers and engagement by several thousand percent, and we hope to see that trajectory continue into 2024. Please follow us on Facebook at https://www.facebook.com/APSForg/ and on Twitter at https://twitter.com/APSForg. Also, connect with us on Linked In at https://www.linkedin.com/company/anesthesia-patient-safety-foundation-apsf-. We want to hear from you, so please tag us to share your patient-safety-related work, including your academic articles and presentations. We'll share those highlights with our community. If you are interested in joining our efforts to amplify the reach of APSF across the internet by becoming an Ambassador, please reach out via email to Emily Methangkool, MD, the APSF Ambassador Program Director at methangkool@apsf.org, or Amy Pearson, Director of Digital Strategy and Social Media at pearson@apsf.org. *We look forward to seeing you online!*



Amy Pearson, MD, APSF Director of Digital Strategy and Social Media.

SPOTLIGHT on Legacy Society Members

Drs. Michael and Georgia Olympio

My first anesthesia "machine" failure made a dramatic presentation when we had to induce general anesthesia for a patient who became ischemic after carotid cross-clamping. My student could not ventilate the now-intubated patient. Were it not for sudden astonishment leading me to action (while aggressively trying to ventilate, the bag and a cork flew off the bag-arm), our patient might have been severely harmed!

A single dramatic event can trigger a lifetime commitment to patient safety; for me it pertained to technology, and there was no better organization than the APSF to foster a passion for the understanding, application, teaching, and troubleshooting of anesthesia technologies to improve patient safety. While serving as chair of the Committee on Technology, my team endeavored to bring clinicians and industry engineers together for the benefit of patients, by promoting respectful critiques of technical safety issues through the ever-popular *Dear SIRS* (now *RAPID Response*) column in the *Newsletter*.

Without the unwavering support and love from my wife, Dr. Georgia K. Olympio, I could not have dedicated the time that I did to the APSF, and to my education roles at ASA and Wake Forest School of Medicine. Together, we shared the joy and camaraderie of working and associating with the finest anesthesia safety experts. Now, even in the earliest years of our retirement, we feel compelled to pledge Legacy support for the vision of APSF: "That no one shall be harmed by anesthesia care." Please join us in supporting this remarkable foundation!

Steve Sanford

As the former CEO of Preferred Physicians Medical (PPM), a leading insurer of anesthesia practices across the country, our collaboration with the Anesthesia Patient Safety Foundation has been a cornerstone of our success as an anesthesia-only insurance provider. As a corporate contributor for well over 20 years, our financial support of APSF is just one measure of PPM's shared vision regarding the importance of patient safety. In addition, I served for 11 years on both the APSF Executive Committee and the APSF Board of Directors. In that capacity, I saw first-hand the important work of the APSF and had the privilege of working alongside many of the "giants" in the anesthesia patient safety movement. PPM's unique access to anesthesia loss data allowed us to help identify emerging loss trends, contribute timely articles to the *APSF Newsletter,* and in several meaningful ways we were able to have a meaningful impact on patient safety via our partnership with APSF. Our collaboration on postoperative vision loss following spinal surgery, for example, demonstrated our ability to quickly provide patient safety guidance in response to an emerging loss trend and, together with the APSF, alter the anesthesia landscape. This more proactive approach to patient safety was only possible because industry stakeholders are welcomed stakeholders in the anesthesia patient safety movement.

For me, my personal involvement in the APSF allowed me to reimagine the traditional insurance industry view of risk management and reorganize our efforts around providing meaningful patient safety guidance to both our member insureds as well as the larger anesthesia community. This change, more than any other, helped transform PPM as an organization and in turn had a dramatic impact on our success in the insurance marketplace. For this reason, I am delighted to lend my personal support toward continuing the mission of the APSF via the APSF Legacy Society.

An abiding belief in safeguarding the future of anesthesiology.

Established in 2019, the ***APSF Legacy Society*** honors those who make a gift to the foundation through their estates, wills, or trusts, thus ensuring that patient safety research and education will continue on behalf of the profession about which we are so deeply passionate.

APSF recognizes and thanks these inaugural members who have generously supported APSF through an estate or legacy gift.

For more information about planned giving, please contact Sara Moser, APSF Director of Development at: moser@apsf.org.

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