THE EDITOR’S DESK

Science and Clinical Potpourri for Your Life and Your Practice

Frailty and Cognitive Impairment—A Bad Combination

*J Am Coll Surgeons.* 2017;225:590.

The concept of measuring and appreciating the effects of frailty on patients we care for is growing. In fact the AANA Journal has an upcoming Journal Course on the topic. We know that frailty and cognition deficiencies have independent associations with poor long-term surgical outcomes. In this study of more than 300 patients it was found that overall long-term surgical mortality was 12% for fit patients (defined as no cognitive deficit and no frailty), 13% for those presenting with only cognitive impairment, 25% with only frailty, and over 40% in those who were both frail and cognitively impaired. The combined association (though not able to define cause and effect at this time) seems compelling. We should all be vigilant in assessing our patients preoperative to the extent that we can. Some issues with frailty and with cognitive impairment may be treatable or might be improved upon if we are aware of them.

Music Therapy in the Postop Period

*Lancet.* 2015;386:1659

From time to time we see many anecdotal reports in the literature about music therapy and its effect on anesthetic and surgical management. There are, however, a large number of randomized trials that have been performed in the domain. The beauties of music (besides it being beautiful!) are that it does not involve an invasive intervention, is safe, has minimal cost, and can be administered to the patient with ease.

These authors compiled the results of 73 RCTs that all measured selected indices that were combined in their meta-analysis. Music had a clinically and statistically significant effect in reducing both postoperative pain and postoperative anxiety, and decreased the amount of opiates and other pain relieving drugs. Overall patient satisfaction was boosted, as well. We all might be doing our patients a big favor by introducing music therapy as part of our perianesthetic plan of care. Perhaps we could start the ball rolling by having a discussion with our surgical co-workers about implanting a program in our own institutions.

Cloning Monkeys in China


Researchers in China have successfully produced two genetically identical macaques using what is known as somatic cell nuclear transfer (SCNT). If the technique sounds unfamiliar, you may recall the sheep named “Dolly” who was the first, formally reported cloned mammal. The cloning of “Dolly” used SCNT to achieve that end.

The cloning of the macaque monkeys, performed by workers at the Chinese Academy of Sciences’s Institute of Neuroscience in Shanghai, noted that their work will allow the creation of genetically identical monkeys for biomedical research. The use of the macaques in and of itself generates controversy, but now the addition of cloning potentially moves this to a new level of concern.

Earlier efforts to clone monkeys through SCNT produced embryos, but not viable babies, although a cloned rhesus monkey was created in 1999 through a simpler method called embryo splitting. In the more recent effort, the Chinese researchers used a set of enzymes that had not been tried previously. Out of 60 surrogate mothers only 2 baby macaques were born, a dismally low success rate, but nonetheless success in 2 cases. It should be noted that the only successes came with cells taken from fetal monkeys, as all those attempts using adult cells were unsuccessful.

Reading this leaves one to wonder if there are not labs (internationally) pursuing the cloning of high-order mammals (primates) but are being secretive about it. A host of moral and ethical issues abound in the area of cloning and time will tell how these play out.

Lowering the Blood Alcohol Limit for Driving?

*Science.* January, 2016

Evidence suggesting a lower threshold for blood alcohol concentration
from 0.08% to 0.05% is actively being promoted. The US National Academy of Sciences (NAS) based on compelling evidence, suggests that such a reduction would dramatically decrease driving related injuries and deaths. The evidence comes in part from a 2017 meta-analysis published in Alcoholism: Clinical & Experimental Research. The 11 studies including the analysis came from 6 non-U.S. countries and the state of Maine. The authors estimated that dropping the limit to 0.05% or lower resulted in an 11.1% decline in fatal alcohol-related crashes. The NAS authors, advocating for widespread adoption of the lower rate, wrote that both laboratory and epidemiological studies show that “an individual’s ability to operate a motor vehicle … begins to deteriorate at BAC levels well below 0.05%.” The same authors estimated that lowering the legal limit to 0.05% throughout the United States would save 1,790 lives each year. But the recommendations are not without critics who note the NAS is overreaching its authority and further argue that a 0.05% limit would ensnare tens of thousands of unimpaired drivers in the legal system and cast significant burden on personal lives.

The Fountain of Youth in a Mole Rat?

You may not have great familiarity with the mole rat, but this burrowing rodent with wrinkled, pink skin, has remarkable resiliency. Although an air breather, it can go for astonishing long periods (18 minutes) without oxygen. It also seems to possess anti-cancer properties. But of most recent interest is that it seems to defy aging; the most recent research notes that at advanced age, their rate of death is lower than any other currently studied mammal.

Part of the answer may lie in its ability to aggressively repair DNA and its high titer of chaperones (these are proteins that help other proteins configure/fold correctly). There is still a lot to learn, but rather than calling them ‘nonaging mammals’ let’s just say they seem to live well, and long, and may harbor some useful clues for us humans.

Hikers and Campers Beware: Giardiasis Can Make You Miserable!

We all seem to learn (some the hard way) that drinking from a stream, river, pond or lake can be bad for you. Although there may be many culprits, giardiasis stands out as a bug that can really take a toll on your GI system. Fatigue, bloating, cramping and severe, unremitting diarrhea can make you wish you’d brought tap or bottled water along instead of quenching your thirst from what appeared to be a pristine water source.

The giardia organism is like a microscopic Trojan horse. It literally mimics normal cells by releasing proteins that the body recognizes as looking just like the real deal, but instead, the GI track cell literally invites the invaders in and then pay a miserable price for doing so. The giardia house a surprisingly large number of proteins, at least two of which have the molecular capability of dismantling the protective mucus in the human GI tract, then eat through the cell lining and cause havoc. The giardia is so very successful in its assault on the human gut that for the usual cellular barriers are lost, other opportunistic bacterial species can move in, exacerbating what is already a nasty insult.

The epidemiology of giardia infection is such that over half a million people are afflicted each year, and while we think of it as backwoods affliction, the overwhelming majority of cases occur where sanitation is poor, usually in developing countries. Interestingly about half of the cases of giardia infections go relatively asymptomatic and may in part be explained by the resident species living in our GI tracts, that is our microbiome.

So, be careful not only on hiking and camping trips, but also when travelling, especially outside the country where water sources may be questionable. The researchers unlocking the mysteries of giardia infections hope to lead us on a path of improved prevention and treatment measures.
Perceived Knowledge and Attitudes of Certified Registered Nurse Anesthetists and Student Registered Nurse Anesthetists on Fire Risk Assessment During Time-out in the Operating Room

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Fire risk assessment remains separate from the universal protocol for surgical time-outs. A descriptive cross-sectional design was used to examine the perceived knowledge and attitudes of Certified Registered Nurse Anesthetists (CRNAs) and student registered nurse anesthetists (SRNAs) on fire risk assessment during surgical time-outs. Modified knowledge and attitudes questionnaires were sent to approximately 1,600 active members of the Illinois Association of Nurse Anesthetists through an online survey. Data were analyzed using descriptive, t-test, analysis of variance, and point biserial correlation statistics.

Most of the 140 study participants overwhelmingly reported positive attitudes toward fire risk assessment, but they had self-reported information needs in 11 areas of the operating room fire risk assessment questionnaire. Age, gender, years in practice, and highest education had no statistically significant correlation with knowledge and attitudes regarding fire risk assessment. The perceived knowledge deficits on fire risk assessment may hinder the CRNAs and SRNAs from adopting a tool such as a fire risk assessment checklist that is ready for implementation at their current place of employment. Additional studies are needed to identify the factors that facilitate integration of fire risk assessment using a checklist during surgical time-outs.

Keywords: Anesthesia providers, fire, operating room, safety, surgical time-outs.

Fires in the operating room (OR) are extremely rare but could be fatal.1 The estimated incidence of OR fires is 0.32 per 100,000 operations.2 A death or disability resulting from a burn incurred in the OR is a serious and costly event, which has been included in the Centers for Medicare and Medicaid Services’ (CMS) category of “never events”. CMS defined never events as clearly identifiable and highly preventable events that are deemed to be nonreimbursable, serious, hospital-acquired conditions.3 Because the consequences of a fire in the OR are dire, it is crucial to investigate the inclusion of fire risk assessment in the OR’s well-established universal protocol called surgical time-outs.4 In 2015, the ECRI (formerly Emergency Care Research Institute) has estimated a range from 200 to 240 OR fires occurring annually in the United States.5 The estimation of the actual number of OR fires is difficult to make because of lack of reporting. The rate of OR fires is comparable to other never events such as wrong-sided surgery and retained surgical instruments.5 Case studies of OR fires show the consequences can be devastating for patients and caregivers because of disfiguring burns, and some cases result in death. Research studies on OR fires, including root cause analyses, revealed that the causes of OR fires are largely preventable.6

In high-income countries, burns occur disproportionately to racial and ethnic minorities such that socioeconomic status—more than cultural or educational factors—accounts for most of the increased burn susceptibility and death and disability from a burn in the OR. Risk factors for fatal burns include those related to socioeconomic status, race and ethnicity, age, and gender, as well as those factors pertaining to region of residence, intent of injury, and comorbidity.3

The OR fire triad consists of 3 components that must be present for a fire to occur: an ignition source, an oxidizer, and fuel.7 In the OR, 3 separate people are usually responsible for each part of the fire triad. Typically, the surgeon is responsible for the ignition source, which is often an electrosurgical unit. The anesthesia provider is responsible for the oxidizer, in many cases oxygen. And the nursing staff is responsible for the fuel, which
includes drapes and dressings. The addition of fire risk assessment during the surgical time-out opens lines of communication among members of OR staff to discuss how fire can be avoided. Regardless of the area of responsibility, the entire team in the OR is responsible for the safety of the patient.

For many years, the aviation military has used checklists to ensure proper functioning of equipment and preparation of personnel. In the early days of aviation, the act of flying a plane was not complicated. However, the mechanics of aviation became increasingly complicated, necessitating a checklist for pilots to ensure they had performed all necessary checks and cross-checked the necessary steps for a safe flight. In line with the aviation industry’s successful use of checklists in preventing accidents, Haynes et al published a seminal study on the implementation of a surgical safety checklist; the result of this collaboration with the World Health Organization in the development and testing, was a 19-item checklist to be used by any team performing a surgery. The checklist was found to be an effective intervention in reducing the rate of inpatient complications from 11% to 7% (P ≤ .001) and reducing the death rate from 1.5% to 0.8% (P = .003) before and after implementation of the checklist, respectively. Haynes et al emphasized that the implementation of the surgical checklist, just as with any change in practice, required a change in practice culture at each institution in which it was implemented. Given the data on other surgical safety checklists and the potentially dire consequences of fire, checklists can make a notable difference in fire rates. Other studies have also shown the use of a checklist to be an effective tool in improving safety in the OR.

Currently, it is standard practice or universal protocol for all surgical team members to perform a time-out before any procedure or surgery. These time-outs occur at the bedside before a bedside procedure and in procedural areas such as hospital ORs and ambulatory surgical centers. Typical checks in the time-outs include, but are not limited to, patient name and birth date, team members and their role, correct procedure, correct surgical site, allergy information, and prophylactic antibiotics. These checks help prevent the occurrence of never events such as wrong-sided surgery and retained surgical instruments. Fire risk assessment can be added to the checklist for surgical time-outs to facilitate fire risk communication such as identification of potential sources of the fire triad and physical verification and verbalization of the nearest location of fire extinguishers among surgical team members. The knowledge and attitudes of anesthesia providers have not been previously studied as potential barriers to the adoption of fire risk assessment into the surgical time-out checklist.

To date, research studies examining the knowledge and attitudes on fire risk assessment during surgical time-outs among anesthesia providers have been lacking. This assessment of anesthesia providers’ knowledge and attitudinal barriers to fire risk assessment during surgical time addressed the current knowledge gap on why fire risk assessment is still not integrated into the checklist for surgical time-outs. An anonymous online survey was conducted with the following objectives:

1. To assess the perceived knowledge and attitudes of Certified Registered Nurse Anesthetists (CRNAs) and student registered nurse anesthetists (SRNAs) on fire risk assessment during time-outs.
2. To explore the association of sociodemographic factors with perceived knowledge or attitudes on fire risk assessment among CRNAs and SRNAs.

**Conceptual Framework**

Solberg’s theory of practice change guided the development of this study. Solberg posits that for new knowledge to result in practice change and improved patient care, the parties involved must buy into it. New knowledge must be accompanied by priority, change process capability, and care process content. Priority is defined as obtaining the basic knowledge, increasing change process capability, and enhancing the care process content. When all these 3 elements are combined, they create the potential for improvements in patient care.

One of the first steps to effecting change is the acquisition and sharing of new knowledge. Once the new knowledge is acquired, practice change can effectively begin. Knowledge acquisition can also help in providing a common understanding among all members involved in the improvement or practice change. When there is sufficient knowledge sharing, priority, capability to change, and care process content, improvements can then be made in the delivery of patient care. In this study, the data obtained from CRNAs and SRNAs pertaining to their current perceived knowledge and attitudes on fire risk assessment can serve as guides to the development of educational initiatives aimed at facilitating practice. The insights gained from this study were helpful in delineating the contents of educational initiatives, specifically meeting the adult learning needs of CRNAs’ and SRNAs’ knowledge gaps on fire risk assessment during surgical time-outs.

**Literature Review**

- **Culture of Safety in the Operating Room.** The American Society of Anesthesiologists (ASA) states that the fire triad, which consists of an oxidizer, an ignition source, and a fuel, must be present for fire to occur in the OR. Common oxidizers in the OR are oxygen and nitrous oxide. Fuel includes surgical drapes, gauze, dressings, and hair; and ignition sources include electrosurgical units such as cautery and lasers. Recent reports of OR fires made patient safety advocates more resolute to push
The culture of safety in the OR and current fire safety standards in the OR are central concepts to this study. Although CMS considers an OR fire an event that should never occur, there is currently no standard practice or universal protocol to address the various fire risks among members of the surgical care team. Operating room fires can happen even at the top-tier medical centers in the United States that have comprehensive fire prevention policies and procedures. Between 2009 and 2010, the Cleveland Clinic reported 6 OR fires resulting in 3 patient injuries. These OR fires were reported by Cleveland Clinic administrators to CMS officials during scheduled inspection visits to the Cleveland Clinic. Based on the recommendations from CMS officials, alcohol-based preparations, believed to be the cause of the fires, were removed from the ORs. Alcohol-based preparations have been previously found as fire risks in the OR.

The Association of periOperative Registered Nurses (AORN) has also published a guidance statement regarding fire in the OR. The AORN suggests performing OR fire drills to allow staff to practice the roles they would perform if an OR fire occurred. The AORN, in its guidance statement, emphasizes the importance of and need for education pertaining to fire safety in the OR for all members of the OR team.

The US Food and Drug Administration recommends fire safety practices for healthcare professionals in the OR. There is not, however, a standard of care for routine assessment of the existence of OR fire risk such as the use of a fire risk assessment checklist. There is a paucity of evidence in the literature regarding incorporation of fire risk assessment into the surgical time-out. Practice standards do not exist for OR fire risk assessment, although there are recommendations from industry and professional organizations.

Methods

• Study Design. This study used a descriptive, cross-sectional online survey designed to assess the perceived knowledge and attitudes of CRNAs and SRNAs regarding fire risk assessment during surgical time-outs.

• Sample. The participants in the study included CRNAs and SRNAs who are active members of the Illinois Association of Nurse Anesthetists (IANA), a member of the American Association of Nurse Anesthetists (AANA), the official and national professional organization of CRNAs and SRNAs in the United States. The AANA represents more than 50,000 CRNA and SRNA members nationwide. In a typical online survey, a 30% response rate could be expected, or 485 completed surveys of 1,600 sent, based on the systematic review by Cook et al on web- or Internet-based survey response rate. In this study, a power analysis estimated that a sample of 112 subjects (mean difference of 0.2; SD of 0.75) would have 80% power to detect statistically significant differences between dichotomous sociodemographic groups (eg, male or female) at the 0.05 α level (2-tailed test) using independent-samples t-test statistics.

• Setting. Members of IANA come from and work in various towns and cities in the entire state of Illinois (rural, suburban, and urban areas). Study participants completed the survey on any computer or mobile device of their choice. The sample is a good representative of the distribution of CRNAs around the state of Illinois.
• **Instruments.** The online survey (Qualtrics, Provo, Utah) containing 3 sections used a sociodemographic questionnaire, assessment of perceived knowledge, and assessment of attitudes related to fire risk assessment during time-outs. Sociodemographic information included gender, age, ethnicity, education, and years of work experience. The second part of the online questionnaire was essentially a needs assessment inquiring about the current clinical practice of integrating fire risk assessment into surgical time-outs. Participants wrote their answers as free text.

Overall, the online survey had 22 questions that included 5 on demographic information, 5 attitudinal questions, and 12 questions relating to OR fire safety perceived knowledge. On average, it took less than 15 minutes for the study participants to complete the online survey. The perceived knowledge and attitudes questions used in this study were modified from the original questionnaire developed by Upton and Upton\(^3\) and modified to fit the context of the current study. The original questionnaire was validated and found to have a high reliability \(\alpha\) coefficient with a Cronbach \(\alpha\) of 0.87 when tested among a population of 500 nurses from the United Kingdom.\(^3\)

Minor modifications of the questionnaire’s items were reviewed by 2 research faculty members with a doctor of philosophy and a faculty member with a doctor of nursing practice (DNP) degree and expertise in nurse anesthesia. Each item in the questionnaire was checked for clarity, simplicity, accuracy, and relevancy for this current study. The Cronbach \(\alpha\) for the perceived knowledge and attitudes components of the online survey tool was 0.896, indicating good reliability of the modified instrument used for this current study.

• **Recruitment and Data Collection Procedures.** The target population of CRNAs and SRNAs was approached via recruitment email distributed by the IANA. An email was sent to members of the IANA containing an information sheet that included the purpose of the study, information about privacy, rights of study participants, ability to cease participation in the study without penalty, and information regarding how to reach the investigators. Consent to participate in the study was implied by completing the online study. Participation was anonymous and voluntary.

• **Analytic Procedure.** Statistical analysis software\(^3\) was used to conduct data analyses. Descriptive statistics using means, standard deviation, frequencies, and percentages were used to analyze the data on perceived knowledge and attitudes of the study participants regarding OR fire risk assessment during surgical time-outs. The underlying hypothesis of this study states that there is no difference in the perceived knowledge level and attitudes means of 3 or more groups. Point biserial correlation statistics (a special case of Pearson \(r\)) was used to explore possible associations between attitudes or perceived knowledge mean scores and dichotomous categorical variables such as gender (male and female) and 2 age groupings (20-49 years of age and 50 years and above). Correlations were explored whether gender and age had any associations with perceived knowledge and attitudes on fire risk assessment that may directly or indirectly influence or serve as barriers to fire risk assessment integration into the surgical time-out.

• **Human Subject Protections.** This study received institutional review board approval from DePaul University, Chicago, Illinois. The questionnaires did not contain any personal identifiable information. Data were collected online, and all printed records were kept in a locked cabinet located in a locked and secured room of the principal investigator (K.C.). Any electronic records were kept on a computer that was always password-protected. There were no direct benefits for the study participants for their participation on this research project.

### Results

• **Study Participants.** A total of 140 participants’ complet-

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>91 (65.0)</td>
</tr>
<tr>
<td>Male</td>
<td>48 (35.0)</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
</tr>
<tr>
<td>60 and above</td>
<td>29 (20.7)</td>
</tr>
<tr>
<td>50-59</td>
<td>42 (30.0)</td>
</tr>
<tr>
<td>40-49</td>
<td>25 (27.9)</td>
</tr>
<tr>
<td>30-39</td>
<td>25 (17.8)</td>
</tr>
<tr>
<td>20-29</td>
<td>5 (3.6)</td>
</tr>
<tr>
<td>Race-ethnicity</td>
<td></td>
</tr>
<tr>
<td>Mixed race</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>3 (2.2)</td>
</tr>
<tr>
<td>Black/African American</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>2 (1.5)</td>
</tr>
<tr>
<td>White</td>
<td>131 (94.2)</td>
</tr>
<tr>
<td>Years of experience</td>
<td></td>
</tr>
<tr>
<td>&gt; 20 years</td>
<td>63 (45.0)</td>
</tr>
<tr>
<td>11-20 years</td>
<td>33 (23.6)</td>
</tr>
<tr>
<td>6-10 years</td>
<td>23 (16.4)</td>
</tr>
<tr>
<td>0-5 years</td>
<td>21 (15.0)</td>
</tr>
<tr>
<td>Level of education</td>
<td></td>
</tr>
<tr>
<td>Associate or baccalaureate</td>
<td>24 (17.1)</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>97 (69.3)</td>
</tr>
<tr>
<td>Doctorate: DNP, PhD</td>
<td>19 (13.6)</td>
</tr>
</tbody>
</table>

Table 1. Sociodemographic Characteristics of Study Participants (N = 140)
ed surveys were used for analysis, with an overall online survey response rate of 10.3%. Despite the low survey response rate, the target sample size of 112 was reached with more than 80% power to detect statistical differences in dichotomous groupings of sociodemographic variables. The sociodemographic characteristics of the study participants are described in frequencies and cumulative frequencies in Table 1. Among study participants, most had graduate degrees, with 69.3% (n = 97) holding a master's degree and 13.6% (n = 19) having a doctoral degree.

**Perceived Knowledge and Attitudes on Fire Risk Assessment**

The mean scores of the study participants were positive. Table 2 shows the mean scores of each item on the attitudes scale. The first 5 questions assessed the study participants’ attitudes toward fire risk assessment during time-outs. For the attitudinal questions, a Likert-type scale was used for the responses to the questions as follows: (1) strongly agree, (2) agree, (3) neutral, (4) disagree, and (5) strongly disagree. The item with the highest positive attitudes mean score was the item “Fire risk assessment during time-outs is a waste of my time” (mean = 4.39; SD = 0.826). The attitudes item with the lowest mean score indicating a negative attitude was the item “I stick to tried and trusted methods on fire risk assessment but not during time-outs” (mean = 3.91; SD = 1.108).

The study participants were asked to answer questions assessing their perceived knowledge related to fire risk assessment during surgical time-outs as outlined in Table 3. For these perceived knowledge assessment items, the following Likert-type scale was used: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. For the perceived knowledge-based questions, a higher mean was associated with more perceived knowledge regarding fire risk assessment during surgical time-outs. The item with the highest mean score was the item “I am able to determine how useful fire risk assessment during time-outs is to clinical practice” (mean = 4.11; SD = 0.691). The item with the lowest mean score indicating perceived knowledge deficit on new ideas related to fire risk was the item “I disseminate new ideas related to fire risk assessment during time-outs with my colleagues” (mean = 2.99; SD = 1.299). Most (n = 139; 99%) of participants’ perceived knowledge and ability to

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**Table 2. Mean Scores on Fire Risk Assessment Attitudes Scale**

<table>
<thead>
<tr>
<th>Questionnaire item</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>My workload is too heavy, so I don't have time for fire risk assessment during time-outs.</td>
<td>4.36</td>
<td>0.743</td>
</tr>
<tr>
<td>I don't believe fire risk assessment is necessary during time-outs for nurse anesthesia practice.</td>
<td>4.30</td>
<td>0.996</td>
</tr>
<tr>
<td>I resent having continuing education on fire risk assessment in relation to time-outs.</td>
<td>4.18</td>
<td>0.898</td>
</tr>
<tr>
<td>Fire risk assessment during time-outs is a waste of my time.</td>
<td>4.39\textsuperscript{b}</td>
<td>0.826</td>
</tr>
<tr>
<td>I stick to tried and trusted methods on fire risk assessment but not during time-outs.</td>
<td>3.91\textsuperscript{c}</td>
<td>1.108</td>
</tr>
</tbody>
</table>

\textsuperscript{a}1 = strongly agree; 5 = strongly disagree.  
\textsuperscript{b}Highest mean score.  
\textsuperscript{c}Lowest mean score.

**Table 3. Mean Scores on Fire Risk Assessment Knowledge Scale**

<table>
<thead>
<tr>
<th>Questionnaire item</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My research skills in obtaining information on fire risk assessment during time-outs is:</td>
<td>3.55\textsuperscript{b}</td>
<td>0.911</td>
</tr>
<tr>
<td>2. My information technology (IT) skills related to fire risk assessment during time-outs is:</td>
<td>3.42\textsuperscript{b}</td>
<td>0.883</td>
</tr>
<tr>
<td>3. I monitor and review the current standards on fire risk assessment during time-outs.</td>
<td>3.49\textsuperscript{b}</td>
<td>1.281</td>
</tr>
<tr>
<td>4. I know how to meet my information needs on fire risk assessment during time-outs.</td>
<td>3.91</td>
<td>0.920</td>
</tr>
<tr>
<td>5. I am aware of major information types and sources related to fire risk assessment during time-outs.</td>
<td>3.76</td>
<td>0.974</td>
</tr>
<tr>
<td>6. I am able to identify gaps in my professional practice pertaining to fire risk assessment during time-outs.</td>
<td>3.80</td>
<td>0.824</td>
</tr>
<tr>
<td>7. I am knowledgeable on how to retrieve information on fire risk assessment during time-outs.</td>
<td>3.98</td>
<td>0.766</td>
</tr>
<tr>
<td>8. I am able to critically analyze the set standards for fire risk assessment during time-outs.</td>
<td>3.92</td>
<td>0.816</td>
</tr>
<tr>
<td>9. I am able to determine how valid (close to the truth) are the data related to fire risk assessment during time-outs.</td>
<td>3.88</td>
<td>0.742</td>
</tr>
<tr>
<td>10. I am able to determine how useful fire risk assessment during time-outs is to clinical practice:</td>
<td>4.11\textsuperscript{c}</td>
<td>0.691</td>
</tr>
<tr>
<td>11. I share ideas and information on fire risk assessment during time-outs with my colleagues.</td>
<td>3.48\textsuperscript{b}</td>
<td>1.245</td>
</tr>
<tr>
<td>12. I disseminate new ideas related to fire risk assessment during time-outs with my colleagues.</td>
<td>2.99\textsuperscript{b}</td>
<td>1.299</td>
</tr>
</tbody>
</table>

\textsuperscript{a}1 = strongly disagree; 5 = strongly agree.  
\textsuperscript{b}Lowest mean scores.  
\textsuperscript{c}Highest mean score.
retrieve perceived knowledge on fire risk assessment was not adequate, with 11 of 12 items in the perceived knowledge subscale having a mean score below 4. This score was considered only adequate if the responses were 4 = agree or higher at 5 = strongly agree. The valents of the anchors for perceived knowledge and attitudes questionnaires were intentionally reversed to reduce or eliminate acquiescence leading to a ceiling effect, which makes data interpretation later vague and less meaningful.

• **Association of Sociodemographic Variables With Perceived Knowledge and Attitudes.** The ages of the study participants were divided into 2 groups: those who were between the ages of 20 and 49 years and those who were 50 years of age and older. This grouping was done to conduct statistically powered comparison to detect meaningful differences in mean scores in perceived knowledge and attitudes. The mean scores of participants’ attitudes toward fire risk assessment during time-outs were analyzed using independent-samples *t* test. There was no statistically significant difference in the attitudes regarding fire risk assessment during time-outs between the 2 age groups (*t* = −0.738; *P* = .462) and by gender (male and female participants, *t* = −0.961; *P* = .338). Regarding the mean scores on perceived knowledge related to fire risk assessment during time-outs, there was also no statistically significant difference in the study participants’ perceived knowledge of fire risk assessment during time-outs by age groups (*t* = 1.093; *P* = .276). Details of all statistical *t*-test analyses for differences in mean scores in perceived knowledge and attitudes by dichotomous groupings of age and gender and their correlation statistics are reported in Tables 4 and 5, respectively.

An ANOVA was performed to compare the means of 3 or more groupings of study participants by educational level and years of clinical experience (Table 6). The ANOVA revealed that there was no statistically significant difference in perceived knowledge or attitudes mean scores on fire risk assessment during surgical

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation statistic</th>
<th>Mean score for attitudes</th>
<th>Mean score for knowledge</th>
<th>Gender</th>
</tr>
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<td>Point biserial correlation</td>
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<tr>
<td>Years of clinical experience</td>
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<td>.727</td>
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<tr>
<td>Educational level</td>
<td>Point biserial correlation</td>
<td>0.122</td>
<td>1</td>
<td>.150</td>
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</table>

Table 5. Correlation of Knowledge and Attitudes on Fire Risk Assessment With Sociodemographic Variables (N = 140)

No statistically significant correlation was found between sociodemographic variables such as gender, years of experience, and educational levels with mean scores in knowledge and attitudes on fire risk assessment.
time-outs among study participants with varying levels of experience or different levels of education. The study sample was homogeneous with respect to ethnicity, so no inferential test statistics were performed for this variable. A t test was performed for 2 groupings of gender and age range differences of the sociodemographic variables, but no statistically significant differences in the mean score for perceived knowledge and attitudes were observed.

**Discussion**

To our knowledge, this is the first study that assessed the perceived knowledge and attitudes of CRNAs and SRNAs regarding fire risk assessment during surgical time-outs. The attitudes across all study participants were positive, with a mean score of 4.23 of 5. This is consistent with other recent reports on perioperative nurses’ positive attitudes toward the use of a checklist in the OR, which has been perceived by nurses as an effective tool in averting an error, improving surgical team communication, and reducing complications and morbidity.34 A recent study from Brazil also reported that 470 members of the surgical teams, including most nurse technicians, have positive attitudes toward acceptance of checklist use in the OR. However, surgeons have been found to have negative attitudes toward checklist use and acceptance in the OR.35 The anchors for the Likert-type questionnaires were intentionally varied from perceived knowledge items to attitudes items to prevent a ceiling effect.

The mean scores of perceived knowledge on OR fire assessment across all sociodemographic groups were not statistically significant between or within various groupings based on age, gender, years of clinical experience, and levels of education. It remains unclear what role perceived knowledge deficits or negative attitudes on OR fire risk assessment play in the lack of adoption of standard procedure on fire risk assessment, which is just a quick and easy use of a fire risk checklist in the OR during surgical time-outs. Assessment of perceived knowledge, attitudes, skills, motives, and barriers are fundamental steps toward changing the culture of practice on OR patient safety.

The perceived informational deficits on fire risk assessment could hinder the formal development of an OR fire risk checklist that is “shovel ready” for integration into the surgical time-outs as part of the universal protocol at anesthesia providers’ local place of employment. This study also revealed that CRNAs and SRNAs perceived a lack of knowledge about new ideas for disseminating fire risk assessment during time-outs. These informational needs reported by CRNAs and SRNAs can be addressed by new educational initiatives or continuing education credits directed toward preventing OR fires and improving patient safety. Hospital administrators and nursing leaders must continue to assess knowledge deficits (actual and perceived) pertaining to OR patient safety and safe working environment for all surgical team members. Time is a scarce resource among surgical team members. Innovative approaches such as online, web-based on-demand availability of education and training modules on OR fire risk assessment for surgical team members should be developed.

For successful implementation of change in clinical practice, there must be buy-in from key players as posited by Solberg.10 A recent review of the literature on checklist use and successful checklist implementation emphasized the importance of enlisting institutional leaders as local champions, incorporating staff feedback for checklist adaptation, and reduction of any redundancy in the overall checklist procedures,36 particularly in resource-limited settings in developing countries.37 A similar review article also reported that adequate education and training are needed for successful checklist implementation,

<table>
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<th>Comparison</th>
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<th>F</th>
<th>P value</th>
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<tr>
<td>Attitudes mean score by years of clinical experience</td>
<td>Between groups</td>
<td>3</td>
<td>1.221</td>
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<tr>
<td>Within groups</td>
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<td></td>
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<td>Attitudes mean score by educational level</td>
<td>Between groups</td>
<td>2</td>
<td>.369</td>
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<tr>
<td>Within groups</td>
<td>137</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge mean score by years of clinical experience</td>
<td>Between groups</td>
<td>3</td>
<td>.177</td>
</tr>
<tr>
<td>Within groups</td>
<td>136</td>
<td></td>
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</tr>
<tr>
<td>Knowledge mean score by educational level</td>
<td>Between groups</td>
<td>2</td>
<td>2.032</td>
</tr>
<tr>
<td>Within groups</td>
<td>137</td>
<td></td>
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</tbody>
</table>

Table 6. Analysis of Variance Comparing Mean Scores in Attitudes and Knowledge on Fire Risk Assessment Based on 3 of 4 Sociodemographic Groupings by Education Level and Years of Clinical Experience

*No statistical difference was found in the mean scores for attitudes and knowledge between and within 3 or more groups based on educational level or years of clinical experience.*
which is a key driver to checklist effectiveness in improving surgical patient outcomes.38

The findings from this study underscore information needs of the CRNAs and SRNAs and uncover the lack of a standard procedure in the use of fire risk assessment checklist during surgical time-outs. A simple, but comprehensive, validated, and reliable OR fire risk assessment checklist could potentially identify the fire risk factors, improve communication of fire risks among surgical team members, and prevent the occurrence of never events such as patient burn or death due to OR fires.8,9 Because CRNAs are well-trained and highly educated members of the surgical team, they are capable of taking a leadership role to effect change in practice, particularly in the area of OR patient safety.30 The low response rate to our survey is worrisome, not because it casts doubt on the study itself, but because it indicates lack of CRNA/SRNA interest in this vital area, which needs urgent intervention.

• Limitations. This study has a number of limitations. The study participants included only CRNAs and SRNAs in the state of Illinois, so the results may not be generalizable across other geographic locations. The survey also assessed only the perceived knowledge and attitudes of CRNAs and SRNAs and did not include other surgical team members such as anesthesiologists, anesthesiology assistants, and perioperative nurses. The actual knowledge level of participants on fire risk assessment was not assessed given the amount of time required to develop a valid and reliable multiple-choice questions tool, which is suited more for a PhD dissertation than a DNP project. Because of differences in the educational preparation among surgical team members, there may be differences in the perceived knowledge and attitudes based on roles in the surgical team. Several studies have reported negative attitudes of surgeons toward checklist use and acceptance affecting overall teamwork.35,39,40 The sample in this study is composed primarily of whites, which is highly reflective of the current racial distribution in the national AANA membership.30 This precludes the investigators from examining ethnicity as a potential factor for perceived knowledge deficit or poor attitudes on fire risk assessment. However, this study provides preliminary evidence that gender, level of education, years of education, and age are at least not associated with poor perceived knowledge or negative attitudes toward fire risk assessment among surgical time-outs among CRNAs and SRNAs.

• Future Direction for Research. Electronic health records are becoming ubiquitous in daily clinical practice, making the integration of an electronic fire risk assessment checklist easier to use and thereby improving acceptability ratings. Future studies aimed at examining potential barriers to fire risk assessment during time-outs are warranted before full implementation. The use of a checklist as a fire risk assessment tool in the OR should be explored because there are many review articles supporting the effectiveness of checklists in preventing human errors in the OR, including fires.7,9,22,34,41-46

Implications for Practice. The survey results also indicate that CRNAs and SRNAs have self-reported informational needs on many aspects of fire risk assessment during surgical time-outs. Education should be the first step toward the integration of fire risk assessment into the surgical time-outs. The areas of educational need such as information technology and research skills in retrieving information relevant to OR fire risk assessment and ways to share new ideas on OR fire risk should be addressed by future educational initiatives on OR fire safety. Additional training should be provided to all surgical team members to enhance their perceived knowledge of fire risks in the OR and to reinforce the need to eliminate one element of the fire triad using a checklist that facilitates structured meaningful and relevant communication among surgical team members.40,47,48

Perceived barriers to knowledge must be removed to facilitate practice culture change from all members of the surgical team.40 There is still no current standard procedure that requires implementation of the assessment of fire risk in the OR. Moving forward, a standard of practice using an evidence-based OR fire assessment checklist should be developed and tested in ORs and ambulatory surgical centers for its applicability, usability, acceptability, and effectiveness in reducing human error that could lead to a patient’s burn injuries or death due to a highly preventable OR fire. A recent publication examining barriers and facilitators to checklist implementation revealed many barriers, including poor planning, lack of accountability, design issues, implementation issues, problematic integration into existing processes, and resistance from senior clinicians such as surgeons and anesthesiologists.41 A systematic way of integrating a fire assessment checklist into existing processes should be planned carefully, and all surgical team members must be involved in the planning stages to avoid the pitfalls described by Mayer et al48 and Russ et al.40,48 Obtaining the patient’s feedback on the use of a checklist can also be very beneficial in ultimately improving overall surgical outcomes.49

Conclusion

Consistent with other study findings involving perioperative nurses, CRNAS and SRNAs have positive and favorable attitudes toward fire risk assessment and the use of checklists in the OR. However, their self-perceived knowledge deficits on fire risk assessment could hinder the development, adoption, and integration of fire risk assessment into the existing universal protocol for surgical time-outs. Perceived knowledge deficits on fire risk assessment must be addressed before implementation of an OR fire risk assessment checklist. Actual measurement of fire risk assessment knowledge using valid and reli-
able tools should be an area for further research. Ways to improve sharing and dissemination of new information related to OR fire risks are warranted among CRNAs and SRNAs as well as other members of the surgical team.

REFERENCES


44. Semel ME, Resch S, Haynes AB, et al. Adopting a surgical safety checklist could save money and improve the quality of care in U.S.


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DISCLOSURES
The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.
In nonobstetric procedures, epidural volume extension (EVE) has been suggested to lower intraoperative opioid requirements while improving motor recovery when added to spinal anesthesia. This systematic review with meta-analysis was performed to evaluate the efficacy of EVE in elective cesarean delivery. We searched PubMed, Embase, and The Cochrane Review Database for randomized controlled trials evaluating EVE compared with single shot spinal and/or combined spinal/epidural anesthesia. The primary outcomes were efficacy of EVE, as defined by the need for intraoperative opioid supplementation, and time to complete motor recovery.

Eighteen randomized controlled trials consisting of 1,670 patients were evaluated. Subgroup analyses of EVE with local anesthetic were statistically significant in decreasing the need for intraoperative analgesic supplementation (risk ratio = 0.30; 95% confidence interval [CI] = 0.13-0.68; P = .004; I² = 50%). Faster motor recovery was also seen (MD −24.14; 95% CI = −47.31 to −0.98; P = .04; I² = 98%). Sequential EVE has been affirmed as a method to decrease intraoperative opioid requirements compared with single shot spinal or combined spinal/epidural anesthesia. Improved motor recovery times were also statistically significant but should be extrapolated with caution because of high heterogeneity of the included studies.

Keywords: Cesarean section, combined spinal-epidural, epidural volume expansion.

The near simultaneous injection of local anesthetic into the subarachnoid and epidural spaces was first described in 1937 in more than 200 cases. This technique, originally called episubdural anesthesia, is known today as combined spinal-epidural anesthesia (CSE) and is widely used in a variety of obstetric and surgical procedures. Even in 1937, Soresi recognized that by combining the 2 techniques, many disadvantages of a single technique were eliminated, while still providing surgical anesthesia, relaxation, and postoperative pain control. Although CSE was first suggested for caesarean delivery in 1979, it was not until 1982 that CSE was performed using a needle-through-needle technique. This innovation allowed both subarachnoid and epidural injections through the same intervertebral space and decreased procedure time.

The dose of local anesthetic is one of the factors that determines the degree and severity of spinal anesthesia–induced hypotension (SIH) during an elective cesarean delivery. Estimates of the incidence of SIH are between 15% and 33% of cases. Lowering the dose of the anesthetic below the median effective dose (ED₃₀) of the local anesthetic, combined with administration of opioid, has been successful in mitigating SIH and other maternal and fetal complications. However, this technique has a few potential disadvantages, including an increased need for intraoperative pain supplementation, conversion to general anesthesia, incomplete motor blockade, and inadequate anesthesia. To enhance the efficacy of low-dose local anesthetic, placement of an epidural catheter as part of the CSE technique has been advocated, which allows for “top-up” dose of local anesthetic or opioid.

A modified version of the CSE technique is the use of epidural volume extension (EVE). This approach incorporates the use of normal saline, opioid, or a small amount of local anesthetic into the epidural space immediately after intrathecal injection of the local anesthetic. When EVE uses local anesthetic, the technique is known as sequential CSE. Theoretically, expanding the epidural space extends sensory blockade from spinal anesthesia. Although there are other proposed mechanisms of EVE, the widely accepted mechanism of action is thecal compression of the subarachnoid space due to volume effect, which promotes cephalad displacement of local anesthetic in the cerebrospinal fluid. The local anesthetic effect, another accepted mechanism of EVE, is due to leakage of the local anesthetic from the spinal needle hole.
and the diffusion of the local anesthetic into the thecal space. Both the volume and local anesthetic effects of EVE during CSE were examined in earlier studies in non-obstetric cases. Stienstra and colleagues found that EVE with normal saline and local anesthetic increased the sensory block height. Furthermore, Takiguchi and colleagues reported that injecting 10 mL of saline in the epidural space immediately after subarachnoid block (SAB) increased the sensory blockade.

Published narrative reviews have highlighted a number of benefits of EVE. Aside from increasing the sensory block levels, EVE allows the use of lower intrathecal doses of local anesthetic. In a study in nonobstetric patients, the minimum effective dose of plain bupivacaine was reduced. The lower dose of intrathecal local anesthetic reduces the incidence of hypotension and speeds motor recovery after the procedure. However, results of published trials examining the efficacy and safety of CSE with EVE in elective cesarean delivery have been inconsistent. Therefore, we performed this systematic review and meta-analysis to investigate the efficacy and safety of CSE with EVE during elective cesarean delivery.

Methods
The review and meta-analysis was carried out using the guidelines outlined in Cochrane Handbook for Systematic Reviews of Interventions and the checklist from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement.

- **Search Strategy.** We searched PubMed, The Cochrane Reviews, MEDLINE, Cumulative Index to Nursing & Allied Health Literature (CINAHL), and Embase for evidence between January and November 2016 for the following text and keywords: epidural volume extension, EVE, cesarean delivery, and obstetric anesthesia alone or in combination. Full-text, English-language articles were reviewed along with the references of relevant published trials. The ancestry approach and the related articles section in PubMed were also used to retrieve potentially relevant sources.

- **Study Selection.** Two authors (T.K., T.T.) of the current review examined the title and abstract of each relevant article. Only published randomized controlled trials (RCTs) investigating the effect of EVE, regardless of the type of solution used, during an elective cesarean delivery were included in the full article review. Studies comparing EVE to single-shot spinal anesthesia (SSS) and CSE were also included in the review. Retrospective studies, cohort studies, case reports, abstract-only articles, editorials, expert opinions, animal studies, duplications, and poster presentations were excluded for review and analysis. Any disagreements were resolved by discussion and consensus with the third author (J.K.). Data from all included trials were extracted and summarized using a standardized form, which was reviewed and verified by the 2 authors (T.K., T.T.). Study demographics, methodologic protocols, types of EVE solution, types of local anesthetic drug, concentration and dose, and primary and secondary outcomes of each study were summarized and tabulated for analysis. In studies with more than 2 comparison groups, extracted data were processed before it was suitable for analysis. We then followed the guidelines as recommended by Cochrane Handbook for Systematic Reviews of Interventions to avoid double counting of participants and introducing bias into the analysis.

- **Risks of Bias.** The methodologic quality of each trial was scored according to the guidelines described by The Cochrane Collaboration. Assessment criteria included random sequence generation, allocation concealment, blinding of outcome data assessment, and selective reporting. Each category was appraised to “high risk,” “low risk,” and “unclear risk.” Assessment data were recorded independently, and any discrepancies were resolved by discussion and consensus.

- **Statistical Analysis.** We used Review Manager (RevMan 5.3, The Nordic Cochrane Centre, The Cochrane Collaboration) for meta-analysis. The primary outcomes of this review were the efficacy of EVE, as it relates to the need for intraoperative opioid supplementation, and the time to complete motor recovery after surgery. There is no universally accepted sensory dermatomal level for adequate surgical anesthesia in cesarean delivery. Therefore, the frequency of intraoperative analgesia supplementation given intravenously or via epidural catheter and conversion to general anesthesia due to failed SAB were used as markers of EVE efficacy. This outcome measure was treated as a dichotomous variable, and no attempt was made at standardization of drug types, dosages, or routes. The secondary outcome for this review is time to first request of postoperative opioid supplementation. Similar to outcomes on intraoperative analgesia requirements, interventions used to treat postoperative pain were not standardized.

For dichotomous outcomes, risk ratio (RR) and 95% confidence interval (CI) were calculated and analyzed using the random effects model. Continuous variables were analyzed using mean difference with inverse variance method. Heterogeneity of the studies was assessed using the I² statistic. An I² of more than 50% was considered to have substantial heterogeneity. If heterogeneity was observed, subgroup analyses were performed. Sensitivity analysis was performed to assess robustness of all included trials. The Begg funnel plot and the Egger test were used to test for symmetry and publication bias.

Results
We initially reviewed 58 studies for eligibility based on titles and abstracts. Of the 40 examined full-text articles, we identified 18 RCTs for systematic review providing a total of 1,670 patients; all were published between
the years 1992 and 2015 in English-language, peer-reviewed journals. Data from 17 RCTs were subsequently included in the meta-analysis (Figure 1).

**Demographic Characteristics.** Demographic data were largely homogenous. All patients were ASA class 1 or 2, except in one study that did not report patient classification. Lumbar interspaces used for the delivery of the local anesthetic were L1-2, L2-3, L3-4, L4-5, or a combination of these. Tuohy introducer sizes 16 g to 18 g were used in each of the studies, although one study did not specify a type/size of introducer. Pencil-point needles were used for SAB in all but 2 studies, which used the Quincke-type needle, and another study that did not differentiate. All patients received normal saline or lactated Ringer's solution as prehydration.

Ten studies compared the use of CSE with EVE vs single-shot spinal (SSS). Of the 18 included studies, 13 trials used normal saline for EVE solution, the rise above "adequate surgical level" was 0 to 4 dermatomes. Of the 5 studies comparing SSS to sequential EVE, dermatomal rise above "adequate surgical level" was 0 to 3 dermatomes. Of the 18 studies, 7 RCTs recorded the time when desired sensory block was achieved before incision. Pooled analysis showed no difference in terms of the onset of sensory block considered adequate for surgical anesthesia (mean difference [MD] = −1.41; 95% CI = −5.72 to 2.89; P < .00001; I² = 97%). Sensory regression was similar in patients treated with sequential EVE and those treated with SSS or CSE (MD −2.23; 95% CI −8.09 to 3.63; P = .46; I² = 70%). The sensory block characteristics of included studies are summarized in the Table.

After induction of anesthesia and during the recovery phase, motor blockade was assessed using the modified Bromage scale. The scoring system ranges from 0 to 4, with 4 representing complete immobility of the lower extremities and 0 representing complete mobility. The motor block characteristics of included studies are summarized in the Table.

The type and dose of intrathecal local anesthetic differed between studies, perhaps because of variability of clinical practice. Thirteen studies used 0.5% hyperbaric bupivacaine for spinal anesthesia. Doses of bupivacaine ranged from 6 mg to 18 mg, with 9 mg as the most common. Two studies involved injections of 0.5% isobupivacaine in 9- to 10-mg doses, and 4 studies specified levobupivacaine in 5- to 15-mg doses. In addition, 11 studies added narcotic to the spinal anesthetic; fentanyl, 10 to 50 µg, in 8 studies and sufentanil, 2.5 to 5.0 µg, in 2 studies. Seven studies used the same subarachnoid dose of local anesthetic in the SAB group as they did in the EVE group. Nine studies used different baricities or doses, or both, between study groups.

**Primary Outcomes.** The main outcomes, use of intraoperative analgesia supplementation and time to
<table>
<thead>
<tr>
<th>Source</th>
<th>N</th>
<th>Study groups</th>
<th>Site/patient position</th>
<th>Type/timing/volume (mL) of EVE</th>
<th>Sensory level/assessment method of surgical anesthesia</th>
<th>Assessment method for motor block</th>
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<tbody>
<tr>
<td>Beale et al, 2006</td>
<td>52</td>
<td>CSE with EVE</td>
<td>L2-L3, L3-L4/Left lateral</td>
<td>NS/NR/7</td>
<td>T5/Touch</td>
<td>NR</td>
<td>Up/down sequential technique to determine ED&lt;sub&gt;50&lt;/sub&gt; of hyperbaric bupivacaine</td>
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<td></td>
<td></td>
<td>CSE Varying doses of bupivacaine with fentanyl, 25 µg in CSE</td>
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<td>ED&lt;sub&gt;50&lt;/sub&gt; of hyperbaric bupivacaine for EVE (5.1 mg) and non-EVE (6.1 mg)</td>
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<td></td>
<td>Sensory regression time to T10 NR</td>
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<td>Blumgart et al, 1992</td>
<td>28</td>
<td>Sequential CSE&lt;sup&gt;6&lt;/sup&gt;</td>
<td>L2-L3, L3-L4/Sitting</td>
<td>Bupivacaine 0.5% and NS/10 min after SAB/10</td>
<td>T4-T5/Pinprick</td>
<td>Bromage scale</td>
<td>All CSE IT dose of 0.5% hyperbaric bupivacaine (&lt;163 cm, 1.6 mL; &gt;163 cm, 1.8 mL)</td>
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<td></td>
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<td>CSE with EVE CSE</td>
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<td>Similar effect on sensory extension in CSE with saline and sequential CSE</td>
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<td>Median sensory dermatomal rise 3-4 segments; sensory regression time NR</td>
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<td>Levobupivacaine 0.25%/NR/10-12</td>
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<td>CSE dose of IT 0.25% levobupivacaine (&lt;162 cm, 10 mL; &gt;162 cm, 12 mL)</td>
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<td></td>
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<td>SSS</td>
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<td>SSS dose of levobupivacaine (&lt;162 cm, 7.5 mg; &gt;162 cm, 8 mg) with 5 µg of sufentanil</td>
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<td>Dermatomal rise and sensory regression time to T10 NR</td>
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<td>All CSE IT 0.5% hyperbaric bupivacaine, 8 mg</td>
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<td>Faster sensory regression to T10 in CSE with saline EVE and CSE alone (93 min vs 98 min)</td>
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<td>Median block level is higher in CSE with EVE vs CSE alone (T3 vs T4)</td>
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<td>Sequential EVE better at providing analgesia than CSE with saline EVE</td>
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<td>Choi et al, 2000</td>
<td>66</td>
<td>Sequential CSE</td>
<td>L2-L3, L3-L4/Right lateral</td>
<td>Bupivacaine 0.25% and NS/10 min after SAB injection/10</td>
<td>T4/Pinprick</td>
<td>Bromage scale</td>
<td>For CSE, IT 0.5% hyperbaric bupivacaine, 6 mg, with fentanyl, 20 µg</td>
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<td></td>
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<td>CSE with EVE CSE</td>
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<td>For SSS, 0.5% hyperbaric bupivacaine, 9 mg, with 20 µg of fentanyl</td>
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<td></td>
<td></td>
<td>Faster sensory recovery in sequential EVE vs SSS</td>
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<td></td>
<td>For CSE with saline, IT 0.5% hyperbaric levobupivacaine, at 0.025 mg/cm high</td>
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<td></td>
<td>For spinal anesthesia, 0.5% hyperbaric levobupivacaine (5 mg/cm high) with fentanyl (&lt;165 cm, 15 µg; &gt;175, 25 µg)</td>
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<td>Time to surgical level and sensory regression to T10 NR</td>
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<td></td>
<td></td>
<td>All CSE IT 0.5% hyperbaric bupivacaine, 6 mg, with fentanyl, 25 µg More patients required supplemental ketamine in CSE with no EVE compared with CSE with saline or Hespan EVE</td>
</tr>
<tr>
<td>Choi et al, 2006</td>
<td>100</td>
<td>Sequential CSE</td>
<td>L3-L4/Right lateral</td>
<td>Bupivacaine 0.25%/5 min after SAB injection/10</td>
<td>T4/Pinprick</td>
<td>Bromage scale</td>
<td>For CSE, IT 0.5% hyperbaric bupivacaine, 6 mg, with fentanyl, 20 µg</td>
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<td>SSS</td>
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<td>For SSS, 0.5% hyperbaric bupivacaine, 9 mg, with 20 µg of fentanyl</td>
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<td>Faster sensory recovery in sequential EVE vs SSS</td>
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<td>Fabris et al, 2013</td>
<td>76</td>
<td>CSE with EVE</td>
<td>L3-L4, L4-L5/Sitting</td>
<td>NS/Immediately after SAB injection/18-20</td>
<td>NR/Pinprick</td>
<td>Bromage scale</td>
<td>For CSE with saline, IT 0.5% hyperbaric levobupivacaine, at 0.025 mg/cm high</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>For spinal anesthesia, 0.5% hyperbaric levobupivacaine (5 mg/cm high) with fentanyl (&lt;165 cm, 15 µg; &gt;175, 25 µg)</td>
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<td></td>
<td></td>
<td>Time to surgical level and sensory regression to T10 NR</td>
</tr>
<tr>
<td>Gupta et al, 2012</td>
<td>99</td>
<td>CSE with saline EVE</td>
<td>L4-L5/Left lateral</td>
<td>NS 6% hydroxyethyl starch 0.9% sodium chloride injection (Hespan)</td>
<td>T6/Pinprick</td>
<td>Bromage scale</td>
<td>All CSE IT 0.5% hyperbaric bupivacaine, 6 mg, with fentanyl, 25 µg More patients required supplemental ketamine in CSE with no EVE compared with CSE with saline or Hespan EVE</td>
</tr>
<tr>
<td>Study</td>
<td>Patients</td>
<td>Technique</td>
<td>Levels</td>
<td>Local anesthetic &amp; Opioid</td>
<td>Time to surgical level</td>
<td>Sensory regression</td>
<td>Conclusion</td>
</tr>
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<tr>
<td>Karaman et al.29 2005</td>
<td>80</td>
<td>Sequential CSE Epidural</td>
<td>L2-L3, L3-L4/NR</td>
<td>Bupivacaine 0.25% with 50 µg of fentanyl/10 min after SAB injection/10</td>
<td>T4/Pinprick</td>
<td>Bromage scale</td>
<td>CSE IT 0.5% hyperbaric bupivacaine (&lt; 165 cm, 1.5 mL; &gt; 165 cm, 1.8 mL) Epidural anesthesia, 0.5% bupivacaine, 16 mL, with fentanyl, 100 µg; additional 2 mL of bupivacaine per segment unblocked until T4 Postoperative pain treated with epidural morphine</td>
</tr>
<tr>
<td>Kaur et al.32 2012</td>
<td>106</td>
<td>CSE with EVE CSE SSS</td>
<td>L3-L4, L4-L5/ Sitting</td>
<td>NS/5 min after SAB injection/10</td>
<td>T5/Pinprick</td>
<td>Bromage scale</td>
<td>SSS 0.5% hyperbaric bupivacaine, 10 mg, with fentanyl, 25 µg All CSE IT 0.5% hyperbaric bupivacaine, 7 mg, with fentanyl, 25 µg Time to reach surgical level and regression time to T10 NR</td>
</tr>
<tr>
<td>Kucukguclu et al.34 2008</td>
<td>233</td>
<td>2 CSE groups (0.5% plain bupivacaine and 0.5% hyperbaric bupivacaine) 2 CSE groups with EVE (0.5% plain bupivacaine and 0.5% hyperbaric bupivacaine)</td>
<td>L3-L4, L4-L5/ Sitting</td>
<td>NS/5 min after SAB injection/10</td>
<td>T4/Pinprick</td>
<td>Bromage scale</td>
<td>All CSE IT bupivacaine dose dependent (&lt; 163 cm, 8 mg; &gt; 163, 9 mg) Fentanyl, 20 µg, was added to all anesthetics Dermatomal rise and sensory regression equivalent between CSE groups and CSE with EVE</td>
</tr>
<tr>
<td>Lew et al.27 2004</td>
<td>62</td>
<td>SS CSE with EVE</td>
<td>L4-L5/ Right lateral</td>
<td>NS/5 min after SAB injection/6</td>
<td>T4/Pinprick</td>
<td>Bromage scale</td>
<td>Spinal anesthesia, 0.5% hyperbaric bupivacaine, 9 mg, with fentanyl, 10 µg CSE, IT 0.5% hyperbaric bupivacaine, 5 mg, with fentanyl, 10 µg Time to reach surgical level NR; sensory regression to T10 faster with CSE/EVE</td>
</tr>
<tr>
<td>Loubert et al.31 2011</td>
<td>86</td>
<td>SSS CSE CSE with EVE</td>
<td>L3-L4, L4-L5/ Sitting</td>
<td>NS/Immediately after SAB injection/5</td>
<td>T4/Pinprick</td>
<td>Bromage scale</td>
<td>CSE with EVE, IT hyperbaric bupivacaine, 7.5 mg CSE without EVE, hyperbaric bupivacaine, 10 mg Spinal anesthesia, hyperbaric bupivacaine, 7.5 mg All patients received IT fentanyl, 25 µg Time to surgical level and sensory regression to T10 NR</td>
</tr>
<tr>
<td>Malvasi et al.20 2010</td>
<td>200</td>
<td>SSS Sequential CSE</td>
<td>L1-L2/ Sitting</td>
<td>Lidocaine 0.5%/ Immediately after SAB injection/3-7 depending on height</td>
<td>NR/NR</td>
<td>NR</td>
<td>Spinal anesthesia, 0.15% levobupivacaine, 5 mL, with 5 µg of sufentanil CSE with EVE, IT 0.15% levobupivacaine, 4 mL, with 5 µg of sufentanil Time to surgical level and sensory regression to T10 NR</td>
</tr>
<tr>
<td>Salman et al.35 2013</td>
<td>132</td>
<td>SSS CSE with EVE Sequential CSE</td>
<td>L3-L4, L4-L5/ Right lateral</td>
<td>NS Levobupivacaine 0.5%/5 min after SAB injection/5</td>
<td>T4-T5/Pinprick</td>
<td>Bromage scale</td>
<td>Spinal anesthesia, IT 0.5% levobupivacaine (&gt; 160 cm, 10 mg; 161-164 cm, 12 mg; 165-169, 14 mg; &gt; 170 cm, 15 mg) with fentanyl, 20 µg CSE facilitates early onset of sensory block and faster motor recovery</td>
</tr>
<tr>
<td>Thorén et al.22 1994</td>
<td>42</td>
<td>SSS Sequential CSE</td>
<td>L2-L3/ Sitting</td>
<td>Bupivacaine 0.5%, fractionated dose</td>
<td>T4/Pinprick</td>
<td>NR</td>
<td>Spinal anesthesia, 0.5% hyperbaric bupivacaine, 12.5 mg CSE with EVE, IT 0.5% hyperbaric bupivacaine, 1.5 mL</td>
</tr>
<tr>
<td>Tripathi et al.33 2015</td>
<td>80</td>
<td>2 CSE groups, IT 0.5% isobaric bupivacaine, 2 mL 2 CSE with EVE, IT 0.5% isobaric bupivacaine, 2 mL</td>
<td>L3-L4, L4-L5/ Right lateral</td>
<td>NS/5 min after SAB injection/15</td>
<td>T5/Pinprick</td>
<td>Bromage scale</td>
<td>All CSE without EVE, IT 0.5% isobaric bupivacaine, 2 mL, and 0.5% isobaric bupivacaine, 1.5 mL All CSE with EVE, IT 0.5% isobaric bupivacaine, 2 mL, and 0.5% isobaric bupivacaine, 1.5 mL Time to surgical level and sensory regression to T10 NR</td>
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</tbody>
</table>

continues on page 114
Table. Included Randomized Controlled Trials Reporting on the Efficacy and Safety of Epidural Volume Extension in Combined Spinal-Epidural Anesthesia During Elective Cesarean Delivery

<table>
<thead>
<tr>
<th>Source</th>
<th>Study groups</th>
<th>N</th>
<th>Site/patient position</th>
<th>Type of volume extension fluid</th>
<th>Assessment method of surgical anesthesia</th>
<th>Sensory level/assessment method of surgical anesthesia</th>
<th>Time to surgical level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyagi et al., 2009</td>
<td>56</td>
<td>2 CSE groups, 2 EVE groups</td>
<td>L4-L5, Sitting</td>
<td>0.9% NS, immediately after SAB injection</td>
<td>Pinprick</td>
<td>T6</td>
<td>Tyagi et al., 2011</td>
<td>40</td>
</tr>
</tbody>
</table>

Abbreviations: CSE, combined spinal epidural anesthesia; ED50, median effective dose; EVE, epidural volume extension; IT, intrathecal; NR, not reported; NS, 0.9% normal saline; SAB, subarachnoid block; SSS, single-shot spinal anesthesia.

a) Site of epidural space identification and participant’s position during regional technique.

b) Type of epidural volume extension fluid (0.9% normal saline vs local anesthetic).
c) Sensory dermatomal level for adequate surgical anesthesia.
d) Bromage scale is a method to assess motor block of the lower extremities: 0 = full flexion of knees and feet; 1 = able to move knees; 2 = able to move feet only; and 3 = unable to move lower extremities.
e) Use of a local anesthetic for epidural volume extension.

Intraoperative Analgesia. The use of intraoperative analgesia supplementation was investigated in 13 studies. The overall effect of the RCTs that examined the use of EVE compared with control showed no statistical difference between the 2 groups (RR = 0.71; 95% CI = 0.38-1.34; P = .22; I² = 66%; Figure 2). Similarly, subgroup analysis of 7 studies comparing normal saline EVE against control demonstrated no statistical significance in the use of intraoperative analgesia supplementation (RR = 1.06; 95% CI = 0.71-1.59; P = .78; I² = 27%). However, when 7 studies comparing local anesthetic EVE were evaluated there was a significant difference between EVE and saline, with EVE requiring less intraoperative analgesia (RR = 0.30; 95% CI = 0.13-0.68; P = .004; I² = 50%).

Bupivacaine 0.5%, 22,36 0.25% bupivacaine, 29,30 0.25% levobupivacaine, 21 and 0.5% lidocaine 20 were used as EVE solutions. In 2 studies, fentanyl, 100 µg, 29 and sufentanil, 1 µg/mL, 20 was added to the EVE solution.

Time to Complete Motor Recovery. The aggregate effect of 10 RCTs that evaluated the effects of CSE with EVE showed faster motor recovery compared with control (MD = −24.14; 95% CI = −47.31 to −0.98; P = .04; Figure 3). The pooled analysis resulted in a very substantial heterogeneity (I² = 98%). Results of subgroup sensitivity analyses for CSE with EVE vs SSS and CSE without EVE did not change the I² statistics. Two studies reported that motor block between the SSS group and EVE group was statistically significant (P < .001), and their authors opined that the shorter block in the EVE group allowed for more rapid mobilization, but no motor block assessment data were produced. Two studies evaluated motor block before surgical procedure but made no assessments regarding motor recovery postoperatively. Additionally, although 2 studies discussed postoperative evaluation of motor recovery using modified Bromage scores, the authors did not provide data from their evaluation. These last 6 studies could not be included in the analysis of this outcome. One study did not include motor assessments at all.

Secondary Outcome: Time to First Postoperative Analgesia. Ten studies totaling 626 patients reported the time to first postoperative analgesia request. Pooled analysis of included studies showed no significant differences between CSE/EVE and control for postoperative analgesia (MD = 0.76, 95% CI = −16.16 to 17.67; P = .00001, I² = 92%; Figure 4).
Further subgroup analyses comparing the use of EVE with SSS and CSE alone did not differ in results. Different types of EVE (normal saline vs local anesthetic) were again not statistically significant for this outcome. Only 2 studies\textsuperscript{28,29} reported that time to first postoperative pain control request was shorter in patients treated with EVE.

- **Risks of Bias.** Random sequence generation and allocation concealment were well implemented. One study\textsuperscript{20} consecutively assigned participants to study groups, which potentially introduced selection bias. Four
introduced bias through a lack of allocation concealment. Some studies were determined to have an unclear risk of bias related to performance and detection. In 6 studies, the authors did not discuss blinding of participants involved in the placement of the block (performance bias). Blinding of outcome assessment, a type of detection bias, was unclear in 7 studies. This type of bias may cloud patient reporting of outcomes, encouraging patients to report pain either sooner or later based on clues from the observer. Figure 5 summarizes the risks of bias.

Discussion
To our knowledge, this is the first systematic review and meta-analysis evaluating the effectiveness and safety of EVE for elective cesarean delivery. Epidural injection of normal saline or a small amount of local anesthetic immediately after spinal anesthesia was proposed to extend the sensory block height during cesarean delivery while allowing use of a lower dose of local anesthetic for spinal anesthesia. This adjustment in CSE technique was first characterized by Rawal and colleagues. Until recently, normal saline was more commonly used in the clinical setting than was local anesthetic.

The results of our review demonstrated that the use of EVE is associated with significantly shorter times to complete motor recovery following cesarean delivery. The improved motor block characteristics of EVE are clinically relevant in the implementation of the Enhanced Recovery After Surgery (ERAS) initiative in patients undergoing cesarean delivery. With early regression of motor blockade after spinal anesthesia, 2 key components of ERAS for cesarean delivery, early mobilization and catheter removal, are met. Until recently, normal saline was more commonly used in the clinical setting than was local anesthetic.

The results of our review demonstrated that the use of EVE is associated with significantly shorter times to complete motor recovery following cesarean delivery. The improved motor block characteristics of EVE are clinically relevant in the implementation of the Enhanced Recovery After Surgery (ERAS) initiative in patients undergoing cesarean delivery. With early regression of motor blockade after spinal anesthesia, 2 key components of ERAS for cesarean delivery, early mobilization and catheter removal, are met. Although it is unlikely that patients will be immediately discharged home after cesarean delivery, faster motor recovery allows for early postanesthesia recovery room discharge and presumably decreases cost.

Pooled analysis of included studies demonstrated that patients treated with sequential local anesthetic CSE have lower intraoperative analgesia requirements. A potential clinical disadvantage of using a low-dose intrathecal local anesthetic is the increased need for intraoperative analgesic supplementation because of pain, discomfort, or failure to achieve sensory blockade adequate for surgical incision. In a previously published meta-analysis, low-dose bupivacaine was related to a higher risk of intraoperative pain. In our systematic review, analgesic requirement for sequential CSE was lower compared with CSE alone or SSS. This finding may be explained by the local anesthetic effect of EVE. This effect is theorized to occur by the diffusion of the local anesthetic to the subarachnoid space or drug transfer across the dura puncture hole.

On the other hand, EVE showed no significant improvement over control regarding the time of first postoperative opioid request. In theory, groups with EVE would require pain medications earlier than would groups with no EVE because of the lower dose of local anesthetic used in the subarachnoid space. In our review, only 2 studies reported shorter times to first postoperative pain supplementation.

There are limitations to this meta-analysis. First, most of the studies in this review had a relatively small sample size. Individual groups commonly had fewer than 50 participants per group. Second, a large variability in study protocol existed. For example, study design varied on lumbar interspace approach, needle size and type, and SAB drug and dose. Other study design challenges included varying volumes and types of solutions used for EVE. There was no standardization for EVE injection because studies were variable in terms of timing of injection from “immediately” to 10 minutes after CSE placement.

This review suggested areas where future studies are needed. Although our current analysis indicated statistical significance in the areas of decreased intraoperative analgesia needs and improved motor recovery times, we caution the extrapolation of our results to clinical practice because of the small sample size of most of the studies. Larger scale studies with homogenous design, such as similar SAB and similar EVE drug, dosing, and timing, would minimize heterogeneity across studies. Stricter blinding of participants to prevent performance and detection bias would improve methodologic quality. A cost analysis comparing SSS with sequential EVE would be of interest.
Conclusion

Findings of our systematic review with meta-analysis affirm that EVE is an effective approach to decrease intraoperative analgesia requirements while improving motor recovery following elective cesarean delivery. Larger, high-quality randomized trials would strengthen statistical significance.

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DISCLOSURES
The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.
The 2011 Institute of Medicine report on the future of nursing recommended that nurses practice to the full extent of their education and training. Nurse anesthetists in certain regions of the country have been unable to maintain regional anesthesia skills because of anesthesia practice models. Factors including increased patient loads, economic motivators, and desire to maintain skill sets are driving evolution of the anesthesia practice model. In many practices, Certified Registered Nurse Anesthetists (CRNAs) now have the opportunity to expand their practice scope to include regional anesthesia. This has created the need for a pathway to rapidly develop or augment skills for CRNAs who have not been performing regional anesthesia. Well-designed and facilitated simulation methods can be effective for teaching and evaluating clinical skills with incorporation of rigorous assessment instruments to ensure consistency in training outcomes. The purpose of this quality improvement project was to determine the effectiveness of a blended-learning regional anesthesia training curriculum on improving CRNA knowledge, skill, and attitude in regional anesthesia administration as part of a clinical credentialing pathway. Forty-nine CRNAs completed all course components, including meeting all skill training thresholds through deliberate practice and use of validated checklists. Knowledge and confidence levels demonstrated significant gains.

Keywords: Checklists, deliberate practice, epidural anesthesia, simulation, spinal anesthesia.

The 2011 Institute of Medicine’s Future of Nursing report and the Consensus Model for APRN (Advanced Practice Registered Nurse) Regulation, Licensure, Accreditation, Certification and Education have expressed the value of APRNs being able to practice to the full extent of their training. The American Association of Colleges of Nursing (AACN) also supports increasing the entry level of education for APRNs, including Certified Registered Nurse Anesthetists (CRNAs). The AACN indicates that these efforts will support the US nursing workforce and help to improve the utilization of valuable healthcare resources.

Many CRNAs in the US workforce have not been able to maintain their privileges for regional anesthesia practice, for a variety of reasons. Recent changes in practice environments present the opportunity for CRNAs to now be credentialed for regional anesthesia. Simulation education has proved effective in teaching other clinical skills to a threshold level of competence with translation to success in the clinical area. Examples include placement of a central venous line and lumbar puncture. Development of similar simulation skills laboratories and workshops to help CRNAs improve knowledge, skill, and confidence relative to administration of spinal and epidural anesthesia could potentially help to bridge the gap between initial training and the re-introduction of regional anesthesia skills after an interruption in regional anesthesia practice.

This issue of an interruption in practice has created a need to provide CRNAs with an effective hospital-level recredentialing educational pathway. One possible solution, which has demonstrated effectiveness, is a blended-learning approach. A blended-learning curriculum incorporates both online and face-to-face (simulation) components. Such a curriculum for regional anesthesia training could potentially facilitate the CRNA credentialing pathway and address the gap that exists when CRNAs are trained in regional anesthesia during their anesthesia education must refresh the skill for current practice needs.

This article describes the development of a blended-learning training course for nurse anesthetists at the Peter M. Winter Institute for Simulation, Education,
and Research (WISE), an internationally renowned multidisciplinary training and research facility located in Pittsburgh, Pennsylvania. An alpha practice course was implemented initially with development of checklists as a pilot study, followed by a beta evaluation by experienced obstetric anesthesia instructors. Finally, the course was deployed for CRNAs as part of the credentialing process. Full project implementation incorporated online learning activities, realistic simulation on-task trainers, deliberate practice, structured feedback, and focused debriefing. Best practices for simulation educational methods were used whenever possible.

**Historical Background.** Historically, the scope of practice of nurse anesthetists has sometimes been limited depending on the state of the license, facility of practice, hospital bylaws, local culture, and other healthcare providers involved in the patient’s care. Nurse anesthetists, although educated and trained to perform spinal and epidural blocks, may be out of practice in these techniques because of these prohibitive practice restrictions. One effect of the passage of the Patient Protection and Affordable Care Act of 2010 was an expansion of the number of patients entering the healthcare system. Additionally, there has been an emphasis on the importance of multidisciplinary teamwork in the pursuit of safe, high-quality, cost-effective anesthesia care. The stimulus for removal of practice restrictions for nurse anesthetists is multifactorial and includes the economic benefit of keeping the costs of healthcare affordable and the need for these skilled practitioners to practice to their full capability within the context of maintaining patient safety. Thus, CRNAs in many practices across the US are being offered an opportunity to practice to the full level of their education and training. However, because of the changing practice landscape, there now exists a gap for some CRNAs between the initial training program and the current opportunity for clinical use of skills that are within the scope of practice of CRNAs. Furthermore, epidural and spinal anesthesia are technically challenging anesthesia techniques that require practice to achieve competence and maintain proficiency. Several studies have demonstrated that experience in anesthesia training in a simulated environment before patient encounters can improve procedural efficiency, decrease error rates, and positively affect quality of care and patient safety.

The theoretical basis is well established for use of simulation to aid in acquisition of psychomotor skills and development of expertise. Simulation training can refine technical skills and expand the teaching paradigm to include critical thinking or management of rare complications, such as those seen with spinal and epidural block placement. Traditional healthcare simulation courses involve a simulation exercise followed by a facilitated postevent debriefing in which learners discuss what was done correctly and what could be improved the next time, usually without additional opportunities to apply the specific new knowledge. Research in development of expert performance suggests that deliberate practice is a hallmark in the development of high-level performance. Successful training in deliberate practice involves the following factors: (1) motivated learners, (2) well-defined learning objectives, (3) precise measurements of performance, (4) focused and repetitive practice, and (5) informative real-time feedback concerning performance.

**Rationale and Specific Aims.** To close the gap between initial training for practice and a current need to utilize skills that are within the CRNA scope but have not been used in practice for a time, the authors developed an evidence-based regional anesthesia training course as a blended curriculum designed to facilitate regional anesthesia credentialing. The course development included an online educational component and a hands-on simulation component focused on deliberate practice. Following successful course completion, the credentialing pathway could be accomplished by completing a supervised clinical component. This article describes the development and evaluation of a blended curriculum (Nurse Anesthetist Regional Anesthesia Training [NARAT] course) that qualified CRNAs for the final step of the credentialing pathway.

The main purpose of this project was to develop a blended simulation curriculum incorporating online knowledge components, hands-on deliberate practice, and checklists to increase the knowledge, confidence (attitude), and skills of CRNAs in regional anesthesia practice. A secondary purpose was to determine the success of this preparation in facilitating participants’ credentialing trajectory toward independent regional anesthesia practice.

**Review of the Literature**
Decay of skill and knowledge is a major issue, especially when trained or acquired skills are needed after long periods of nonuse. There are proven ways to address these knowledge deficits and challenges. One such educational method is expertly developed simulation, which incorporates best procedures such as deliberate practice, feedback, debriefing, and rigorous assessment using checklists. The traditional “apprentice” model in healthcare education has undergone a pedagogical shift to a simulation-based learning model. Experiential learning, deliberate practice, and the ability to provide immediate feedback are the primary advantages.

**Deliberate Practice.** The term deliberate practice was first used by Ericsson in instructional science research and has been adopted in medical education. Deliberate practice involves repetitive performance of intended cognitive or psychomotor skills in a focused domain, coupled with rigorous skills assessment. Deliberate practice has been studied most often in the domains of music, sports,
and chess. Experts are usually supported by trainers or coaches who design structured practice activities aimed at performance improvement and who then provide specific, informative feedback. The participants gradually learn to monitor, control, and evaluate their own performance, enabling high-quality independent practice. Conscious efforts to counteract automaticity and gain high-level control of performance are deemed necessary to go beyond routine behavior and achieve expertise.

Deliberate practice requires working at the edge of competency, is effortful, requires feedback and focuses on remediation of weaknesses. Building comfort level and confidence levels in students is very important and enables the learners to attain fluency with their current level of performance. They are then equipped to reapply deliberate practice to attain the next level of performance. Deliberate practice can be applied to any aspect of performance. It is effective for both cognitive skills and motor skills. It is fair to say that expertise will not be attained without the regular use of deliberate practice to one's domain of performance.

**Simulation.** The literature for simulation training has expanded exponentially in recent years. Healthcare, like aviation, is driven by safety, more specifically patient safety. As the link between simulation and patient safety becomes increasingly apparent, simulation training is being adopted as the education method of choice for acquisition of a number of critical behaviors, including technical skills and teamwork. In almost every well-controlled study, simulation is superior to standard education methods.

Several studies have demonstrated that experience in anesthesia training in a simulated environment before patient encounters can improve procedural efficiency, decrease error rates, and positively affect quality of care and patient safety. Laurent et al. used a global rating scale in a study as an assessment tool for the simulation training. Friedman and associates researched the clinical impact of epidural anesthesia simulation on short- and long-term learning curves of providers. Even though simulation training has been considered an important anesthesia training tool, Fehr and colleagues suggested that further study of the transferability of anesthesia simulation training to clinical care and demonstration of improved patient outcomes was necessary. Feedback and debriefing are critical to effective learning in simulation and should be guided by individual learning needs.

Epidural and spinal anesthesia are technically challenging regional anesthetic techniques that can be improved with continued skill execution. Simulation education for technical skill acquisition of regional anesthesia traditionally is focused on haptics from the Greek word haptikos meaning "to sense or touch." Deliberate practice eases haptic finesse and skill acquisition of placing a spinal or epidural block.

**Checklists.** Anesthesia care has become more complex with an increased number of “routine” tasks and responsibilities that cannot realistically be remembered even by experts. Nanji and Cooper stated that checklists in anesthesia have resulted in a reduction in process variability and have led to improved outcomes and reduced incidences of complications. Wong et al. evaluated task-specific checklists while using a global rating scale for ultrasound-guided regional anesthesia. The American Society of Regional Anesthesia and Pain Medicine has developed checklists to effectively improve performance during the treatment of local anesthetic systemic toxicity, a life-threatening event. Checklists appear to be effective tools for improving patient safety in various clinical settings by strengthening compliance with guidelines, eliminating human variables, reducing the incidence of adverse events, and decreasing morbidity and mortality. Well-constructed checklists codify interventions, remove ambiguity, and increase reliability of care processes. In educational settings, checklists can serve not only as evaluation tools but also as an efficient means of communicating a set of expectations regarding effective performance. The goals of checklists for the NARAT course included the following: (1) acting as cognitive guides for the participants, (2) ensuring that all critical actions were taken, (3) reducing variability between providers, and (4) enhancing coordination during high workload and stressful situations. Checklists for basic procedural skills require an approach to standard setting in which patient safety concerns are paramount. Only by requiring a high level of performance in the simulation laboratory can we promote patient safety in the more unpredictable clinical environment.

**Merging Deliberate Practice, Simulation, and Checklists.** Simulation experiences involving checklists have been an accepted part of training, assessment, and research in the aviation industry, nuclear power industry, and the military. These industries have widely accepted standards that have been emulated in healthcare training, including in regional anesthesia training courses. The Agency for Healthcare Research and Quality has likewise encouraged the use of critical event crisis checklists for operating room emergencies involving anesthesia. These checklists have been developed and tested in experiential simulation learning environments.

One key characteristic related to use of checklists is in development and validation. The literature is consistent in emphasizing the importance of careful checklist development, with the Delphi method (which uses expert consensus building) recognized as a valuable tool in developing checklists that are able to assess skill performance. The overall consensus in the literature is that checklists are a valuable and accepted adjunct in simulation training designed to improve clinical performance. Incorporating checklists into simulation training, which
includes important processes such as anesthesia care, can help to ensure that the essential steps are manageable, standardized, and consistently performed.40,41 Udani et al42 focused on simulation-based mastery learning with deliberate practice to improve clinical performance in spinal anesthesia for anesthesiology residents. Simulation was combined with the use of checklists and deliberate practice to train anesthesiology residents, with primary outcomes reported as the percentage of checklist tasks performed correctly.42 Their study demonstrated the effectiveness of a simulation-based curriculum in significantly improving anesthesiology residents’ performance of subarachnoid block.42 Furthermore, the deliberate-practice training component added a significant, independent, incremental benefit to performance improvement.42

- **Debriefing.** Debriefing is a form of structured feedback that follows a simulation event and is a conversation—al period for reflection aimed at sustaining or improving future performance.43 Extensive learning can be achieved during debriefing and often depends on the debriefing skills of the facilitator as well as the learner’s perceptions of a safe and supportive learning environment as created by the facilitator.43 In contrast, poorly facilitated debriefings may create adverse learning, generate bad feelings, and may lead to a degradation of clinical performance, self-reflection, or harm to the educator-learner relationship.43 Debriefing provides an opportunity to clarify the learner’s knowledge and rationale for actions during the simulation experience.44 A systematic review of high-fidelity simulation literature reported that 51 studies listed educational feedback during debriefing as the single most important feature of simulation-based education.44

**Methods**

Exempt approval for the project was granted by the University of Pittsburgh Office of Human Subjects Protection. The first phase of the project involved alpha and beta course development to ensure that content was valid and that all instructors were knowledgeable about the course content and specific aims of this study and were prepared to instruct the course. All CRNA instructors for NARAT completed at least 50 epidural or spinal block placements in the last year and had an extensive knowledge base on regional anesthesia. Checklists for sterile technique, spinal block placement, and epidural block placement were adapted from previously published regional anesthesia checklists, with modifications designed to meet NARAT-specific course objectives. The modified Delphi approach was used to refine and ensure content validity of the developed checklists.45 Three expert CRNA instructors evaluated each checklist and offered feedback on each item. Each checklist action was listed in order (where appropriate) and assigned equal weight using a dichotomous scoring system (satisfactorily performed or unsatisfactorily performed). The iterative process allowed for systematic improvement and correction of any omissions or areas for improvement on each checklist item. The checklist review process continued until full consensus from the experts on all items was achieved.

The second phase of the project involved administering a precourse demographic and experience survey that focused on prior experience with spinal and epidural anesthetics, prior experience on the simulator trainer, prior practice on a spinal or epidural anesthesia trainer, preexisting skills, and comfort level before completing the course. A 15-minute video was produced that provided step-by-step instructions corresponding to the procedural and performance assessment checklists, to promote standardization. Minimum passing thresholds for the knowledge examination and skill checklists were established using a modified Angoff method.46 Precourse and postcourse evaluation surveys were developed. An 18-item postcourse survey was administered 6 months after successful course completion to evaluate perceived value and credentialing trajectory. Checklists for each participant as well as precourse and postcourse surveys were analyzed.

- **Interventions.** Development of the blended curriculum for spinal and epidural anesthesia training included online precourse didactic content, checklists, deliberate practice with mastery learning elements, and experiential learning with expert instructors. Baseline knowledge assessments were administered at the beginning of the course. Participants were required to achieve a threshold of 80% on the baseline assessment in order to progress to the hands-on component. A precourse/postcourse survey on attitudes was administered. The sample consisted of 49 CRNAs from a single large academic healthcare system who enrolled in the NARAT course, agreed to participate in this project, and completed all course elements including the precourse and postcourse surveys. The course was administered by staff at WISER. The online course consisted of 7 modules, all of which were referenced to standard textbooks. Completion of online materials took approximately 4 hours, as reported by the expert instructors. Completion of all course elements was tracked via the Simulation Information Management System at WISER. Each page that a student opened in the course allowed tracking of completion of material review.

The hands-on practice included use of 2 specific task trainers. A spinal injection trainer (Life/form Spinal Injection Simulator, Nasco Inc) was used for spinal anesthetic insertion training. It has the advantage of realistic tactile feedback combined with a spinal column that can be filled with fluid to mimic cerebrospinal fluid when the spinal needle is successfully placed. The Obese Adult Lumbar Puncture/Epidural trainer (Simulab) was used for all epidural insertion training. The obese simulator was used because it has the advantage of loss of resistance
at 4.5 to 5 cm during epidural insertion training. Actual sterile kits (spinal and epidural) and sterile gloves used in the clinical setting were used for sterile technique evaluation as well as for practicing techniques.

- **Development of Course Materials.** Course materials were developed through a literature review of best practices for checklist development, deliberate practice, simulation, and structured feedback/debriefing. Course materials, evaluation instruments, checklists for skill evaluation, and surveys were developed through modification of existing instruments, including iterative modification incorporating clinical expert consensus. As noted, the modified Delphi method was used for checklist refinement. Minimum passing thresholds were established using a modified Angoff method. The Angoff method is a commonly used and legally defensible method for setting passing or cut scores for high-stakes examinations or assessments.\(^{46}\) It can also be used for setting passing scores on clinical checklists. The use of the Angoff method to evaluate a skills checklist allows expert evaluators collectively or individually to determine if a hypothetical minimally competent student would perform each item on the checklist correctly.\(^{46}\) The purpose in developing such a checklist is to ensure that performance of critical steps has little variability during the educational process and also as a performance guide for students (when given access to the checklists).

Five expert clinical instructors were enlisted to determine the passing threshold for the checklists. Each expert used a score of yes (1) or no (0) in the modified Angoff method for determining the minimum passing thresholds for participants. The scores were averaged on each item and then for the entire checklists to determine cut scores. For the NARAT course, the checklists were used to score performance and to regulate flow of the deliberate-practice process. The checklists thus were used both as a training process guide and in evaluation of the processes being trained.

<table>
<thead>
<tr>
<th>Precourse survey</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average length of time as a CRNA, years</td>
<td>15.5</td>
</tr>
<tr>
<td>No preexisting regional skills</td>
<td>42 (86)</td>
</tr>
<tr>
<td>Experience with placement of epidural or spinal block</td>
<td>28 (57)</td>
</tr>
<tr>
<td>Had placed 1-5 “spinals” as a CRNA</td>
<td>31 (63)</td>
</tr>
<tr>
<td>Had placed 1-5 “epidurals” as a CRNA</td>
<td>40 (83)</td>
</tr>
<tr>
<td>Performed 1-5 sterile procedures a month</td>
<td>30 (61)</td>
</tr>
<tr>
<td>Performed 6-10 sterile procedures a month</td>
<td>19 (39)</td>
</tr>
<tr>
<td>Right-hand dominant</td>
<td>46 (93)</td>
</tr>
<tr>
<td>Last time any participant had placed a spinal or epidural block, months</td>
<td>≥ 24</td>
</tr>
</tbody>
</table>

### Table 1. Participants’ Experience as a Certified Registered Nurse Anesthetist (CRNA)

Results

- **Demographics (Precourse).** All the participants had prior anesthesia training on a simulator (SimMan, Laerdal Medical), spinal/epidural model, or other mannequin. Additional information regarding the participants’ experience as a CRNA and hand dominance was collected (Table 1).

- **Knowledge and Skills.** The independent online pre-course didactic work had an 80% threshold examination for the participants to be able to continue with the hands-on didactic portion. Fifty-two participants were originally enrolled. Three were not successful in meeting the threshold knowledge of 80% for the online didactic portion of the course and were dismissed from the hands-on didactic portion.

Forty-nine CRNAs successfully completed each item on the skills component. Deliberate practice was encouraged throughout the skill training until CRNAs indicated they were comfortable. A skills assessment was then conducted using the checklists. All CRNAs were required to achieve a 100% score on the checklist or were redirected to practice until competent and were then retested to the 100% threshold.

- **Attitudes (Precourse vs Postcourse).** Postcourse scores for comfort and confidence level for both spinal and epidural blocks were improved compared with precourse results. Means of both the comfort and confidence levels of placing spinal blocks after course completion; comfort/confidence level of placing epidural blocks after course completion; trajectory to credentialing; the role the NARAT course played in the credentialing process; attitude regarding skill improvement and development that included sterile gloving, preparation of the kit, and technique; evaluation of checklists; and attitude regarding safety. On the post-course survey, participants were also asked to rate the value of the course in facilitating their credentialing for regional anesthesia privileges at a single major healthcare organization in Western Pennsylvania.

- **Credentialing.** Forty-nine CRNAs successfully completed all aspects of the course and were thus eligible to be credentialed in the clinical setting. The goal was for
all 49 participants to be credentialed to perform spinal and epidural blocks in the clinical setting. However, only 5 (10%) of the participants were eventually credentialed at their home institution. All 5 CRNAs who were credentialed were from the same clinical facility in the healthcare organization. Their facility incorporated a supportive postcourse immersion rotation that enabled these CRNAs to practice their refreshed skills in the clinical environment soon after completion of the course. This factor was reportedly instrumental in the successful credentialing of 5 CRNAs who participated in the NARAT course.

**Discussion**

In this quality improvement project, best practices and guidelines for simulation course deployment, development, and improvement were used. These included use of the Delphi method/Angoff method for checklists, deliberate practice, realistic simulation, and debriefing and structured feedback. Initially, there was a plan to evaluate reported success and complication rates among CRNAs that were already credentialed in regional anesthesia with the CRNAs who participated in the NARAT course, as an attempt to bridge the gap in the literature of simulation training in the laboratory with transfer of skills to actual clinical practice. Unfortunately, only 5 CRNAs were successfully credentialed after their participation in the NARAT course. All 5 CRNAs were employed at the same facility, which had established a structured postcourse clinical training program. Although outside the sphere of control, this result emphasizes the critical nature of the training facility-clinical practice connection and the need to ensure that the training program trajectory includes agreement by each clinical facility that the staff will engage in completion of the credentialing pathway.

**Interpretation.** A blended curriculum including online components and best practices in simulation training techniques was effective in establishing a high level of knowledge and skill for all participants that established their eligibility to become credentialed in spinal and epidural block skills in a clinical setting. Incidental observations demonstrated that age may influence confidence and comfort levels regarding actual performance of spinal and epidural blocks. The older the practitioner, the less confident and comfortable he or she is performing certain tasks. This finding could be because the CRNAs are further away from their initial training or are less motivated at the end of their careers. Simulation-based deliberate-practice training can help to facilitate the comfort and confidence levels of CRNAs and other anesthesia providers in skill maintenance and can upgrade readiness for return to hands-on practice. Checklists were effectively developed and deployed for evaluation as well as to guide processes in the simulation training. Further study is warranted for evaluation of anesthesia practices and task performance milestones of confidence and comfort levels during performance of spinal and epidural anesthesia.

**Barriers to Credentialing and Practice.** Barriers to CRNA and APRN practice are complicated and multifactorial, and can vary substantially based on the practice setting. Reported barriers to credentialing specific to this project included the following:

- Lack of clinical support from leadership and anesthesiologists
- Fewer opportunities for CRNAs attempting to get credentialed at teaching institutions that have training responsibilities to residents and fellows
- Lack of interest of other hospital staff to assist CRNAs in patient positioning for spinal/epidural anesthesia
- Lack of opportunities based on clinical assignments for CRNAs
- No consistent opportunity to perform spinal/epidural anesthesia
- Discomfort performing regional anesthesia techniques with the production pressures that are common in the clinical arena and/or with the criticism that is voiced by supervising physicians in the presence of an awake patient.

**Limitations.** Limitations of this project included the small sample size of 49 CRNAs that were all from a single academic healthcare organization. It is possible that the organization’s culture influenced the results. It was difficult to demonstrate that the course intervention influenced clinical performance (including success and complication rate reduction) because only 5 CRNAs were ultimately credentialed as a result of the program. The

<table>
<thead>
<tr>
<th>Measure</th>
<th>Precourse Mean</th>
<th>Precourse SD</th>
<th>Precourse Median</th>
<th>Postcourse Mean</th>
<th>Postcourse SD</th>
<th>Postcourse Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epidural</td>
<td>2.0</td>
<td>1.0</td>
<td>2.0</td>
<td>4.0</td>
<td>0.58</td>
<td>4.0</td>
</tr>
<tr>
<td>Spinal</td>
<td>2.43</td>
<td>0.77</td>
<td>3.0</td>
<td>4.14</td>
<td>0.69</td>
<td>4.0</td>
</tr>
<tr>
<td>Confidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epidural</td>
<td>2.14</td>
<td>0.9</td>
<td>2.0</td>
<td>4.0</td>
<td>0.58</td>
<td>4.0</td>
</tr>
<tr>
<td>Spinal</td>
<td>3.0</td>
<td>1.1</td>
<td>3.0</td>
<td>4.14</td>
<td>0.69</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Table 2. Precourse/Postcourse Comparison of Comfort and Confidence Levels for Spinal and Epidural Technique for NARAT Course Participants

Abbreviation: NARAT, Nurse Anesthetist Regional Anesthesia Training.
lack of a precourse agreement connecting the training program to each clinical facility for finishing the credentialing path was a substantial limitation.

Conclusion
The development and maintenance of ongoing competency is critical for CRNAs who wish to perform spinal and epidural anesthesia but who have had a lapse in opportunity since graduation from their anesthesia programs. How these individuals navigate credentialing pathways toward resuming regional anesthesia practice is of concern across the industry. The integration of blended curricula, including high-quality simulation experiences with rigorous verification of knowledge and skill, is an important supplement to the traditional supervised apprenticeship model. These efforts are essential to bridging the existing CRNA practice gap (those whose initial training included regional anesthesia experience but who have not had the opportunity to maintain their regional skills in their recent practice). Simulation provides a safe environment in which to develop and hone skills with procedures, and to maintain or reestablish competency. Further development of checklists, deliberate practice, simulation, and structured feedback experiences has the potential to change laboratory performance, care practices, and patient outcomes if adequate clinical support is available in completing the credentialing pathway and then assessing clinical performance and patient care outcomes.

An important incidental observation was that age seems to be a factor in the anesthesia provider’s comfort level of performing a spinal or epidural. This is an important factor given the demographics of the CRNA workforce and may warrant future evaluation.

Some elements were essential during development of the blended course that was designed to help CRNAs improve the knowledge, attitude, and skills needed for competent regional anesthesia practice. These essential elements included recruitment and development of expert clinical instructors, quality control in curriculum development, preestablishing a supportive postcourse clinical process, and rigorous checklist development processes.

REFERENCES

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DISCLOSURES
The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.
According to the American Society of Plastic Surgeons, there were approximately 1.8 million cosmetic and reconstructive surgeries performed in the United States in 2012. Very few anesthesia-related mortality statistics and detailed descriptions of adverse events during cosmetic/plastic surgery are found in existing literature. This article describes the use of thematic analysis, and subsequent findings, of a cosmetic closed-claim database generated by the American Association of Nurse Anesthetists (AANA) Foundation Closed Claim Research Team. From the most current dataset of 245 claim files provided by the insurance company (CNA), we isolated 25 claims regarding patients undergoing cosmetic and/or related plastic surgery procedures performed from 2003 to 2012. Three major themes emerged from the claims data: (1) normalization of deviance, (2) ineffective communication patterns, and (3) nonadherence to the AANA Standards for Nurse Anesthesia Practice. Detailed descriptions of the adverse events as they relate to the major themes are provided, and suggestions are offered for actions that may mitigate future adverse events in this subset of the population.

Keywords: Adverse outcomes, Certified Registered Nurse Anesthetist, cosmetic surgery, malpractice closed claims.
why and provide a more elaborate understanding of the phenomenon of interest. Advantages and disadvantages of closed claim analyses have been previously described. The purpose of this research is 3-fold: identify themes that emerged from the cosmetic surgery closed claim dataset; describe a rich clinical picture of what transpired leading to the outcome; and provide insight that may change practice to improve anesthesia care.

The data analyzed for this study represent cosmetic procedures performed between 2003 and 2012, which accounts for 10.2% (n = 25) of the surgical categories in the most recent cohort of claims (N = 245). Cosmetic surgery and plastic surgery are closely related specialties, but not identical. The overall goals and focus of cosmetic surgery procedures are enhancing appearance and improving aesthetic appeal, symmetry, and proportions. Cosmetic surgery is elective and includes breast enhancement procedures, facial contouring and rejuvenation procedures, body contouring, and skin rejuvenation. Plastic surgery focuses on repairing defects to reconstruct normal function and appearance. It is a surgical specialty dedicated to the reconstruction of facial and body defects due to birth disorders, trauma, burns, and disease and is reconstructive in nature.

Claims involving patients undergoing either cosmetic or plastic surgery were included and placed under a single category identified as cosmetic. The research questions were:

1. What themes emerged related to anesthetic technique that appeared to contribute to adverse events?
2. What themes emerged related to human behaviors that appeared to contribute to adverse events?
3. Did themes emerge that demonstrated deviations from the AANA Standards for Nurse Anesthesia Practice?

The purpose of this article is to report the answers to these questions framed within the clinical context of care provided by Certified Registered Nurse Anesthetists (CRNAs) during cosmetic surgical procedures.

### Methods

The insurer, CNA, made available to the AANA Foundation Closed Claim Research Team 245 closed-claim files for this most recent inquiry. With use of keywords as filters, data were extracted from the 245 files, resulting in 25 files identified as cosmetic and/or plastic surgery. The authors reviewed the 25 claims and validated the type of surgery as the inclusion variable. The method to conduct the research, inclusive of analytic processes, followed the Thematic Framework Approach described elsewhere. Modifications of the thematic framework were slight and only due to the uniqueness of the dataset and documents in each closed-claim file. A data collection instrument, previously developed and

<table>
<thead>
<tr>
<th>Patient characteristic</th>
<th>No. (%) of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>23 (92)</td>
</tr>
<tr>
<td>Male</td>
<td>2 (8)</td>
</tr>
<tr>
<td>ASA class</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5 (20)</td>
</tr>
<tr>
<td>2</td>
<td>14 (56)</td>
</tr>
<tr>
<td>3</td>
<td>6 (24)</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>27.2</td>
</tr>
<tr>
<td>Age, y</td>
<td>50.4</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of Cosmetic Claims Sample (N = 25)

**Table 2. Outcomes of Cosmetic Claims**

<table>
<thead>
<tr>
<th>Clinical outcome</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve injury</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Brain injury</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Burns</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Cauda equina syndrome</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Chronic pain</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Death</td>
<td>12 (48)</td>
</tr>
<tr>
<td>Necrosis/amputation</td>
<td>1 (4)</td>
</tr>
</tbody>
</table>

Table 3. Type of Cosmetic Procedures

1. Bilateral breast reduction
2. Excision of facial lesion
3. Abdominoplasty and mammoplasty
4. Lipectomy and breast augmentation
5. Release of burn contracture
6. Face-lift including rhinoplasty
7. Placement of IV catheter postoperatively
8. Multiple facial procedures
9. Abdominoplasty
10. Liposuction and face-lift
11. Excision of multiple facial lesions
12. Liposuction
13. Liposuction and abdominoplasty
14. Abdominoplasty and breast augmentation
15. Breast augmentation and face-lift procedures
16. Liposuction and fat transfer
17. Face-lift
18. Liposuction
19. Breast augmentation
20. Face-lift
21. Endoscopic face-lift
22. Breast augmentation
23. Multiple facial procedures
24. Liposuction
25. Face/neck/brow-lift
tested for interrater reliability, allowed for the capturing of detail from each claim file. The instrument has 4 distinct sections that prompt the researchers to document, in free form, events that lead to the claim, and include the reviewer’s narrative, reviewer’s assessment, listing of accusations, and a description of key lessons learned. These 4 written narratives provided the major contribution of words for thematic analysis. Adopting the Thematic Framework Approach easily allowed for maintaining qualitative trustworthiness, the equivalent to quantitative validity and reliability. Additionally, comparisons of the anesthetic technique and specialized and behavioral actions of the CRNA were made to the AANA Standards for Nurse Anesthesia Practice.

Results
Adhering to the previously described approach, completion of analysis of the 25 cosmetic claims ensued.

**Drug selection and dosing**
- Failure to individualize drug dose for patient
- Administration of excessive sedation
- Administration of excessive local anesthetic dose
- Administering $\beta$-blocker before local anesthetic with epinephrine as a routine despite bradycardia
- Administration of caustic drug in a peripheral foot vein

**Monitoring**
- Failure to employ ETCO$_2$ monitoring
- Unrecognized esophageal intubation

**Management**
- Failure to immediately intubate when clearly necessary
- Proceeding with multiple attempts to place epidural block in a patient with a history of lumbar spine disease/previous lumbar surgery and complications
- Proceeding with IV insertion despite paresthesia
- Administering deep sedation without provision of oxygen or securing airway
- Administering high-flow oxygen near ignition source
- Early discharge of morbidly obese patient with OSA following 13-hour surgery
- Proceeding with surgery/anesthesia despite low unexplained preoperative SaO$_2$
- Failure to conduct comprehensive preoperative evaluation or proceeding despite lack of necessary preoperative testing

**Equipment**
- Placing a heated saline bag under patient’s axilla for positioning
- Failure to use safety straps for positioning
- Use of a chair for positioning because OR table was broken

**Patient selection/match for facility**
- Performing anesthesia/surgery on patients with ASA status 3 or greater
- Performing anesthesia/surgery in extremely obese patients in office/freestanding surgical centers
- Performing multiple procedures in patients in office/freestanding surgical centers
- Performing procedures lasting excessive times in office/freestanding surgical centers

<table>
<thead>
<tr>
<th>Table 4. Identified Behaviors Representing Normalization of Deviance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbreviations: ETCO$_2$, end-tidal carbon dioxide; IV, intravenous; OR, operating room; OSA, obstructive sleep apnea; SaO$_2$, arterial oxygen saturation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Identified Behaviors Representing Normalization of Deviance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug selection and dosing</strong></td>
</tr>
<tr>
<td>• Failure to individualize drug dose for patient</td>
</tr>
<tr>
<td>• Administration of excessive sedation</td>
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<tr>
<td><strong>Monitoring</strong></td>
</tr>
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<td>• Failure to employ ETCO$_2$ monitoring</td>
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<td>• Proceeding with surgery/anesthesia despite low unexplained preoperative SaO$_2$</td>
</tr>
<tr>
<td>• Failure to conduct comprehensive preoperative evaluation or proceeding despite lack of necessary preoperative testing</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
</tr>
<tr>
<td>• Placing a heated saline bag under patient’s axilla for positioning</td>
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<td>• Failure to use safety straps for positioning</td>
</tr>
<tr>
<td>• Use of a chair for positioning because OR table was broken</td>
</tr>
<tr>
<td><strong>Patient selection/match for facility</strong></td>
</tr>
<tr>
<td>• Performing anesthesia/surgery on patients with ASA status 3 or greater</td>
</tr>
<tr>
<td>• Performing anesthesia/surgery in extremely obese patients in office/freestanding surgical centers</td>
</tr>
<tr>
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</tr>
<tr>
<td>• Performing procedures lasting excessive times in office/freestanding surgical centers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5. Ineffective Communication Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of the cosmetic claims sample, outcomes, and types of procedures are shown in Tables 1 through 3.</td>
</tr>
<tr>
<td>Most cases involved female patients with an ASA physical classification of 2 for elective procedures performed in ambulatory surgery facilities. Major themes that emerged from the dataset included (1) normalization of deviance, (2) ineffective communication patterns, and (3) deviations from the AANA Standards for Nurse Anesthesia Practice. Examples of behaviors validating the theme “normalization of deviance” are provided in Table 4, examples validating the theme “ineffective communication” are provided in Table 5, and specific</td>
</tr>
</tbody>
</table>

| Lack of disclosure |
| Dishonesty |
| Lack of transparency |
| Failure to advocate |
| Intimidation |
standards of care that were not adhered to are described in this section. Table 6 reveals that frequently more than 1 theme played a role in the outcome of care.

- **Normalization of Deviance.** Normalization of deviance is defined as the gradual process through which unacceptable practices or standards become acceptable. \(^{12}\) As the nonstandard behavior is repeated without catastrophic results, it becomes the social norm for the organization or, in these cases, for the providers of care. \(^{12}\) The following cases are excerpts drawn from the files demonstrating evidence of normalization of deviance.

- **Case 1.** In a scenario involving a bilateral breast augmentation and mammoplasty, the anesthetic plan was a nondescript field block with a mixture of lidocaine, bupivacaine, and epinephrine, and intravenous sedation. Sedation included propofol administered via a continuous infusion and intravenous bolus doses of midazolam and fentanyl. Intravenous labetalol, a \(\beta\)-adrenergic blocking agent, was administered before the field block. The baseline heart rate before administration of any anesthesia medications was noted to be 50/min to 60/min. The total dose of local anesthetic exceeded recommended doses based on patient weight. Following incision, the heart rate decreased from 58 to 59/min to 39/min. Shortly thereafter, the patient became asystolic. Although resuscitation efforts were successful and vital signs stabilized within minutes, the patient never regained full consciousness and died a few days later. The postmortem report denoted the cause of death as anoxic encephalopathy secondary to cardiac arrest consistent with acute heart failure and coronary artery insufficiency. Documented in the claim notes, the CRNA expected the patient to experience tachycardia from the epinephrine as part of the field block, and labetalol was administered to counteract the expected tachycardia. When asked why a \(\beta\)-blocker was given, the anesthetist indicated, “It is the way I always do it.”

- **Case 2.** A 41-year-old woman with a body mass index of 31.6 kg/m\(^2\) and a history of hypertension presented for liposuction of the flank and buttocks to a freestanding ambulatory surgery center. Sedation was the noted anesthesia plan. After prone positioning and

### Table 6. Themes Identified in Cosmetic Surgery Closed Claims

<table>
<thead>
<tr>
<th>File No.</th>
<th>Procedure</th>
<th>Normalization of deviance</th>
<th>Ineffective communication</th>
<th>Nonadherence to standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Liposuction</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Multiple facial procedures</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Breast augmentation</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Face-lift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Face-lift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Liposuction</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Abdominoplasty/breast augmentation</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Abdominoplasty/liposuction (^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Multiple lesions/excisions</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Multiple facial procedures</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>IV catheter insertion (postoperatively) (^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Release of burn contractures/grafts</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>13</td>
<td>Face-lift/thinoplast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Lipectomy/breast augmentation</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Abdominoplasty/breast augmentation</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Excision of facial mass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Bilateral breast reduction (^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Liposuction flank/facelift</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Multiple facial procedures (^a)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td>Liposuction/fat transfer</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>21</td>
<td>Abdominoplasty</td>
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<tr>
<td>22</td>
<td>Breast augmentation</td>
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<td></td>
<td></td>
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<tr>
<td>23</td>
<td>Multiple facial procedures</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>24</td>
<td>Liposuction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Multiple breast/body/facel procedures</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

\(^a\)Claims with no theme identified.
application of oxygen, intravenous midazolam, fentanyl, propofol, and ketamine were administered immediately before the surgeon injected lidocaine and saline into the buttocks. The patient’s oxygen saturation decreased to 80%, and after 15 to 20 minutes of failed attempts to increase it, the patient was repositioned supine. There was no indication of use of end-tidal carbon dioxide monitoring. Subsequently the patient was intubated but progressed to a full cardiac arrest and eventually died after transfer to the hospital.

- **Ineffective Communication Patterns.** The Joint Commission has defined effective communication patterns as the transfer of content from a sender to a receiver in which both the sender and receiver achieve a shared understanding and perceive the content in the same way. Communication failures are known to be the leading cause of inadvertent patient harm; many factors contribute to these failures unique to healthcare. The authors of this report operationally defined ineffective communication as those patterns of communication in stark contrast to The Joint Commission definition of effective patterns. Table 5 depicts the ineffective communication patterns that illuminated this theme. The following cases are excerpts drawn from the files demonstrating evidence of ineffective communication patterns.

- **Case 1.** A 72-year-old woman presented for elective outpatient cosmetic surgery involving a facelift and multiple other facial procedures. The planned anesthetic was general anesthesia with placement of an endotracheal tube. In the patient’s medical record—and documented as “unremarkable”—was a recent cardiac consultation and assessment, a “cleared for surgery” note from the primary care provider (PCP), and a laboratory report revealing a preoperative hemoglobin (Hb) level of 10 g/dL. The CRNA consulted the surgeon about the low starting Hb level; reassurance was given that blood loss would be minimal. At that time, the CRNA contacted the PCP concerning the Hb level; however, no additional useful information was provided. The same clearance note and cardiac catheterization report were resent to the anesthetist; the anesthesia before initiating epidural anesthesia/analgesia.

- **Case 2.** A patient underwent a 290-minute breast augmentation in a freestanding ambulatory surgical facility. The operating room table had been out for repair, and a makeshift table resembling a dental chair was used in its place. The arms of the chair were not adjustable for appropriate patient positioning. Whether the CRNA felt persuaded, coerced, or even intimidated and therefore proceeded with the case using the dental chair instead of the appropriate table is unclear but may be presumed from documentation in the file. However, during the anesthetic, the CRNA continuously asked the surgical team to reposition the pseudo arm boards. Although the CRNA documented positioning changes made during the procedure, the patient emerged complaining of left arm numbness. She later received a diagnosis of a brachial plexus nerve injury. Despite the operating room table being broken, the “team” agreed to do the lengthy procedure in the makeshift chair.

- **Nonadherence to the AANA Standards for Nurse Anesthesia Practice.** Themes emerged demonstrating deviations from the AANA Standards for Nurse Anesthesia Practice. Direct comparisons were made between documented care processes in the claims to the AANA Standards. The AANA Standards preamble states that adherence to the standards cannot ensure specific outcomes. Their intended applicability, however, is to promote high-quality care, assist the CRNA in evaluating care, provide a common base for CRNAs to use in their development of a high-quality practice, assist the public in what to expect from anesthetists, and support and preserve the basic rights of the patient. The following are examples of nonadherence to Standards I, IV, VII, and VIII.

**Standard I:** Perform and document a thorough preanesthesia assessment and evaluation.

- Failure to further investigate a low preoperative oxygen saturation before proceeding with general anesthesia
- Failure to identify a history of lower back pain, back injury, spinal surgery, and past difficulty with regional anesthesia before initiating epidural anesthesia/analgesia

**Standard IV:** Implement and adjust the anesthesia care plan based on the patient’s physiologic status. Continuously assess the patient’s response to the anesthetic, surgical intervention, or procedure. Intervene as required to maintain the patient in optimal physiologic condition.

- Failure to monitor respirations and titrate anesthetic accordingly
- Failure to recognize an esophageal intubation
- Failure to monitor ventilation (end-tidal carbon dioxide)

**Standard VII:** Evaluate the patient’s status and deter-
mine when it is safe to transfer the responsibility of care. Accurately report the patient’s condition, including all essential information, and transfer the responsibility of care to another qualified healthcare provider in a manner that assures continuity of care and patient safety.

- Failure to transfer to a greater resourced hospital a patient who had low beginning Hb level and subsequently experienced substantial intraoperative blood loss
- Failure to transfer a patient from a freestanding surgical center to a hospital with sustained motor block following an epidural anesthetic
- Transfer of care to nonqualified, nonlicensed providers.

**Standard VIII:** Adhere to appropriate safety precautions as established within the practice setting to minimize the risks of fire, explosion, electrical shock and equipment malfunction. Based on the patient, surgical intervention or procedure, ensure that the equipment reasonably expected to be necessary for the administration of anesthesia has been checked for proper functionality and document compliance. When the patient is ventilated by an automatic mechanical ventilator, monitor the integrity of the breathing system with a device capable of detecting a disconnection by emitting an audible alarm. When the breathing system of an anesthesia machine is being used to deliver oxygen, the CRNA should monitor inspired oxygen concentration continuously with an oxygen analyzer with a low concentration audible alarm turned on and in use.

- Failure to use proper precautions to prevent fire in the operating room.

**Discussion**

Anesthesia is vital to patient safety during surgical, diagnostic, and other related procedures. Safety comprises not only the chosen technique but also the actions of providers, the team, and the patient, in each respective setting. Any one of these components can and does influence the outcome of care. Analysis of adverse events associated with anesthesia through the review of closed malpractice claims was originally noted in the literature in 1985 when Dr F. Cheney published the article describing cardiac arrest following spinal anesthesia.16 Years later and following a similar trajectory, the AANA Foundation assembled a CRNA research team for similar purposes, with the exception that the closed-claim project is explicit to cases involving CRNAs. The intent was to use established and reliable methods to gain knowledge about adverse events during anesthesia; to identify if contributions to the unfavorable outcome were by members of the team, including the anesthetist; and to isolate components of care negatively influencing outcomes. Once details were analyzed, reporting of findings and ultimately recommendations to modify practice patterns, for the goal of improving patient care, could be made.3

Historically, closed-claim research, conducted as retrospective reviews of medical records, legal documents, and other documents, permitted quantification of morbidity and mortality rates. Additionally, if enough information was available, a descriptive narrative accompanied the metrics. We are limited to this type of method for closed-claim research because an experiment or other research approach such as qualitative participant observation17 is illogical and not an option. It would be unethical to design an experiment comparing unacceptable practices with established standards of care. It would also be impractical to design a participant-observation qualitative study because this requires an unbiased observer to be present for every anesthetic and to transcribe all details of adverse events. Because adverse events are rare, the participant-observation approach is unfeasible. The study of adverse events in anesthesia is therefore limited to the analysis of documents within closed claims.

There is no disputing the value of the retrospective review of anesthetics and surgery proceedings when adverse events occur; in the same manner is the process of root cause analysis. However, a large gap remains, especially when there is no scientific or physiologic reason that explains a poor outcome. In the landmark analysis of cardiac arrest during spinal anesthesia, the claims analysis identified 2 patterns that most likely contributed to patient morbidity and mortality: sedation that produced a comfort state concomitant with unidentified cessation of breathing, and an inadequate appreciation of the interaction between regional anesthesia sympathetic blockade and how this affects resuscitation efforts.16 Dissemination of the results of this research allowed providers to understand what transpired that led to the poor outcomes and therefore an immense opportunity to improve patient care prospectively. What remains in the gap is an understanding of how and why we make the decisions we do, how we move forward in solving care dilemmas, and how we prevent anesthesia-related contributions to the unfavorable outcome. The most recent claims provided to the research team by CNA offered an opportunity to fill this gap in knowledge specific to adverse events during cosmetic surgical procedures.

Employing thematic analysis research methods, we can now begin to answer the research questions posed: what patterns emerged related to the anesthetic technique that appeared to contribute to the adverse event, what themes emerged related to human behaviors that appeared to also contribute to the poor outcome, and did deviations from the AANA Standards for Nurse Anesthesia Practice occur? The information gleaned provides an illumination of each respective situation. Portions of previously conducted closed-claim research had partial descriptive narratives, for example, where the researchers tried to identify whether the provider performed according to applicable standards of care at the time and therefore demonstrate vigilance. In addition, it was easy to make
correlations between adherence to care standards and remuneration. As expected, adherence to the standards of care led to payouts that were much less. This is valuable information no doubt, but unfortunately does not illuminate actions of the provider, team, and patient to the extent that is necessary to understand what truly transpired. Employing thematic analysis, we have added critical information to traditional descriptive methods.

The number of cosmetic surgical procedures in the most recent dataset of closed-claim files was large enough to warrant isolating these files for independent analysis. We sought to determine if there was something unique about the components of anesthesia care for these types of procedures. According to the American Society of Plastic Surgeons website,18 nearly 1.8 million cosmetic surgical procedures were performed in 2016. The top 5 surgical procedures involved breast augmentation, liposuction, nose reshaping, eyelid procedures, and facelifts. These are also the types of procedures inclusive of this dataset. Although the number of claims analyzed (N = 25) appears small relative to the 1.8 million cosmetic surgical procedures performed annually in the United States, any number is worthy of investigation.

Normalization of deviance and ineffective communication patterns were 2 of 3 themes that emerged during data analysis. Additionally, nonadherence to, or deviation from, the AANA Standards for Nurse Anesthesia Practice were identified; these were considered congruent with the 2 overarching themes. Worth repeating, the definition of normalization of deviation is the gradual process through which unacceptable practices or standards become acceptable. Initially addressed in nonhealthcare settings (ie, aeronautics and aviation), this phenomenon is becoming increasingly evident in the healthcare milieu. Becoming insensitive to deviant practices that these practices no longer appear objectionable is a major feature. This type of behavior develops in a gradual and subtle manner and may continue for extended periods without catastrophic events. Eventually, critical factors line up, problems occur, and only then there appears to be an impetus to discontinue the behavior.19 Examples of normalization of deviance in anesthesia and surgical settings, such as failing to do time-outs before procedures, not following the universal protocol, shutting off alarms, omitting neuromuscular blocking reversal agents, and breaches of infection control guidelines, have all been reported.20 We also identified other patterns of deviant behavior during the claims analysis and, as such, we continue to search for answers as to why the deviation occurred. Conceivably drivers, such as time, cost, and even peer pressure created barriers to performance considered safe and standard-adhering. Perhaps in the cosmetic surgical setting, the pressure to get the surgery done prevails because most procedures are elective, private pay, and desired by the patient. These motivations to proceed are very different from nonelective procedures where the surgery and anesthetic itself is critical for survival, or at best, an enhanced quality of life. Maybe anesthetists feel an obligation to improvise to appease the patient and truly do not see the potential harm that may ensue. The Figure illustrates a model developed by the authors depicting movement from safe to unsafe practice patterns and the benefits that may be presumed for those deviating. The result is usually catastrophic but not immediately recognized like the benefits are. There

**Figure.** Movement From Safe to Unsafe Practice Patterns

X axis represents practice patterns and adherence to accepted standards of care and moves from right to left. Y axis represents the relative benefits of deviating from safe practices, which are listed to the right of the graph. As providers, patients, and/or teams deviate from safe practices (represented by green star) to unsafe practices (red stop sign), the benefits for those deviating increase. † indicates increased.
is tremendous opportunity to learn from other trades, gain an awareness of this concept, and identify steps that prevent deviant behaviors and practices from persisting.20

Additionally, it is important to recognize that the phenomenon of normalization of deviance is not indicative of a lack of critically important knowledge.21 The psychology of decision making has been studied across disciplines to determine why cognitive errors are made in both judgment and processes. It has been discovered that cognitive errors are intimately related to decision-making processes; they occur more often than any technical errors.21 Errors in decision making are different from gaps in knowledge; however, identifying why these errors are made is crucial to preventing them from happening repeatedly. There appears to be a relationship between cognitive errors as a component of decision-making processes and patterns of normalization of deviant behaviors inherent in these findings.21

Possibly another reason for deviant actions turned normal is that CRNAs develop a false sense of security with drugs that are used, monitors heavily relied on, and the minimal overall numbers of adverse events that do occur. This may precipitate a skewed view of reality and a false sense of comfort. Have we become too relaxed with our team, our processes, and our technical equipment, that we improvise in more ways than we realize? Has improvisation not been met with negative consequences often enough to reinforce compliance with standard-of-care practices?

The second major theme that emerged from this dataset is the concept of ineffective communication and related patterns. Communication, both effective and ineffective, is addressed extensively in healthcare while relating it to patient safety and error reduction. It is not a new concept but certainly worthy of further consideration. Unlike normalization of deviance, there is not a unique or clear definition of what constitutes ineffective communication; therefore, identifying patterns that are in opposition to universally accepted effective communication processes and behaviors seems appropriate. The Joint Commission has defined effective communications patterns as the transfer of content from a sender to a receiver in which both achieve a shared understanding and perceive the content in the same manner.13

Good communication practices among the healthcare team improve the quality of care provided to patients that ultimately precipitates favorable outcomes. Additionally, good communication is considered an inalienable right and a prerequisite for building genuine and meaningful relationships between patients, nurses, and other health professionals.22 There is a clear and strong association between nurse-physician communication and collaboration and positive patient outcomes such as lower mortality rates.23-25

This analysis, rather straightforward, easily identified several ineffective communication patterns. It was obvious when a communication failure by the provider, team member, or patient appeared to contribute to the adverse event or poor outcome. Instances of nondisclosure from the patient, deceit on the part of patients and other members of the team, a lack of transparency specific to knowing something about the patient and/or setting but keeping it to oneself, a failure on the part of the CRNA to advocate on behalf of the patient, and intimidation, were all evident. These failures in the high-risk perioperative setting cannot persist. Bezemer et al26 studied communication failures affecting patient safety in the operating room by conducting intraoperative random observations and found 76 communication failures during 150 hours of observation. Because of the findings, a team training curriculum followed, which included teamwork importance and communication skills. The result of the team training was a significant reduction in communication failures.

We accept the challenges that exist among healthcare professionals and their inability to facilitate effective communication practices, practices that indeed potentially favorable patient outcomes. The intricacies of each distinct setting, the fact that multiple providers prioritize numerous activities independently and often in a silo context, the existence of hierarchical organizational structures, and a lack of established educational curricula that focus on teamwork and communication skills are all factors that can contribute to adverse events related to faulty communications.27

The findings of this cosmetic closed-claim thematic analysis direct us to consider, for CRNAs and the entire perioperative team, team training that focuses on effective communication strategies and education on the concept of normalization of deviance and the psychology of decision making. There currently exist many opportunities for healthcare professionals to learn about patient safety initiatives from a plethora of perspectives and regulatory processes; however, much of the impetus to engage in education with a focus on improving patient safety, reducing errors, and minimizing adverse outcomes is based on self-motivation. The results of this study beg the question: should formal requirements for credentialing, as it relates to patient safety and effective communication strategies, be mandated?

Table 7. Limitations of Retrospective Cosmetic Closed Claim Analysis

- Use of secondary source data
- Presence of missing or conflicting data
- Inferior level of evidence compared with prospective research
- Small sample size
- Lack of control of extraneous variables
- Actual number of total adverse events unknown
A crucial component to mitigating risks leading to anesthesia mishaps and patient injury begins with ensuring that an educated and cohesive team is in place. Often we look to organizations to provide this structured education, but should we wait for such external opportunities? Although most healthcare organizations do invest in educating their workforce on strategies to improve patient safety, what remains clandestine is the extent of the programs and devoted resources to the cause. We would venture to say that most systems do not provide true team training or simulation experiences that provide the insight needed to build teams, avert poor communication, and assist providers in recognizing behaviors consistent with normalization of deviance. Focus on, and development of, teamwork and communication are the foundational changes needed to bring about improved patient outcomes. Interventions to improve care must be inextricably linked with efforts to improve teamwork, and with networks of teams to centralize the common goal of patient safety. Without this approach, a “silo syndrome” develops where over time individual workgroups manifest their own culture to meet their needs rather than interacting on common agendas across the organization, industry, or profession, resulting in fragmented practice standards that put patients at risk.

There are a few methodologic weaknesses associated with our study. One of the authors (M.G.) has already identified the limitations associated with retrospective chart reviews. Another limitation is the use of secondary source data. Ideally, thematic analysis methods are considered highly reliable when the researcher has access to primary source data such as interview transcripts between the researcher and the anesthetist who provided care during the adverse event. Without this approach, the analysis of qualitative data in multi-disciplinary health research is compromised.

In conclusion, themes emerged from the dataset of closed-claim files for cosmetic surgery that appeared to contribute to adverse events. They included anomalous anesthetic techniques, aberrant patterns of human behavior, and noncompliance with the AANA Standards for Nurse Anesthesia Practice. Rarely was a single theme identified as the lone contributor to the adverse event.

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Communication errors result in substantial perioperative morbidity and mortality. More than 70% of medical errors are related to poor communication. Despite practice guidelines and regulatory directives to standardize patient handoffs, evidence shows that the transfer of patients by anesthesia providers remains informal and brief. The purpose of this evidence-based practice improvement project was to implement a standardized handoff to improve the quality and continuity of the transfer of information, perceptions of patient safety, and healthcare worker satisfaction. Twenty CRNAs were selected using purposive nonprobability snowball sampling to create a Team Strategies to Enhance Performance and Patient Safety (TeamSTEPPS) change team. Participants completed an anonymous preintervention survey regarding their handoffs of anesthetized patients. Education was provided regarding the problem and current practice guidelines. The team modified and adopted their own version of Wright’s PATIENT mnemonic, which was implemented for 2 weeks. The change team completed an anonymous postintervention survey. Preintervention and postintervention survey data were analyzed using paired t test with a range of P < .0001 to .0003, demonstrating statistically significant improvements in the quality and continuity of the transfer of information, perceptions of patient safety, and healthcare worker satisfaction.

Keywords: Anesthetized patient, perioperative safety, standardized handoff, TeamSTEPPS.
indicating an improvement in team communication when a checklist was used.6

A prospective randomized controlled trial of 120 post-anesthesia handoffs demonstrated that the percentage of overall items handed off increased significantly with the use of a written checklist tool.4 A 2-part controlled trial with an 85% response rate (n = 51) demonstrated inclusion of key patient information, including code status, problem list, and medication lists 100% of the time when a structured handoff tool was implemented compared with less than 55% at baseline (P < .01) in subjects who did not receive the intervention.7 This finding indicated that the implementation of a structured handoff tool resulted in significant improvement in the quality and continuity of information transfer.7 Although quality and continuity of information transfer is an important outcome measure, without healthcare worker satisfaction, implementing any type of process change can be extremely difficult.

• Improved Healthcare Worker Satisfaction. Metrics for satisfaction are a relatively important measure for implementation and evaluation of a handoff tool.5 The use of a structured form or checklist that promoted transfer of pertinent information was shown to be a facilitator of handoffs, also promoting nurse satisfaction, whereas too little information, too much information, and inconsistent quality were seen as barriers to handoffs that led to the dissatisfaction of nurses.8

Satisfaction with a structured handoff tool was demonstrated by Wright,9 involving a large convenience sample (N = 1,000) of Certified Registered Nurse Anesthetists (CRNAs) from 3 hospitals with a response rate of 30.2% (n = 302). Most of the 30 CRNAs who completed an evaluation questionnaire agreed or strongly agreed that they like the idea of adopting a standardized handoff process.9 All agreed or strongly agreed that the use of the PATIENT mnemonic (Figure 1, first column) to facilitate standardized handoffs of anesthetized patients was effective and organized.9 A structured handoff tool also improved residents’ confidence in the handoff process, indicating satisfaction.7 Whereas quality and continuity of information transfer and healthcare worker satisfaction were predominate themes that demonstrated improvement with the use of a standardized handoff procedure, neither is as fundamentally important to the implementation of a standardized handoff procedure as the issue of patient safety.

• Improved Patient Safety. Implementing a standardized checklist improved communication in the surgical suite, demonstrating a positive standardized effect size that indicated improvements in morbidity, 0.123; mortality, 0.088; and compliance with safety measures, 0.268 (P < .05).6 In a 2-part controlled trial of 241 subjects (control, n = 80; experimental, n = 161), the rate of perceived near-miss events after implementation of a structured handoff tool was reduced by 23.5% (P = .0341).7 “Improving patient safety” has been identified as a distinguishing trait that is most likely to lead to the adoption of a standardized transfer process and a change in practice (n = 234, 77.4%).9

• Evidence-Based Practice Guidelines. Although theory provides a framework for predicting what will happen when original research is conducted, it is practice guidelines based on proven evidence that guide EBP improvement projects.

The AORN has established a guideline on patient handoffs for healthcare workers based on research and evidence provided by the DoD PSP and standards set forth by The Joint Commission National Patient Safety Goals. The purpose of the guideline is to provide structure and support to performing standardized handoffs while transferring care of surgical patients to diminish the risk of error and improve patient outcomes.2 The AORN’s mission is to collaborate with professional and regulatory organizations, industry leaders, and other healthcare partners to promote safety and optimal outcomes for patients undergoing operative and other invasive procedures.2 Addressing a national movement to improve communication between healthcare teams, which was prompted by the Institute of Medicine’s challenge to prevent medical errors and The Joint Commission’s analysis of more than 3,000 sentinel events implicating communication breakdowns during handoffs, the AORN joined with the

![Modified PATIENT Mnemonic to Facilitate Standardized Handoffs of Anesthetized Patients](image-url)

**Figure 1.** Modified PATIENT Mnemonic to Facilitate Standardized Handoffs of Anesthetized Patients

Abbreviations: ETCO2, end-tidal carbon dioxide; I and O’s, intake and outtake; IVs, intravenous lines; O2, oxygen; PIP, peak inspiratory pressure; pre-op, preoperative; RR, respiratory rate; vent, ventilation.

(Adapted from Wright.)
DoD PSP to model a toolkit for use in the perioperative environment.\textsuperscript{1,3} This toolkit is a product created out of the evidence-based team training curriculum used by the Department of Defense (DoD) called Team Strategies to Enhance Performance and Patient Safety (TeamSTEPPS); it provides a guideline for standardizing patient handoffs in accordance with the 2007 Joint Commission National Patient Safety Goals Requirement 2E.\textsuperscript{2,10} The AORN recommends that each healthcare facility adopt, develop, and implement a tool that promotes standardization of the handoff process, with the goal of improving patient care and enhancing patient safety.\textsuperscript{2} The AORN recognizes that each perioperative setting is unique. The organization does not endorse any tool, but rather it provides a guideline for handoff tool development to standardize the handoff process, benefiting from DoD PSP successes, while also aligning with the Joint Commission requirements and allowing for adaptions in unique practice settings.

The DoD has used these TeamSTEPPS techniques for more than 20 years and has demonstrated evidence of improved communication, patient safety, and reduction of errors related to communication breakdowns. Borrowed in part from communication processes in the aviation industry, TeamSTEPPS provides a conceptual framework designed to guide EBP change projects with a focus on effective communication in healthcare to improve patient safety.\textsuperscript{10} The TeamSTEPPS model integrates Kotter's Eight Step Process of Successful Change, but further delineates the process by outlining 3 phases, which include up to 17 steps.\textsuperscript{11,12} TeamSTEPPS was recently adopted as the official quality improvement infrastructure at the author's large regional medical center and is specifically designed to be tailored to the organization in which it is being implemented. Various steps in phases 1 and 2, such as conducting a site assessment, gaining leadership commitment, and preparing the environment, were previously addressed. A sense of urgency is created by presenting statistical evidence, in this case related to morbidity and mortality due to medical errors caused by communication breakdowns during handoffs.\textsuperscript{10,11} Next, the change team is built by choosing key players and proven leaders who can lead the change process.\textsuperscript{10} The team then develops a change vision and strategy, in this case determining which phase of the perioperative continuum will be the first point of implementation and what type of tool should be created or adapted for standardizing handoffs. Communication is focused on promoting buy-in from resisters by acknowledging their concerns and by strengthening and improving the change project through answering tough questions.\textsuperscript{10} Once the implementation phase begins, short-term goals are set, such as the successful handoff of perioperative patients for 2 weeks using the new standardized process. Successes are shared to empower others to get involved. Finally, a critical mass is reached, and the group, who has influence over the individual, is performing standardized handoffs routinely.\textsuperscript{13} A new culture is formed. Sustainment focuses on continuing cycles of planning, training, assessment, and implementing, to continually improve the process and ensure continued success.

**Methods**

- **Project Design.** This EBP quality improvement project used a pretest/posttest quality improvement design. It follows The Johns Hopkins EBP model\textsuperscript{14} and guidelines, and implements concepts and principles of the TeamSTEPPS framework, explained earlier. Proposals were submitted to the institutional review boards at both the hospital and the university to obtain approvals. This project did not involve human subject research and qualified for expedited, exempt review. Participation in this project was voluntary.

- **Sample.** The project consisted of 20 CRNAs involved in the transfer of care of anesthetized patients in the perioperative department of an 800-bed regional medical center in West Central Florida. This project used purposive, nonprobability, snowball sampling from a convenience sample of CRNAs to create a “change team.” Early adopters, innovators, laggards, and potential naysayers were specifically selected.

- **Instrument.** The preintervention and postintervention surveys were based on a pilot instrument published by Wright\textsuperscript{9} on Examining Transfer of Care Processes in Nurse Anesthesia Practice, which this investigator was given permission to adapt. The preintervention survey consisted of 1 categorical question, 5 multiple-choice items, and 3 open-ended questions. Items were modified to more closely address the indicators of this project: continuity and quality of transfer of information, perioperative staff satisfaction, and perioperative staff perception of patient safety. The postintervention survey contained 3 categorical items, including 2 demographic questions, 5 multiple-choice items, and 3 open-ended questions. The survey instruments are provided in Table 1.

- **Intervention.** The intervention consisted of education of the change team, followed by the modification, adoption, and implementation of a standardized handoff procedure in the perioperative setting using the TeamSTEPPS model.\textsuperscript{10} This project was conducted through a series of scheduled face-to-face meetings and
supplemental follow-up email communications.

At the first meeting, the author educated the team through a brief digital slide (PowerPoint, Microsoft Corp, Redmond, WA) handout, which consisted of defining the problem, creating a sense of urgency, and proposing a strategy to address the problem. Current practice guidelines, The Joint Commission requirements, statistical data, and evidence from the literature with references were provided. The team members were introduced to various options for their consideration and discussion through individual slides such as “Where Do We Start?” “Deciding on the Right Tool for the Job,” and “What’s in My Toolbox?”. A more comprehensive packet of 8 different handoff communication tools from various healthcare facilities across the country, available from the AORN Toolkit, was provided to each team member. By the end of the first meeting, the change team unanimously decided to begin to address the problem by starting intraoperatively with the handoff of care of anesthetized patients between CRNAs, and to look at the PATIENT mnemonic as a starting point. A follow-up email was sent to the change team within 24 hours including a delineation of next steps.

One week after the conclusion of the first meeting, the team reconvened to discuss ideas for further development and possible readiness for adoption of a standardized handoff tool. Ideas for possible modification of the PATIENT mnemonic were elicited, and the team agreed to add 2 words, as seen in Figure 1. Pacemaker was added under the P portion of the mnemonic because of recent policy changes regarding anesthetic management of patients with pacemakers and implanted defibrillators. Medications was added as an adjunct of the Anesthetic portion of the mnemonic to encourage review of specific medications given during the anesthetic. The team members agreed to adopt the modified PATIENT mnemonic for use as the designated standardized handoff tool for the transfer of care of the perioperative anesthetized patients at their hospital. A follow-up email was sent to introduce the new modified “PATIENT” handoff, and participants were instructed to begin using it.

### Preintervention Survey
- Over the past two weeks, how many times did you use a standardized handoff process when either giving or receiving report of an anesthetized patient?
- I am satisfied with the current transfer of care process for use when giving/receiving report of an anesthetized patient.
- The current handoff process is appropriate.
- The current handoff process lends itself to mistakes.
- The current handoff process is comprehensive.
- The current handoff process provides an effective way of transferring important information.
- Positive aspects of the current handoff process.
- Suggestions for improvement/barriers to the current handoff process.
- Additional comments.

### Postintervention Survey
- How long have you been working as a Certified Registered Nurse Anesthetist?
- On average, how many hours per week do you spend providing anesthesia care as a Certified Registered Nurse Anesthetist?
- Over the past two weeks, how many times did you use a standardized handoff process consisting of a mnemonic, or other standardized handoff tool when either giving or receiving report of an anesthetized patient?
- The standardized handoff process is appropriate.
- The standardized handoff process lends itself to mistakes.
- The standardized handoff process is comprehensive.
- The standardized handoff process provides an effective way of transferring important information.
- I am satisfied with the standardized transfer of care process for use when giving/receiving report of an anesthetized patient.
- If you have used the standardized handoff process in the past two weeks, please briefly describe any positive aspects of the process.
- If you have used the standardized handoff process in the past two weeks, please provide suggestions for improvement/barriers to use.
- If you have chosen not to use the standardized handoff process over the past two weeks, please explain.
- Please provide any additional comments.

### Table 1. Survey Instruments

<table>
<thead>
<tr>
<th>Survey Instruments</th>
<th>Preintervention Survey</th>
<th>Postintervention Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>· Over the past two weeks, how many times did you use a standardized handoff process</td>
<td>· Over the past two weeks, how many times did you use a standardized handoff process</td>
</tr>
<tr>
<td></td>
<td>· I am satisfied with the current transfer of care process for use when giving/receiving</td>
<td>· I am satisfied with the standardized transfer of care process for use when giving/</td>
</tr>
<tr>
<td></td>
<td>report of an anesthetized patient.</td>
<td>receiving report of an anesthetized patient.</td>
</tr>
<tr>
<td></td>
<td>· The current handoff process is appropriate.</td>
<td>· The standardized handoff process is appropriate.</td>
</tr>
<tr>
<td></td>
<td>· The current handoff process lends itself to mistakes.</td>
<td>· The standardized handoff process lends itself to mistakes.</td>
</tr>
<tr>
<td></td>
<td>· The current handoff process is comprehensive.</td>
<td>· The standardized handoff process is comprehensive.</td>
</tr>
<tr>
<td></td>
<td>· The current handoff process provides an effective way of transferring important</td>
<td>· The standardized handoff process provides an effective way of transferring important</td>
</tr>
<tr>
<td></td>
<td>information.</td>
<td>information.</td>
</tr>
<tr>
<td></td>
<td>· Positive aspects of the current handoff process.</td>
<td>· Positive aspects of the process.</td>
</tr>
<tr>
<td></td>
<td>· Suggestions for improvement/barriers to the current handoff process.</td>
<td>· Suggestions for improvement/barriers to use.</td>
</tr>
<tr>
<td></td>
<td>· Additional comments.</td>
<td>· Additional comments.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

implementation. Implementation of the newly modified and adopted standardized handoff tool by the TeamSTEPPS change team began 4 weeks after the sample of 20 CRNAs was selected. The CRNAs were given 72 hours to complete the anonymous preintervention survey 2 weeks before beginning education of the team, and subsequently completed the anonymous postintervention survey within a 72-hour window after the standardized handoff was implemented for a period of 2 weeks.

### Data Analysis
Data obtained through Likert-type questions from preintervention and postintervention surveys.
surveys were analyzed using a paired t test. A descriptive analysis of survey responses was also provided. In the interest of identifying relevant patterns or trends, the author also performed a thematic analysis of the free-text responses to open-ended questions. The author began by reading and rereading these responses to become familiar with them. Words and short phrases were highlighted in code using various colors, from which emerging themes were identified and then named.

**Results**

- **Demographics.** The results of demographic questions indicated that most CRNAs involved in this project had worked as a CRNA for 5 years or less and had spent more than 36 hours per week providing anesthesia care.

- **Analysis of Paired t Test.** Analysis of a paired t test indicated statistically significant improvement when participants’ preintervention (nonstandardized) handoff procedure was compared with the postintervention standardized procedure in the following areas: number of standardized handoffs performed, satisfaction with the transfer process, appropriateness of the handoff process, whether the handoff lends itself to mistakes, whether the handoff process is comprehensive, and whether the handoff process was effective for transferring important information. These results are reported in Table 2.

- **Descriptive Analysis.** A descriptive analysis was also performed to compare preintervention survey data with postintervention survey data. These data demonstrated improvement in all categories (Table 3). Although only 6% of the 20 CRNAs (n = 1) reported performing 6 or more standardized handoffs during the 2 weeks before the intervention, 72% of CRNAs (n = 13) reported that they performed a standardized handoff at least 6 times, and as many as 15 times or more, during the 2 weeks following the intervention (Figure 2). No CRNAs strongly agreed with being satisfied with the handoff process before the intervention; however, 50% (n = 9) strongly agreed with being satisfied with the transfer process after the intervention. Although 67% (n = 12) of CRNAs reported that they disagreed or strongly disagreed with the handoff process being appropriate before the intervention, just 6% (n = 1) reported disagreeing or strongly disagreeing that the handoff process was appropriate following the implementation of the standardized process. Ninety-five percent of CRNAs surveyed (n = 17) agreed or strongly agreed that the preintervention handoff process lent itself to mistakes, whereas only 11% of CRNAs surveyed (n = 2) agreed or strongly agreed that the standardized handoff process lent itself to mistakes (Figure 3). Although 78% (n = 14) of CRNAs disagreed or strongly disagreed that the handoff process was comprehensive before the intervention, 6% (n = 1) disagreed or strongly disagreed that the standardized handoff process was comprehensive. Finally, whereas 67% (n = 12) disagreed or strongly disagreed that the preintervention handoff process was effective for transferring important information, 6% (n = 1) disagreed or strongly disagreed that the standardized handoff process provided for effective transfer of important information.

- **Thematic Analysis of Open-Ended Questions.** A thematic analysis of the responses to open-ended questions was performed. Three open-ended questions were asked at the end of the preintervention survey, and 4 were asked at the end of the postintervention survey.

Preintervention questions were as follows:

1. “Please briefly describe any positive aspects of the current handoff process.” Twelve participants responded. Six participants did report positive aspects, with 1 reporting both positive and negative aspects. Five participants reported negative aspects but no positive aspects. One response simply reported “none.” Positive aspects of the preintervention handoff process included 4 related to the format, 1 related to the length, and 1 related to quality. Negative aspects of the preintervention process included 3 related to format and 3 related to quality.

2. “Please provide suggestions for improvement/barriers to the current handoff process.” Sixteen participants responded. Seventeen barriers to the preintervention handoff process were reported, including 8 related to quality, 6 related to engagement, 2 related to format, and 1 related to length. There were 11 suggestions for improvement reported, including

**Table 2. Results of Paired t Test for Likert-Type Scores**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Preintervention mean (SD), n = 20</th>
<th>Postintervention mean (SD), n = 18</th>
<th>t(17)</th>
<th>P (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of standardized handoffs performed</td>
<td>1.30 (0.57)</td>
<td>3.16 (1.10)</td>
<td>−7.08</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Satisfaction with transfer process</td>
<td>2.15 (0.74)</td>
<td>3.39 (0.78)</td>
<td>−5.05</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Handoff process is appropriate</td>
<td>2.35 (0.49)</td>
<td>3.39 (0.78)</td>
<td>−4.49</td>
<td>.0003</td>
</tr>
<tr>
<td>Handoff process lends to mistakes</td>
<td>3.60 (0.60)</td>
<td>1.78 (0.65)</td>
<td>8.42</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Handoff process is comprehensive</td>
<td>2.20 (0.52)</td>
<td>3.22 (0.73)</td>
<td>−4.49</td>
<td>.0003</td>
</tr>
<tr>
<td>Effective transfer of important information</td>
<td>2.32 (0.58)</td>
<td>3.39 (0.78)</td>
<td>−4.61</td>
<td>.0002</td>
</tr>
</tbody>
</table>
5 related to engagement, 5 related to format, and 1 related to quality. There were no suggestions made related to length of the handoff process.

3. “Please provide any additional comments.” Two participants reported 2 additional barriers related to quality and 1 related to length, in addition to a suggestion for improvement in quality and 1 suggestion for improvement in format. One participant reported that the overall quality of the current handoff process was “relatively good” but “there is always room to improve safety.”

Postintervention questions were as follows:

1. “If you have used the standardized handoff process in the past 2 weeks, please describe any positive aspects of the process.” Ten participants responded. Positive aspects of the standardized handoff process included 10 related to quality, 2 related to length, and 1 related to format. One additional emerging theme, not seen before, was related to the satisfaction of the participants related to the standardized handoff process. Five separate comments indicated that the participants were satisfied with the standardized handoff process.

2. “If you have used the standardized handoff process in the past 2 weeks, please provide suggestion for improvement/barriers to use.” Six participants responded. Three participants reported barriers related to engagement by the receiving CRNA, and 1 participant reported a suggestion for improvement in quality, specifically related to the inclusion of a “wake-up plan,” which refers to information that would guide the receiving CRNA regarding considerations related to the emergence from anesthesia. One participant reported that he or she had not used a standardized process before this project but that “there were no barriers to use.”

3. “If you have chosen not to use the standardized handoff process over the past 2 weeks, please explain.” Only 1 participant responded, stating, “Sometimes the [receiving] CRNA doesn’t want to listen to all of it.”

### Table 3. Results of Descriptive Analysis (N = 18)\(^a\)

<table>
<thead>
<tr>
<th>Survey item</th>
<th>Preintervention, No. (%)</th>
<th>Postintervention, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standardized handoffs performed, No.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>13 (72)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>1-5</td>
<td>4 (22)</td>
<td>5 (28)</td>
</tr>
<tr>
<td>6-10</td>
<td>1 (6)</td>
<td>9 (50)</td>
</tr>
<tr>
<td>≥ 15</td>
<td>0 (0)</td>
<td>4 (22)</td>
</tr>
<tr>
<td><strong>Satisfaction with transfer process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>4 (22)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Disagree</td>
<td>8 (44)</td>
<td>8 (44)</td>
</tr>
<tr>
<td>Agree</td>
<td>6 (33)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>9 (50)</td>
</tr>
<tr>
<td><strong>Handoff process is appropriate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Disagree</td>
<td>12 (67)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Agree</td>
<td>6 (33)</td>
<td>8 (44)</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>9 (50)</td>
</tr>
<tr>
<td><strong>Handoff process lends to mistakes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>6 (33)</td>
</tr>
<tr>
<td>Disagree</td>
<td>1 (6)</td>
<td>10 (56)</td>
</tr>
<tr>
<td>Agree</td>
<td>5 (28)</td>
<td>2 (11)</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>12 (67)</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Handoff process is comprehensive</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>1 (6)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Disagree</td>
<td>13 (72)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Agree</td>
<td>4 (22)</td>
<td>11 (61)</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>6 (33)</td>
</tr>
<tr>
<td><strong>Effective transfer of important information</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>1 (6)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Disagree</td>
<td>11 (61)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Agree</td>
<td>6 (33)</td>
<td>8 (44)</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>9 (50)</td>
</tr>
</tbody>
</table>

\(^a\)Percentages may not total to 100 because of rounding.
4. “Please provide any additional comments.” Only 1 participant responded, writing, “It is a great tool for giving report.”

From these responses, 4 themes describing the handoff processes were identified: (1) format of the handoff, (2) quality of the handoff, (3) length of the handoff, and (4) engagement of the person receiving the handoff.

- **Sustainment.** As a result of this project, use of the standardized handoff procedure has become the policy of the anesthesia department in the study hospital, and documentation of its use has been integrated into the anesthesia information management system. As part of a comprehensive orientation program, all new-hire CRNAs are oriented to the standardized handoff tool and procedure before beginning work, and they receive a pocket version of the handoff tool.

**Discussion**

Analysis of a paired $t$ test indicates statistically significant improvement when comparing participants’ pre- and postintervention handoff procedures. This analysis demonstrated that the greatest improvements achieved by the change team were related to the number of standardized handoffs performed and whether the CRNA believed that the handoff process lent itself to mistakes. Improvements in these areas indicate that this project was successful in making a significantly positive change in behavior and attitude surrounding the transfer of care of patients.

A descriptive analysis of survey responses was also performed to compare preintervention survey data to postintervention survey data. These data demonstrated improvement in all 6 categories.

Thematic analysis identified 4 main themes: (1) format, (2) quality, (3) length, and (4) engagement. Another emerging theme, satisfaction, was identified in the analysis of open-ended questions in the postintervention survey. This analysis appeared to indicate a positive trend in these areas in a comparison of the preintervention themes to the postintervention themes. Unfortunately, this thematic analysis indicated that some CRNAs still did not want to take the time to listen to a comprehensive standardized handoff.

One of the most vital aspects contributing to the success of a quality improvement project is buy-in from those who will be required to make a change. By following the TeamSTEPPS model for creating a change team, this project involved its end-users in a local improvement team, which, by design, contributed to buy-in. Open-ended questions pointed out the importance of end-user involvement contributing to the broad adoption and buy-in of this project. This project benefited from the facility’s recent adoption of TeamSTEPPS as its quality improvement infrastructure, which helped to address some initial steps in the TeamSTEPPS process, such as conducting a site assessment and gaining leadership commitment.

The standardized handoff tool was easy to modify and adopt, and simple to use. Not only was buy-in directly achieved from those in the sample group, there was indirect buy-in achieved from those not included in this project once the results became known to others. Following the conclusion of this project, the author was approached by operating room nurses and anesthesiologists, and was solicited for direction on how they too could learn more about the standardized handoff procedure so that they could begin implementing it themselves. This project not only achieved its stated objectives but also, importantly, has gone beyond that by building momentum across the perioperative continuum and throughout the facility.

The greatest areas of improvement were noted in the increased number of standardized handoffs performed following the intervention, and a reduction in tendency of the handoff to lend itself to mistakes following the intervention. These 2 results are important because they demonstrate an increased compliance with The Joint Commission requirements and AORN practice guidelines, while indicating improvement in communication during the handoff process. Communication breakdowns
during handoff have been established as the cause for more than half of all sentinel events in healthcare. 

- Limitations. A review of the literature found few published studies that measured an actual improvement in patient safety, and rather more that report an improvement in the perception of patient safety. This may be due to a well-established culture of underreporting of mistakes. For this reason, a direct impact on reduction of errors or near-misses could not be measured, and this project evaluated the end-users’ perception of patient safety. Future research should focus on more rigorous study designs and include the transfer of care between anesthesia providers.

Although similar interventions have been implemented and studied among CRNAs, this project has limited generalizability because it was conducted within a single 800-bed regional medical center and involved a subset of perioperative staff limited to only CRNAs. Future work should be extended to other perioperative staff members and additional areas of the perioperative continuum.

One barrier of this quality improvement project was the difficulty coordinating schedules of a large number of anesthesia personnel from one facility to meet at the same time. Although the author attempted to overcome this barrier by using email to facilitate the dissemination of information, it is this author’s belief that presenting this information in person was more effective and allowed for immediate feedback and discussion. Had this limitation not existed, data analysis may have demonstrated even more buy-in and improvement in results. Although the sample size consisted of nearly half of the CRNAs employed at the facility during the implementation of this project, a sample size of 20 is generally considered relatively small in statistical analyses. Due to the small sample size, a $\chi^2$ test was ultimately limited to a narrative description of the survey results. Future surveys should be conducted with larger sample sizes and for a longer time.

- Recommendations. As recommended by AORN, The Joint Commission, and the DoD PSP, all perioperative healthcare workers need to standardize the patient handoff procedure with the goal of improving patient handoff communication, patient safety, and reduction of medical errors due to communication breakdown. This EBP quality improvement project using a TeamSTEPPS approach indicates that the quality of transfer of information, perceptions of patient safety, and healthcare worker satisfaction were improved through the implementation of a standardized handoff procedure when CRNAs transferred care of anesthetized perioperative patients. Based on these results, it is recommended that all anesthesia providers implement a standardized procedure for the handoff of anesthetized patients.

As a result of this project, use of the standardized handoff procedure has become the policy of the study hospital’s anesthesia department, and its documentation has been integrated into the anesthesia information management system. As part of a comprehensive orientation program, all new-hire CRNAs are oriented to the standardized handoff tool and procedure before beginning work, and they receive a pocket version of the handoff tool.

Conclusion

Medical and surgical errors resulting from communication breakdown during the transfer of care of patients are the major cause deaths annually. Despite the requirements and recommendations previously discussed, many healthcare workers report having no systematic process for handoff of care of patients. This EBP quality improvement project demonstrates that the quality of transfer of information, perceptions of patient safety, and healthcare worker satisfaction improved, and adherence to the current clinical guidelines provided by the AORN, The Joint Commission, and the DoD PSP were achieved through implementation of a standardized handoff procedure.

REFERENCES


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**DISCLOSURES**
The author has declared no financial relationships with any commercial entity related to the content of this article. The author did not discuss off-label use within the article.

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Propofol Drug Shortage Associated With Worse Postoperative Nausea and Vomiting Outcomes Despite a Mitigation Strategy

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Deborah Wagner, PharmD
Brad J. Phillips, MSN, CRNA
Amy Shanks, PhD
Aleida Thompson, MS
Karen Wilkins, MD
Norah Naughton, MD, MBA
Terri Voepel-Lewis, RN, PhD

Drug shortages negatively affect patient care and outcomes. Postoperative nausea and vomiting (PONV) can be mitigated using risk assessment and prophylaxis. A 2012 propofol shortage provided an opportunity to study the impact of using prophylactic antiemetics and changing the technique from a propofol infusion to inhaled agents in an ambulatory surgery setting. We retrospectively collected data for 2,090 patients regarding PONV risk factors, anesthetic management, and PONV outcomes for periods before, during, and after the shortage. Patients during the propofol shortage experienced a higher incidence of PONV (11% vs 5% before the shortage), greater need for rescue antiemetics (3% vs 1%), and longer duration of stay (mean [SD] = 124 [115] minutes vs 118 [108] minutes). More patients in this group reported PONV at home (14% vs 7%), and 2 required unplanned admission or return to the hospital. During the shortage, patients had a 2-fold increase in the odds of PONV when adjusted for all risk factors. Antiemetics moderated the association between gender and PONV but did not change the effect of the shortage. Findings suggest that despite mitigation efforts, the inability to use propofol infusion was associated with worse PONV outcomes.

Keywords: Drug shortages, postdischarge nausea and vomiting, postoperative nausea and vomiting, prophylactic antiemetics, risk factors for postoperative nausea and vomiting.

Drug shortages have had a negative impact on patient care, safety, and outcomes in the United States for more than a decade. The specialties of anesthesiology and oncology have been particularly affected, given a general lack of replacements for the drugs in short supply. In response to severe shortages, the Food and Drug Administration (FDA) published a final rule in July 2015 aimed at identifying potential drug shortages sooner, preventing or mitigating their impact, and developing long-term prevention strategies. The impact of this rule has yet to be evaluated, and currently, drug shortages remain a threat to patient well-being.

A nationwide propofol shortage occurred in late 2012, greatly limiting its use in surgical settings. For instance, in our ambulatory surgery facility, anesthesia providers were primarily limited during the shortage to using single-dose propofol for the induction of general anesthesia. Before the shortage, a total intravenous anesthesia (TIVA) technique, which combined a propofol infusion with inhaled nitrous oxide was primarily used. During the shortage, TIVA had to be replaced with inhalational agents. Of particular concern was the impact of this shortage on postoperative nausea and vomiting (PONV). In ambulatory settings, TIVA is widely used because of its association with improved patient recovery profiles, including decreased PONV in the postanesthesia recovery unit (PACU) and, possibly, after discharge. In an attempt to mitigate the negative impact of the shortage on patient outcomes, providers in our setting were encouraged to follow our standardized departmental PONV prophylaxis and treatment guidelines (Figures 1 to 3). The resulting change in anesthetic technique provided a unique opportunity to describe and evaluate the impact of the propofol shortage on patient care (replacement therapies) and outcomes (PONV and recovery) in our multispecialty, freestanding ambulatory surgery facility.

Materials and Methods
Following institutional review board approval (HUM 00086553) with waiver of consent, we conducted a retrospective observational study using our electronic
anesthesia database (Centricity, GE Healthcare). This database contains all the electronically recorded anesthesia history and physical data, intraoperative and PACU data, and postoperative follow-up information.

Specifically, we obtained a limited database that included the perioperative records for all patients older than 18 years who underwent general anesthesia at the ambulatory surgery facility between August 2012 and
April of 2013. Three groups were identified based on when they received anesthesia: group 1, before the shortage (August through October 2012); group 2, during the shortage (November through mid-January 2013); and group 3, after the shortage (late January 2013 through April 2013). A 1-week period from January 15 to January 22, 2013, was excluded from the database to allow for full redistribution of propofol back into the facility following

**Figure 2.** Rescue of Prophylaxis Failure and Postdischarge Care for the Adult Patient

**Recommended Doses of Drugs (For Rescue):**
- Diphenhydramine: 12.5 mg IV
- Granisetron: 0.1 mg IV
- Ondansetron: Do not repeat dosage: 4 mg IV
- Ondansetron ODT: 8 mg tablet
- Prochlorperazine: 5-10 mg IV
- Scopolamine transdermal patch: 1.5 mg

**Considerations:**
- Ondansetron: Consider not using Ondansetron and Droperidol together, especially if there is evidence of preoperative QTc prolongation. Both cause QTc prolongation.
- For Pregnant or Lactating Women: Drugs of choice are Diphenhydramine and Ondansetron – use of Scopolamine is contraindicated.
the shortage. Anesthetic techniques used were always determined by individual providers, whereas practice guidelines for the use of antiemetics were recommended.

The following preoperative and perioperative data were included for this research: demographics; ASA classification; body mass index; smoking status; history of motion sickness or nausea while reading in a vehicle; history of PONV; surgical service case type; anesthesia duration; and all antiemetic medications, opioids, and inhaled agents used. The following postoperative data were also recorded: number and type of antiemetics given, the incidence of PONV, length of stay in the...
PACU, emergency department (ED) visits, and unplanned admission for PONV. Postoperative nausea and vomiting was documented in the PACU based on a 0 to 3 patient self-report scale, where 0 = no nausea or vomiting and 3 = severe nausea with or without vomiting. For the purpose of analysis, we coded PONV as 0 (none) or 1 (any PONV documented in the record). Documentation of postoperative nausea and vomiting after discharge was solicited via a phone interview of the patient.

Statistical analysis was performed using SAS version 9.3 (SAS Institute). Basic descriptive statistics were calculated for the 3 groups. Data are presented as frequencies (ie, number and percentage), means with standard deviations, or medians with 25th and 75th percentiles, wherever appropriate. Kolmogorov-Smirnov tests demonstrated that all the continuous variables were skewed; thus, Kruskal-Wallis tests were used to compare these data, and Pearson $\chi^2$ with Fisher exact tests were used to compare the categorical data between groups.

### Results

A total of 2,090 patients met study inclusion criteria. Of these, 662 patients underwent anesthesia during the preshortage period (group 1); 728, during the shortage period (group 2); and 700, after the shortage (group 3). Patients during the propofol shortage were more often male, healthier (ie, more often ASA class 1), and had fewer baseline risk factors for PONV, but underwent a similar mix of surgical procedures compared with pre- and postshortage groups (Table 1). Table 2 describes the differences in patient management before, during, and after the shortage. As expected, the TIVA technique with nitrous oxide was used for most cases before the shortage (87% of cases), whereas volatile inhalants (eg, sevoflurane or desflurane) were the primary agents used during the shortage (83% of cases). The wide use of TIVA resumed following the shortage.

• **Mitigation Strategy.** Nearly all patients received at least one prophylactic antiemetic across the 3 study periods, with the most common agents being ondansetron (60%) and metoclopramide (35%). However, the use of prophylactic antiemetics varied significantly between the groups.
periods (excluding propofol). Although there was a difference between groups in the number of prophylactic antiemetics received, patients during the shortage did not receive significantly more of these agents (see Table 2). Patients during the propofol shortage had fewer PONV risk factors. Although more patients received 3 or more agents during the shortage (42%) compared with before (38%), this difference did not reach statistical significance (odds ratio [OR] = 1.17; 95% CI = 0.95-1.43; P = .146). A significant decrease in the number who received 3 or more agents was observed in the period following the shortage compared with during the shortage (OR = 0.55; 95% CI = 0.44-0.69; P < .001). Ondansetron was the only agent used more frequently during the shortage compared with the period immediately before (5% during vs 3% before; OR = 1.82; 95% CI = 1.05-3.15; P = .031).

### Table 2. Anesthetic and Prophylactic Antiemetic Management by Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before shortage (n = 662)</th>
<th>During shortage (n = 728)</th>
<th>After shortage (n = 700)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anesthetic management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total intravenous anesthetic with N2O</td>
<td>573 (87)</td>
<td>83 (12)</td>
<td>627 (90)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Inhaled volatile agents</td>
<td>8 (1)</td>
<td>553 (83)</td>
<td>2 (0)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Received an opioid</td>
<td>650 (98)</td>
<td>689 (95)</td>
<td>694 (99)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Oral morphine equivalents, total mg, mean; median (IQR)</td>
<td>8.1; 8 (4-8)</td>
<td>10.4; 8 (6-14)</td>
<td>8.1; 8 (4-10)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td><strong>Prophylactic antiemetic management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 1 antiemetic received</td>
<td>651 (98)</td>
<td>694 (95)</td>
<td>694 (99)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Received 0-1</td>
<td>31 (5)</td>
<td>52 (7)</td>
<td>33 (5)</td>
<td></td>
</tr>
<tr>
<td>Received 2</td>
<td>379 (57)</td>
<td>371 (51)</td>
<td>468 (67)</td>
<td></td>
</tr>
<tr>
<td>Received ≥ 3</td>
<td>252 (38)</td>
<td>305 (42)</td>
<td>199 (28)</td>
<td></td>
</tr>
<tr>
<td>Total No. of prophylactic antiemetic agents received, mean; median (IQR)</td>
<td>2.35; 2 (2-3)</td>
<td>2.36; 2 (2-3)</td>
<td>2.27; 2 (2-3)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td><strong>Anesthetic duration, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery duration, min</td>
<td>61 (36-93)</td>
<td>59 (34-96)</td>
<td>58 (34-93)</td>
<td>.723</td>
</tr>
<tr>
<td>Emergence, min</td>
<td>8 (4-11)</td>
<td>6 (4-9)</td>
<td>7 (5-11)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

### Table 3. Postoperative Outcomes by Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before shortage (n = 662)</th>
<th>During shortage (n = 728)</th>
<th>After shortage (n = 700)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PONV in the hospital</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 1 episodes of PONV</td>
<td>35 (5)</td>
<td>82 (11)</td>
<td>61 (9)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Rescue antiemetic in PACU</td>
<td>7 (1)</td>
<td>24 (3)</td>
<td>8 (1)</td>
<td>.002</td>
</tr>
<tr>
<td>PACU length of stay, min, mean; median (IQR)</td>
<td>118.1; 108 (89-136)</td>
<td>123.8; 115 (93-143)</td>
<td>120.1; 110 (89-139)</td>
<td>.020</td>
</tr>
<tr>
<td><strong>Postdischarge PONV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 1 episodes of PONV</td>
<td>36 (7)</td>
<td>84 (14)</td>
<td>63 (10)</td>
<td>.001</td>
</tr>
<tr>
<td>Readmit to emergency department</td>
<td>0 (0)</td>
<td>2 (0)</td>
<td>0 (0)</td>
<td>.154</td>
</tr>
</tbody>
</table>
Postoperative Outcomes. Patients during the propofol shortage experienced a statistically shorter emergence time (see Table 2), higher incidence of PONV, greater need for rescue antiemetics, and longer duration of stay in the PACU (Table 3). In addition, more patients in this group reported PONV at home, and 2 needed escalation of care (ie, unplanned admission or returned to the ED for PONV). Given differences in baseline factors and opioid use between groups, we used a logistic regression model to examine whether the shortage period was independently associated with PONV when controlled for gender, number of risk factors, and opioid use. This model demonstrated that patients had a 2-fold increase in the odds of having PONV during the shortage (OR = 2.3; 95% CI = 1.5-3.5; \( P < .001 \)) when adjusted for all other risk factors (Table 4). We used a second step in this model to examine the potential influence of prophylactic antiemetics on this outcome. This model showed that antiemetics moderated the association between gender and PONV (OR = 1.3; 95% CI = 0.9-1.9; \( P = .128 \)) but did not change the effect of the shortage (OR = 2.2; 95% CI = 1.4-3.5; \( P < .001 \)).

Discussion
Findings from this retrospective study demonstrated that a late 2012 propofol shortage was associated with a significantly higher incidence of PONV despite the presence of fewer baseline risk factors and the availability of a risk-based antiemetic protocol. This finding suggests that despite mitigation efforts, the inability to use TIVA was associated with worse PONV outcomes for patients. The use of a propofol infusion for anesthetic maintenance is a component of the Society for Ambulatory Anesthesia (SAMBA) guidelines algorithm, shown to reduce the risk of PONV by 19% compared with the use of volatile agents.\(^7\)\(^-\)\(^12\) Indeed, the reported incidence of PONV after general anesthesia without prophylaxis is 20% to 30% in the general surgical population and can be as high as 70% to 80% in high-risk patients. However, a 20% decrease in PONV per antiemetic administered has been demonstrated.\(^13\) Our risk-stratified antiemetic protocol was based on such data demonstrating the potential benefits of antiemetic use for PONV reduction. Despite the high number of risk factors present in our patients, the overall incidence of PONV across periods was low (ie, 5%-11%) compared with previous reports, supporting the efficacy of our antiemetic guidelines.

The observed increase in the incidence of PONV during the propofol shortage in our setting was likely due in part to the use of volatile agents, which are associated with a higher risk of this outcome.\(^7\)\(^-\)\(^12\) It is possible that opioid consumption, which was higher during the shortage, may have contributed to this outcome; however, we did not observe an association between this factor and PONV when adjusted for other risk factors (see Table 4). Although it remains unknown, adherence to the risk-stratified antiemetic guideline during the shortage may have, in part, mitigated a potentially worse effect of the propofol shortage on outcomes. Most antiemetics have low side effect profiles and are generic and relatively inexpensive.\(^12\) Thus, their prophylactic use for ambulatory surgery, particularly for patients who are at high risk of PONV, should be considered a low-risk alternative to reduce PONV and associated risks such as prolonged length of stay or unplanned admission. Application of a risk-stratified approach may, therefore, be helpful during propofol or other antiemetic drug shortages.

There are several limitations to this study. First, this is a single-center study and may not be generalizable to settings with different practices. Additionally, this dataset was obtained from electronically captured data at the time of patient care and was therefore subject to documentation bias (eg, underreporting of PONV or history of risk factors) and potential charting inaccuracies (eg, drug administration). Next, the use of the risk-mitigation strategy was in place over all periods and thus may have dampened its full effect on patient outcomes during the shortage period. Finally, the duration of the propofol shortage was short and thus limited the number of subjects exposed to the change in anesthetic technique.

### Table 4. Association Between Risk Factors and the Outcome In Hospital Postoperative Nausea With or Without Vomiting (PONV): Results of a Logistic Regression Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Adjusted odds ratio (95%CI)</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before shortage</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>During shortage</td>
<td>2.3 (1.5-3.5)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>After shortage</td>
<td>1.8 (1.1-2.8)</td>
<td>.012</td>
</tr>
<tr>
<td>Total No. of baseline risk factors(^a)</td>
<td>1.5 (1.2-1.9)</td>
<td>.001</td>
</tr>
<tr>
<td>Female gender</td>
<td>1.4 (1.0-2.1)</td>
<td>.049</td>
</tr>
<tr>
<td>Total oral morphine equivalents</td>
<td>1.0 (1.0-1.1)</td>
<td>.147</td>
</tr>
</tbody>
</table>

\(^a\)Risk factors include any history of motion sickness or PONV, as well as current nonsmoker.

Model C-statistic = 0.64.
Consequently, the sample size may have been insufficient
to demonstrate additional significant differences in prac-
tices and outcomes.

It is likely that unpredictable drug shortages will con-
tinue, and, thus, identification of alternative strategies to
optimize patient outcomes will be vital. The findings
from this study suggest a negative association between
the propofol shortage period and PONV outcomes despite
a risk-mitigation strategy in place at the time of the short-
age. Although the full impact of our risk mitigation efforts
remains unknown given the noted study limitations, these
data may help to guide future efforts aimed at reducing the
negative impact of drug shortages on anesthesia practice.

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AANA Journal Course—Residual Neuromuscular Blockade: Evidence-Based Recommendations to Improve Patient Outcomes

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Neuromuscular blocking drugs are administered to facilitate endotracheal intubation and induce paralysis to allow surgeons access to their anatomical target. Traditionally, qualitative measures; such as tactile observation of fade by a peripheral nerve stimulator, are used to assess the extent of the patient’s recovery after receiving the neuromuscular blocking agent. Use of these qualitative measures; however, can contribute to high rates of residual neuromuscular blockade (RNMB), placing patients at risk of serious postoperative adverse events. Such adverse events include the need for tracheal reintubation, impaired oxygen and ventilation, increased risk of aspiration and pneumonia, pharyngeal dysfunction, and delayed discharge from the postanesthesia care unit. This problem of RNMB is exacerbated by the use of traditional drugs to reverse the neuromuscular blockade, such as the acetylcholinesterase inhibitor neostigmine. This course will examine the current limitations of qualitative neuromuscular monitoring, introduce the reader to acceleromyography, and outline the advantages of monitoring neuromuscular blockade during the perioperative period. In addition, this course will review the contemporary neuromuscular antagonists, including the newer neuromuscular antagonist sugammadex.

Keywords: Acceleromyography, neostigmine, neuromuscular blockade monitoring, residual neuromuscular blockade, sugammadex.

Objectives:
At the completion of this course, the reader should be able to:
1. Define residual neuromuscular blockade and list its major complications.
2. Describe current practice and limitations of neuromuscular blockade monitoring and reversal.
3. Describe objective monitoring of neuromuscular blockade.
4. Discuss the pharmacology of sugammadex and its advantages over traditional neuromuscular blockade reversal agents.
5. List considerations for reducing rates of residual neuromuscular blockade in the absence of objective monitoring measures, based on current evidence.

Introduction
Neuromuscular blocking agents (NMBAs) are essential pharmacologic adjuncts that facilitate endotracheal intubation and produce skeletal relaxation, allowing surgical access for intra-abdominal and intrathoracic procedures. These medications require vigilant perioperative monitoring to minimize possible complications associated with their use.1 Ensuring complete recovery may prove challenging, as evidenced by the high rate of partial recovery, better known as residual neuromuscular blockade (RNMB), which occurs postoperatively in 20% to 60% of patients who receive nondepolarizers as part of their anesthetic care.2,3 Complications of RNMB include skeletal and upper airway muscular weakness, which may result in partial or complete airway obstruction, concurrent hypoxemia, and respiratory failure requiring reintubation.2-4 Failure to recognize RNMB may ultimately lead to patient death.2-4 A large survey of anesthesia providers in the United States and Europe found that 77% of respondents believed RNMB to be a “significant public health problem” (Figure 1A), yet 85% of respondents indicated never having observed a patient exhibiting “clinically significant residual neuromuscular paralysis” such as respiratory distress.5 The same survey found that respondents could not agree on the method of monitoring (qualitative vs quantitative) or on whether monitoring should be performed at all.5 Among respondents who indicated having access to qualitative and/or quantitative monitors, 41% admitted to not routinely using either monitoring device (Figure 1B).5 Furthermore, the survey found that 34% of providers indicated that they generally omit the use of a reversal agent in at least 25% of their cases.5

See Editor’s note on page 158
Despite a growing body of literature suggesting that RNMB may carry adverse consequences, the American Society of Anesthesiologists does not include neuromuscular monitoring in its Standards for Basic Anesthetic Monitoring, relegating its use as “occasional” in their Practice Guidelines for Postanesthetic Care. Although the American Association of Nurse Anesthetists (AANA) Standards for Nurse Anesthesia Practice state “when neuromuscular blocking agents are administered, monitor neuromuscular response to assess depth of blockade and degree of recovery,” the AANA does not specify a preferred monitoring technique.

Neuromuscular Blockade Monitoring

The more traditional methods of monitoring neuromuscular blockade are qualitative/subjective measures, for example, 5-second head lift, leg lift, grip strength, tongue depressor test, forced vital capacity, and visual or tactile observation of fade by a peripheral nerve stimulator (PNS; see summary in Table 1). Subjective measures involving observation or palpation of the elicited muscle twitches are the most common methods for evaluating neuromuscular blockade.

Traditionally, neuromuscular blockade has been assessed using a PNS, a small instrument (Figure 2) that sends electrical impulses to a peripheral nerve to stimulate the corresponding muscle to contract. The anesthesia provider then subjectively assesses the muscle contraction to determine recovery from or current status of neuromuscular blockade and thus assess for safety in tracheal intubation.

Editor’s Note

The current AANA Journal Course is especially timely given the recently released International Anesthesia Research Society (IARS) “Consensus Statement on Neuromuscular Monitoring.” Before you read and benefit from this course, please review the IARS statement. A brief summary of the statement appears here. The IARS consensus statement was developed to improve the use and safety of neuromuscular blockade monitoring in the perioperative setting. The statement includes recommendations from physician experts about the proper use of neuromuscular monitoring, with the goal of increasing awareness of the potential for residual neuromuscular blockade with its associated risk of death.

Recommendations for anesthesia providers are as follows:

- Objective (quantitative) monitoring—a real-time measurement of the train-of-four ratio equal to or greater than 0.90—should be used during administration of nondepolarizing neuromuscular blockade drugs. Subjective measurements using peripheral nerve stimulator devices should not be used because they “are prone to error.”
- Clinical (subjective) tests for neuromuscular blockade (eg, 5-second head lift) are not adequate and should be abandoned.
- Professional societies must develop practice guidelines and standards for perioperative use of neuromuscular blockade drugs.
- Terms for neuromuscular blockade levels should be standardized.


extubation. The 2 most common nerves used in PNS assessment are the ulnar nerve associated with the adductor pollicis muscle and facial nerve associated with the orbicularis oculi. When using a PNS, the anesthesia provider can choose from various modes to assess neuromuscular function: single-twitch (or single-stimulus), train-of-four (TOF), tetanus (or tetanic stimulation), and double-burst stimulation (DBS).

Single twitch delivers a supramaximal stimulus, to ensure all nerve fibers are stimulated and achieve maximal contraction, to the chosen nerve/muscle system for 0.1 to 0.3 milliseconds. Twitch height after administration of an NMBA is compared with the control twitch height, providing an estimation of overall blockade of the nicotinic acetylcholine receptors by the NMBA. It is important to note that twitch height is an estimation based on visual or tactile observation by the anesthesia provider and that a baseline twitch height must be obtained from the patient before the use of any NMBA when using the single-twitch mode.

Train-of-four is a means of neuromuscular monitoring performed by delivering 4 separate stimuli 0.5 seconds apart at a frequency of 2 Hz for 2 seconds, where the 4 observed twitches are referred to as T1 to T4. Of particular importance is the comparison of T4 (the last twitch) with T1 (the first twitch), as this comparison aids the provider in determining the degree of neuromuscular blockade (Figure 3A). The degree of progressive depression of twitch height in TOF mode is known as the concept of fade; as blockade is deepened, the twitches will progressively fade in height and ultimately disappear, with the fourth twitch disappearing first. A train-of-four ratio (TOFR) of 0.9 or above indicates that the strength of T4 is 90% or greater of the strength of T1 (Figure 3B).

Tetanus is commonly used at a frequency of 50 Hz and results in a sustained contraction of the muscle rather than a single twitch. Again, the concept of fade, or a decreased response to tetanic stimulation, is used to determine the degree of neuromuscular blockade. When fade is present, 70% to 75% of the acetylcholine receptors are estimated to be blocked by the NMBA, and when the blockade is deep, no contraction will be felt at all. Tetanus should be used sparingly to assess the degree of blockade because it is very painful and can cause muscle fatigue. In addition, there is the possibility of posttetanic facilitation, which is an exaggerated response to tetanus due to an increase in acetylcholine caused by enhanced synthesis of acetylcholine after tetanic stimulation. Ultimately, posttetanic facilitation will lead to underestimation of neuromuscular blockade; it has been associated with nondepolarizing agents.

Double-burst stimulation, which was developed primarily to detect RNMB and has been shown to be less painful than tetanus, delivers 2 bursts of tetanic stimuli separated by 750 milliseconds. Two commonly used burst sequences are DBS3,3 (2 bursts of three 0.2-millisecond impulses separated by 750 milliseconds) and DBS3,2 (1 burst of three 0.2-millisecond impulses and 1 burst of two 0.2-millisecond impulses separated by 750 milliseconds).

Regardless of the mode used, evidence supports that vigilant monitoring of NMBAs in the perioperative period

<table>
<thead>
<tr>
<th>Subjective measure</th>
<th>Corresponding train-of-four ratio (TOFR)</th>
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</thead>
<tbody>
<tr>
<td>Visible or tactile fade</td>
<td>Fade is indistinguishable once TOFR exceeds 0.4</td>
</tr>
<tr>
<td>5-Second head lift</td>
<td>TOFR 0.45-0.75 with average approximately 0.6</td>
</tr>
<tr>
<td>Tongue depressor test</td>
<td>TOFR 0.68-0.95; test cannot be used in intubated patients but has highest predictive value of the subjective measures</td>
</tr>
<tr>
<td>Grip strength</td>
<td>Grip strength averaged 57% of the control, with a range of 43%-77% at TOFR 0.7.</td>
</tr>
<tr>
<td>Forced vital capacity</td>
<td>Shown to be impaired at TOFR 0.5</td>
</tr>
<tr>
<td>50-Hz tetanic stimulation</td>
<td>Demonstrates no fade between TOFR 0.16 and 0.46</td>
</tr>
<tr>
<td>100-Hz tetanic stimulation</td>
<td>Demonstrates no fade at TOFR as low as 0.7</td>
</tr>
<tr>
<td>Double-burst stimulation</td>
<td>Undetectable fade at TOFR 0.6-0.87</td>
</tr>
<tr>
<td>Acceleromyography</td>
<td>Found to correlate best with TOFR obtained via mechanomyography; however, acceleromyography was found to exceed TOFR 1.0 at mechanomyography TOFR 0.83-0.95, indicating that acceleromyography is not 100% accurate</td>
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</tbody>
</table>

Table 1. Subjective Measures of Monitoring Neuromuscular Blockade

Figure 2. Peripheral Nerve Stimulator
is vital in decreasing the risk of RNMB.\textsuperscript{3,4,17,18} In terms of qualitative monitoring, the measured values that are considered safe for neuromuscular blockade recovery have changed over the years.\textsuperscript{17} In the 1970s to 1990s, a TOFR of 0.7 or greater was considered the “gold standard” value representing safe levels of recovery from neuromuscular blockade.\textsuperscript{17} However, the current gold standard has risen to a TOFR of 0.9 or greater, as evidence became available suggesting that a TOFR below 0.9 is associated with compromised airway patency, impaired pharyngeal musculature, symptoms of muscle weakness, and even decreased hypoxic ventilatory response, which can lead to respiratory distress.\textsuperscript{2-4,17}

Regrettably, TOFRs determined by qualitative measures are subject to a high degree of potential interrater variance as well as patient variability, which may translate into a lower degree of patient safety. For example, various studies have found that the 5-second head lift, a commonly used qualitative measure to determine adequate recovery from blockade, has been correlated with TOFRs as low as 0.25 and as high as 0.8, indicating a lack of sensitivity in the test.\textsuperscript{17} Furthermore, absence of observed or tactile fade in response to TOF stimulation does not indicate adequate recovery of the block as TOF fade is indistinguishable once the TOFR exceeds 0.4 and when it exceeds 0.6 to 0.7 for DBS.\textsuperscript{10,11} Some qualitative tests for RNMB such as head lift or grip strength are not only imprecise but require that the patient be awake and cooperative.\textsuperscript{3} In addition, a study on the pharyngeal and facial muscle function and spirometry values of 12 volunteers who were given rocuronium to maintain a TOFR of 0.5 to 0.8 (measured via accelerometry) found that respiratory and pharyngeal functions were affected even at a TOFR of 0.8.\textsuperscript{13}

With these results in mind, and considering the research showing qualitative measurements to be imperfect assessments of the TOFR, Cammu et al\textsuperscript{15} suggest that “assessment via accelerometry of the TOFR of adductor pollicis muscle is more useful to predict the effects of residual paralysis on respiratory function than visual assessment of fade of thumb adduction or testing the ability to sustain a head lift for longer than five seconds.” Furthermore, a study of 640 surgical patients, in which rates of RNMB were assessed on arrival to the postanesthesia care unit (PACU) using an accelerometer as well as qualitative methods, such as 5-second head lift and ability to speak and swallow, found that each patient who experienced RNMB had been monitored via qualitative methods (a TOFR of 0.9 was used as the cutoff value for RNMB).\textsuperscript{15} None of the traditional, qualitative clinical tests used had a sensitivity greater than 0.35, and accelerometry was able to more accurately detect RNMB, prompting the authors to suggest the use of accelerometry in the operating room (OR).\textsuperscript{3,15} These findings, the degree of variability of NMBAs and reversal agents, and the fact that a patient may present a unique response to NMBAs and reversal agents suggest the importance of adopting some form of systematic neuromuscular blockade monitoring as a “standard” of perioperative anesthesia care. Moreover, knowledge of the pharmacology of various NMBAs and reversal agents, in addition to awareness of the importance and prevalence of RNMB, may lead to improved safety and optimized outcomes.

**Neuromuscular Blockade Antagonism: Current Practice and Limitations**

The blockade of acetylcholine receptors on the motor end plate to produce skeletal muscle paralysis through the use of NMBAs and their subsequent reversal, while complex, is central to the practice of anesthesia. When a motor nerve is depolarized, voltage-gated calcium channels open up, resulting in an influx of calcium into the motor nerve, causing the vesicles that store acetylcholine to be exocytosed into the synaptic cleft.\textsuperscript{10,19} Acetylcholine then diffuses across the synaptic cleft, eventually binding to nicotinic acetylcholine receptors on the motor end plate, leading to an influx of sodium into and efflux of potassium out of the muscle cell, and resulting in depolarization of the muscle cell.\textsuperscript{10,19} If the depolarization reaches threshold, a muscle contraction ensues.\textsuperscript{10,19}

There are 2 classes of NMBAs: depolarizers, such as succinylcholine, and nondepolarizers, such as ro-

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**Figure 3A.** Train-of-four ratio equal to 0.3 (30%) represents residual blockade.

**Figure 3B.** Train-of-four ratio equal to 0.9 (90%) represents safe recovery from neuromuscular blockade.

Abbreviation: T = twitch.
curonium and atracurium. This course will concentrate on the latter, specifically steroidal compounds such as rocuronium. When administered, nondepolarizing NMBAs produce muscle paralysis by competing with acetylcholine and binding to the nicotinic receptor sites at the motor end plate, thus blocking those receptors and inhibiting muscle contraction.1,3,10,19 Characteristically, nondepolarizing NMBAs will result in the presence of fade with TOF and tetanic stimulation, posttetanic facilitation, and a decreased response to single-twitch stimuli, all of which the anesthesia provider can use to judge adequate neuromuscular blockade and recovery.10,19

Acetylcholinesterase is an enzyme present in the neuromuscular junction that breaks down acetylcholine; in the absence of an NMBA in a normal muscle, acetylcholinesterase is responsible for muscle relaxation.10,19 Traditionally, reversal of NMBAs is achieved via acetylcholinesterase inhibitors, such as neostigmine, which prevent the enzyme acetylcholinesterase from breaking down acetylcholine (Figure 4A).10,19 The blocking of acetylcholinesterase results in accumulation of acetylcholine in the synaptic cleft, ultimately “outcompeting” the NMBA at the nicotinic acetylcholine receptor and reversing muscle paralysis.10,19 However, acetylcholinesterase inhibitors are not selective at the neuromuscular junction; thus, acetylcholine levels increase throughout the body, which can result in undesirable muscarinic effects such as nausea, vomiting, and bradycardia.10,19 For this reason, antimuscarinic medications such as glycopyrrolate are given along with acetylcholinesterase inhibitors to temper these undesirable effects.10,19 Finally, various factors affect the antagonism of NMBAs. These factors include the acetylcholinesterase inhibitor itself; metabolism and elimination of the NMBA from the body independent of the acetylcholinesterase inhibitor; volatile agents that are known to potentiate NMBAs; and various metabolic factors and electrolyte disturbances such as hypermagnesemia, hypocalcemia, and hypokalemia (all of which can potentiate the effects of NMBAs).10,19 Other factors affecting antagonism of NMBAs that are most important to this course are the dose of the acetylcholinesterase inhibitor administered and the depth of blockade that is being attempted to be reversed.10,19

Despite its usefulness in reversing drug-induced paralysis, neostigmine may actually contribute to rates of RNMB if used improperly.3 In addition, neostigmine may either be ineffective or have undesired, contradictory effects depending on the dosage given, the level of neuromuscular block the patient is experiencing, and the NMBA used.3 Depending on dose, neostigmine can block 100% of acetylcholinesterase at the neuromuscular junction, resulting in a persistent, depolarizing-like block from the excess acetylcholine; this ceiling effect is a primary factor in establishing essentially a maximum dose for neostigmine administration.1 A recent study of 10 patients found that administration of 30 µg/kg of neostigmine increased airway collapsibility in healthy volunteers to a degree comparable with neuromuscular blockade with a TOFR of 0.5. These results are concerning. The typical dose range of neostigmine for the reversal of NMBAs is 25 to 75 µg/kg; therefore, these results suggest that even “normal” doses can lead to RNMB and airway compromise.10,20 Furthermore, research has shown that when reversal is attempted with TOF counts of 1 or less, clinical recovery is not only slow but may play a role in the development of RNMB.21 Kopman et al21 examined reversals of nondepolarizing NMBAs with TOF counts of  1 or less and found that safe reversals were excessively delayed, in that 29 of 40 subjects had not reached a TOFR of 0.7 or more within 10 minutes of reversal with neostigmine and 5 of 40 subjects “failed to reach a TOF ratio of 0.70 within 20 minutes.” These findings are worrisome because delayed recovery to safe levels of neuromuscular function may result in RNMB, placing the patient’s safety at risk.21 Kopman et al21 also point out that reversal of deep blocks, which results in low TOFRs, further compounds the issue because visual and tactile observation of low TOFRs has been shown to be difficult and inaccurate for practitioners.

**Value of Objective Monitoring**

Objective monitoring devices that provide numeric output regarding TOF levels are available to monitor neuromuscular blockade and minimize the occurrence of RNMB.1,3,22 Mechanomyography (MMG) measures the force of isometric contraction of a muscle after nerve stimulation (typically the adductor pollicis muscle and the ulnar nerve in the case of NMBA monitoring); it is considered the gold standard in quantitative measure-

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**Figure 4A.** Neuromuscular junction with neostigmine mechanism of action. Note increased acetylcholine concentration compared to rocuronium.
A criticism of AMG devices is that the thumb must be free of manipulation from surgical drapes and from contact with the palm, because these scenarios may lead to erroneous readings. To ameliorate this situation, many newer AMG devices such as the TOF-Watch include a "preload" device that aims to prevent the thumb from coming into contact with the palm during nerve stimulation and ensure that the thumb returns to its original position after stimulation. Whereas little research has been conducted regarding the effectiveness of using a preload, one study involving 60 patients randomized into 2 groups, 1 with the use of a preload mechanism and 1 group without, found that the use of a preload improved the accuracy of AMG by 21% with use of the TOF-Watch SX. An extensive literature review compared AMG and MMG, the results of which suggest that the 2 methods of quantitative monitoring and their respective results should not be used interchangeably.

Research suggests that control readings for AMG are higher than those for MMG; however, use of a preload improved the accuracy of the AMG devices, which in turn improved agreement between AMG and MMG readings (patients in both groups had AMG devices on one hand and MMG devices on the other). In addition, the differences between AMG (with preload use) and MMG were significantly decreased when the TOFR was used in reference to the original control TOF reading (ie, the data was normalized), allowing data from AMG and MMG to be compared. Furthermore, the use of a preload increased the mean control TOFR from 1.07 to 1.13. As previously mentioned, the gold standard that the TOFR be 0.9 or greater to avoid RNMB was determined based on data provided by MMG devices. The literature consistently finds that TOF readings obtained from AMG devices are typically higher than readings obtained from MMG devices. Therefore, it is suggested that baseline TOF values should be referred to when one is determining the TOFR and that the standard TOF value used to ensure complete recovery should be at least 1.00 during use of AMG devices.

A seminal review by Brull and Kopman emphasized objective quantitative measurement as the only method to determine appropriate timing of tracheal extubation and ensure normal muscle function, a recommendation urged by other authorities as well. Fewer patients enter the PACU with a TOFR below 0.9 when AMG is used than when qualitative nerve stimulators are used. A randomized controlled trial (RCT) comparing the use of AMG with the use of PNS revealed that the recovery time to reach a TOFR of 0.9 or greater was 0.9 minutes for the AMG group and 0.8 minutes for the PNS group. Although the authors urge the use of an accelerometer when available, their results revealed that a PNS was as efficacious as an accelerometer in their sample.

An observational study of 27 anesthesia providers compared their ability to judge the TOF using visual and tactile means with TOF values obtained by AMG and MMG devices. Results revealed not only that AMG measurements closely correlated with MMG measurements but also that AMG ratios were safer for reducing rates of RNMB, as visual and tactile fade was imperceptible above a mean MMG ratio of 0.31. Likewise, a study comparing the use of the TOF-Watch SX with traditional subjective measures such as visual and tactile detection in 75 patients cared for by 38 anesthesia providers found that providers frequently assessed higher TOF counts by subjective measurements than the TOF counts obtained by the TOF-Watch SX. Falsely assessing higher TOF counts by subjective measurements underscores the importance of quantitative measuring devices, as incorrect measurements can lead to higher rates of RNMB.

A large multicenter observational study of 326 patients aimed to determine the rates of RNMB in patients whose providers used only subjective monitoring (PNS monitor or visual and tactile observation) to quantify TOF. Observers were blinded to quantitative TOF results recorded by the TOF-Watch SX at 10 time points, including 10 minutes after administration of the reversal agent, immediately before extubation, and at PACU arrival. The study revealed that RNMB, evidenced by a TOFR of 0.9 or below as recorded by a TOF-Watch SX, occurred in 63.5% and 56.5% of patients at tracheal extubation and arrival to the PACU, respectively.

Recently, investigators assessed the effect of implementing universal use of AMG in an institution's OR over the course of a year. The initial mean (SD) TOFR in 91 patients before implementation was 0.9 (0.18; median = 0.94); moreover, the initial proportion of patients with TOFRs at or below 0.5, 0.8, and 0.9 was 4%, 17%, and 31%, respectively. After implementation, the
mean TOFR in 101 patients had increased to 0.95 (SD = 0.08; median = 0.98), and the proportion of patients with TOFRs at or below 0.5, 0.8, and 0.9 had decreased to 0%, 5%, and 15%, respectively.27

An RCT involving 150 patients comparing the use of AMG with a control group that utilized qualitative monitoring methods found that the number of patients with a TOFR of 0.9 or less was significantly lower in the AMG group: 11 patients in the AMG group (14.5%) vs 37 patients in the qualitative monitoring group (50.0%; \( P < .0001 \)).28 Furthermore, the AMG group reported lower perceived muscle weakness in the PACU and reported significantly higher recovery on a 100-mm visual analog scale than the qualitative monitoring group, indicating that patient satisfaction had a positive correlation to lower rates of RNMB.28

New Horizons: Sugammadex
Sugammadex, the first selective relaxant binding agent, is a molecule composed of cyclic dextrose units: a modified \( \gamma \)-cyclodextrin.29 Due to the cyclic structure of sugammadex, there is a large lipophilic internal cavity in the molecule, enabling an encapsulation mechanism of action to occur with the amino steroid class of NMBAs, with evidence showing a favoring of rocuronium > vecuronium > pancuronium.29,30 Sugammadex selectively forms complexes in a 1:1 ratio with the amino steroid class of NMBAs such as rocuronium, reversing paralysis by preventing the drug from binding to the nicotinic acetylcholine receptor sites (Figure 4B).2-4 This encapsulation process makes rocuronium unavailable to the acetylcholine receptor at the neuromuscular junction, allowing acetylcholine to bind without competition and promoting the reemergence of muscle contraction.2

Furthermore, this encapsulation, due to intermolecular forces such as hydrogen bonds, creates an immensely tight complex with the nondepolarizing NMBA, such that only 1 in every 25 to 30 million sugammadex-rocuronium complexes dissociates.19,20 Compared with acetylcholinesterase inhibitors, this unique method of action has been shown to decrease rates of RNMB.2-4 Although not specifically related to RNMB, another advantage of sugammadex compared with traditional acetylcholinesterase inhibitors is that it avoids possible muscarinic side effects, such as bradycardia, bronchoconstriction, and nausea and vomiting, because its mechanism of action does not increase acetylcholine levels (which can lead to muscarinic side effects).1,19 Finally, it should be noted that sugammadex does not interact with any receptor system in the body and is excreted unchanged in the urine because of the external hydrophilic properties of the sugammadex-rocuronium complex.19,29 Despite its promising pharmacologic properties, caution must be exerted when one is using sugammadex, just as when using any other medication.

Tempering injudicious use are findings suggesting caution in the use of sugammadex. Intraoperative anaphylaxis and increased bleeding with prolonged activated partial thromboplastin time and prothrombin time (or international normalized ratio), although infrequent, have been associated with its use3,29,31,32 In contrast, a recent observational study comparing 142 patients in 3 groups—without sugammadex, with administration of 2 mg/kg of sugammadex, and with 4 mg/kg of sugammadex—found no significant difference in measures of blood coagulation after sugammadex at either dose.31 In a randomized, double-blind, placebo-controlled, parallel-group, repeat-dose study of 299 healthy and 176 nonhealthy individuals, in which 151 subjects received 4 mg/kg of sugammadex, 148 subjects received 16 mg/kg, and 76 received a placebo, the frequency of anaphylaxis was 0.3%.33 Recent findings suggest that providers should be aware of the risk of anaphylaxis associated with the use of sugammadex, as its use continues to rise after its relatively recent (2015) approval in the United States.3,32 Of note, sugammadex is a cyclodextrin, which are used in the food industry as carriers and stabilizers of flavors, colors, fat-soluble vitamins, and polyunsaturated fatty acids.34 The authors suggest that patients may become sensitized to sugammadex because of contact with foods or other products, despite having no preoperative history of allergy to cyclodextrin-containing foods.34 Finally, it is important to note that sugammadex reduces the effects of progesterone, and female patients are thus urged to use an additional method of contraception for 1 week following sugammadex use and/or follow the directions for missing 1 dose of their currently used oral contraceptive.29

Despite these risks, initial outcomes of sugammadex use are appealing: a meta-analysis published by The Cochrane Library of 18 RCTs revealed many promising...
findings related to the use of sugammadex compared with more traditional agents such as neostigmine. Of note, 6 studies demonstrated that doses of 2 mg/kg and 4 mg/kg of sugammadex were able to reverse blockade with a mean time of less than 3 minutes, regardless of the dosage of rocuronium used for intubation and/or maintenance. Additionally, 3 studies compared sugammadex with neostigmine and found that reversal using sugammadex was 5 to 17 times faster than when using neostigmine. More importantly, 5 trials compared the safety of sugammadex with that of neostigmine and found no relationship between adverse events and sugammadex use, whereas neostigmine and glycopyrrolate were associated with more changes in blood pressure and heart rate. Another meta-analysis, consisting of 13 RCTs and a total of 1,384 patients, found sugammadex to be both safer and more effective at reversing neuromuscular blockade compared with neostigmine. This meta-analysis found that both respiratory complications (eg, hypoxemia, bronchospasm, and atelectasis) and cardiovascular events (eg, arrhythmias and atrial pressure variance) were more frequently associated with neostigmine than with sugammadex.

The safety of sugammadex use in the pediatric population is unknown. Although the literature regarding this topic is sparse, some studies are encouraging in this regard. Results of an RCT comparing the use of sugammadex and neostigmine in reversal of rocuronium in 60 patients aged 2 to 10 years undergoing abdominal surgery revealed that those given sugammadex experienced statistically significantly shorter (faster) muscle recovery times on average (1.4 [SD 1.2] minutes) compared with the neostigmine group (25.2 [6.5] minutes). No adverse events were reported by either group during the study. This RCT, as well as a recent case report reporting use of sugammadex in a “can’t ventilate/can’t intubate” scenario, further suggests the need for more research in pediatric patients.

Additionally, sugammadex may benefit patients with complex disease states. It has been associated with fewer adverse events such as respiratory and cardiovascular complications compared with neostigmine in a recent meta-analysis.

An RCT of 99 patients randomly assigned to 3 overall groups (saline placebo, sugammadex, and neostigmine) aimed to find doses of sugammadex and neostigmine that would reverse rocuronium-induced blockade (measured as TOFR ≥ 0.2) to a TOFR of 0.9 or greater in 50% of the patients within 2 minutes and 95% of the patients within 5 minutes. The results revealed that neostigmine is not able to reverse a TOFR from 0.2 or higher to 0.9 or more within 10 minutes in 95% of patients. On the other hand, sugammadex is able to reverse a TOFR from 0.2 or greater to 0.9 or more in 93% of patients within 5 minutes at a dose of approximately 0.26 mg/kg. Ultimately, one can conclude from these results that sugammadex may be faster, more reliable, and better at preventing RNMB than neostigmine. These conclusions are supported by the meta-analysis by Carron et al whose findings also suggest that sugammadex is a safer drug than neostigmine; they found that sugammadex use was associated with a significantly lower risk of respiratory and cardiovascular adverse events as well as postoperative weakness.

Unfortunately, sugammadex use is not infallible. Some studies (including the meta-analysis by Carron et al) reveal that, although rates tend to be lower, RNMB still occurs when sugammadex is used to reverse NMBAs. Thus, even with the use of sugammadex, the anesthesia provider cannot rely on drugs alone to prevent RNMB and should not overlook the importance of vigilant perioperative monitoring of neuromuscular blockade while using any NMBAs, especially during emergence and extubation. The fact that anesthesia providers must rely on both monitoring and careful administration of medications during the perioperative period might seem somewhat “self-evident.” However, with current research findings showing that our current, more traditional methods of subjective monitoring and the use of anticholinesterase agents may place patients’ safety at risk, a change in practice may lead to better patient outcomes.

**Recommendations for Clinical Practice to Reduce the Risk of RNMB**

The following are evidence-based recommendations for reducing RNMB risk:

- Consider the PNS as part of routine monitoring practice, become familiar with its shortcomings, and place the PNS monitor on the patient before induction, to ensure proper placement and establish a baseline reading.
- If an accelerometer is available, consider its use over that of a PNS because evidence shows accelerometers aid in the prevention of RNMB.
- Use the adductor pollicis muscle when possible, because the facial nerve and orbicularis oculi muscles have been found to be unreliable and the abductor hallucis and orbicularis oculi have been associated with premature recovery readings.
- Further, direct muscle stimulation of the orbicularis oculi has been shown to confound PNS readings despite the nerve being blocked, leading to overdosing of the NMBAs and overappreciating the degree of recovery from the NMBAs.
- Take care to not give patients unnecessary amounts of neostigmine, as this practice has been associated with paradoxical paralysis. The typical dose range is 25 to 75 µg/kg.
- Allow for a sufficient degree of spontaneous recovery before administration of reversal agents. The timing of neostigmine administration is important to successful reversal of neuromuscular blockade: research has shown...
that reversal attempts with TOF counts of 1 or less are less likely to achieve safe levels of neuromuscular recovery in the same amount of time as patients reversed with all 4 twitches present.\textsuperscript{21,37}

• Consider the use of sugammadex, as current evidence has shown that sugammadex aids in the prevention of RNMB and is safer than more traditional reversal agents such as neostigmine.\textsuperscript{2,35}

Although the aforementioned suggestions will likely minimize rates of RNMB, they are not foolproof. The clinical evidence reveals that the use of qualitative measures and traditional reversal agents such as neostigmine are associated with higher rates of RNMB and that, if available, sugammadex is an attractive alternative to traditional reversal agents. Additionally, literature reveals that sugammadex is associated with decreased rates of RNMB and allows for more reliable blockade reversal compared with acetylcholinesterase inhibitors. Unfortunately, as sugammadex was only recently approved for use in the United States and 200-mg vials reportedly cost more than $90, the novelty and cost associated with sugammadex have hindered its widespread use.\textsuperscript{35,41} Additionally, the cost of reversing a moderate blockade at one major teaching institution with sugammadex at a dose of 2 mg/kg for an 80-kg patient ($80) is similar to that of neostigmine and glycopyrrrolate administered together at 5 mg and 1 mg, respectively ($35 and $30). However, for reversing a deep blockade, the neostigmine/glycopyrrrolate combination yields a savings of $100 compared with sugammadex at a dose of 4 mg/kg for an 80-kg patient ($160). Although evidence is sparse, initial findings suggest that, despite the outright high cost of sugammadex, the prevention of adverse events, lower rates of RNMB, and overall faster recovery time leading to faster OR turnover may translate into overall lower cost.\textsuperscript{42,43} Moreover, overwhelming evidence suggests that quantitative monitoring is superior to traditional qualitative monitoring in reducing postoperative RNMB. With the above evidence in mind (see summary in Table 2), current practice may need to be modified to reduce rates of RNMB and to increase patient safety outcomes.

**REFERENCES**


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<td></td>
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<td>Neostigmine: Increased rates of RNMB and associated adverse events, including death</td>
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<tr>
<td>Bottom line</td>
<td>Traditional methods are associated with increased rates of RNMB and associated adverse events. Objective monitoring techniques and sugammadex have been shown to decrease rates of RNMB but are costly and have limited availability. When sugammadex and other objective measures are not available, anesthesia providers should, at the very least, know the limitations of subjective monitoring and use PNS for intraoperative monitoring.</td>
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**Table 2. Summary of Traditional and Evidence-Based Methods**

Abbreviations: AMG, acceleromyography; PNS, peripheral nerve stimulator; RNMB, residual neuromuscular blockade; TOF, train-of-four; TOFR, train-of-four ratio.


25. Full Prescribing Information: Sugammadex. 2015.


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DISCLOSURES
The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did discuss off-label use within the article.

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CALENDAR OF EVENTS

Advertisers who list their prior-approved CE programs in the Calendar of Events enjoy wider exposure for their approved programs because the $125 per listing fee includes a duplicate listing on the AANA website as well as a link directly to the online Calendar of Events in the bi-monthly Anesthesia E-ssential (the AANA’s electronic newsletter). Additionally, the web address provided in the advertisement will be hyperlinked directly to the websites allowing viewers access to company and program information for more exposure and target-directed traffic.

Go to http://www.aana.com/cecalendarofevents for specific deadline dates. The fee can be paid along with the CE Application submission.

For additional information, contact Ann Carlson, Continuing Education Department, at (847) 655-1190.

April 1, 2018 - December 31, 2018, Florida; Valley Anesthesia, Inc. - 20 CEC. “Valley Anesthesia’s CE for the CRNA.” Walt Disney World Swan & Dolphin Resorts, Lake Buena Vista, FL. Scott Schaus, 5 Penn Plaza, Suite 2375, New York, NY 10001; (651) 395-0777; email, scott@valleyanesthesia.com; www.valleyanesthesia.com.

April 1, 2018 - December 20, 2018, Michigan; Institute For Post Graduate Education - 25 CEC. “CE Anywhere-Self Directed Home Study.” Institute For Post Graduate Education, Hastings, MI. Bernard Kuzava, CRNA, PO Box 28, Hastings, MI 49058; (877) 692-0430; fax (269) 948-2507; email, ipgeseminars@ipge.com; www.ipge.com.

April 1, 2018 - December 31, 2018, Ohio; Dannemiller - 36 CEC. April 1, 2018 - January 29, 2021, Illinois; American Association of Nurse Anesthetists - 1 CEC. “Substance Use Disorder: Best Pathway to Prevention and Handling in Anesthesia Professionals.” (847) 939-3530; email, AANALearn@aana.com; www.AANALearn.com.

April 20, 2018 - April 21, 2018, Maryland; Maryland Association of Nurse Anesthetists (MANA) - 12 CEC. “MANA Spring Regional Ultrasound Workshop.” Chartwell Golf & Country Club, Severna Park, MD. Becca Stinner, 3601 East Joppa Road, Baltimore, MD 21234; (410) 931-8100; email, becca@clemonsmgmt.com; crnasofmd.org.

April 20, 2018 - April 22, 2018, Massachusetts; Airway Management Education Center - 18 CEC. “The Difficult Airway Course: Anesthesia.” Hyatt Regency Boston, Boston, MA. Registration Office, 333 South State Street, Suite V-324, Lake Oswego, OR 97034; (866) 924-7929; fax (404) 795-0711; email, registrations@theairwaysite.com; www.theairwaysite.com.


April 27, 2018 - April 29, 2018, Kansas; University of Kansas Medical Center - 12 CEC. “68th Postgraduate Symposium on Anesthesiology.” InterContinental Hotel on the Plaza, Kansas City, KS. Monya Floyd, 3901 Rainbow Blvd, Kansas City, KS 66160; (913) 588-4478; fax (913) 588-4478; email, mlfloyd2@kumc.edu; www.kumc.edu/anesthes-symposium.

April 27, 2018 - April 29, 2018, Nebraska; Nebraska Association of Nurse Anesthetists - 20 CEC. “2018 NANA Spring Conference.” Embassy Suites by Hilton, Omaha Downtown/ Old Market, Omaha, NE. Emily Wilcox, 1633 Normandy Ct, Suite A, Lincoln, NE 68512; (402) 476-3852; fax (402) 476-6547; email, ewilcox@assocoffice.net; www.neana.org.

April 28, 2018 - April 28, 2018, Connecticut; Lewis Anesthesia for Continuing Education - 7 CEC. “Airway on Demand Workshop.” Courtyard by Marriott Downtown Waterbury, Waterbury, CT. Lewis Anesthesia, 48361-2 Albanese Drive, Fort Hood, TX 76544; (888) 938-2762; email, info@lewisanesthesia.com; lewisanesthesia.com.

May 3, 2018 - May 6, 2018, Florida; Northwest Anesthesia Seminars - 20 CEC. “Topics in Pediatric Anesthesia.” Hilton Sandestin Beach Golf Resort & Spa, Destin, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/nwas/destin/18MFL.html.


May 7, 2018 - May 10, 2018, New Mexico; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Update.” La Posada de Santa Fe, Santa Fe, NM. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/santafe/18mnn.html.

May 7, 2018 - May 11, 2018, Austria; Northwest Anesthesia Seminars - 20 CEC. “Relevant Topics in Anesthesia.” Vienna Marriott Hotel, Vienna, Austria. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/vienna/18mvi.html.

May 7, 2018 - May 11, 2018, France; Northwest Seminars - 20 CEC. “Current Topics in Emergency Medicine.” Paris Marriott Rive Gauche Hotel, Paris, France. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.nwas.com/paris/18mnr.html.

May 13, 2018 - May 13, 2018, South Carolina; Encore Symposiums - 8 CEC. “Spring on Hilton Head Island Pharmacology CPC Review Course.” Sonesta Resort Hilton Head Island, Hilton Head Island, SC. Nancy LaBrie, 1907 Loch Lomond Ct, Winston-Salem, NC. (336) 768-9095; fax (336) 768-9055; email, nancy@escrnas.com; www.escrnas.com.

May 14, 2018 - May 17, 2018, South Carolina; Encore Symposiums - 23 CEC. “Spring on Hilton Head Island 2018.” Sonesta Resort Hilton Head Island, Hilton Head Island, SC. Nancy LaBrie, 1907 Loch Lomond Ct, Winston-Salem, NC. (336) 768-9095; fax (336) 768-9055; email, nancy@escrnas.com; www.escrnas.com.

May 14, 2018 - May 18, 2018, Curacao; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Update.” Renaissance Curacao Resort & Casino, Willemstad, Curacao. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/curacao/18mcu.html.

May 14, 2018 - May 18, 2018, Massachusetts; Harvard Medical School - 54.25 CEC. “Anesthesiology Update 2018.” Fairmont Copley Hotel Boston, Boston, MA. Ronald Mayes, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Yaminis 219, Boston, MA 02215; (617) 667-5039; fax (617) 667-5013; email, rmayes@bidmc.harvard.edu; http://www.hms.harvard.edu.

May 16, 2018 - May 19, 2018, Arizona; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” Andaz Scottsdale Resort & Spa, Scottsdale, AZ. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/nwas/scottsdale/18MFL.html.

May 17, 2018 - May 20, 2018, California; Association of Veterans Affairs Nurse Anesthetists - 19 CEC. “2018 AVANA Education Meeting.” Hilton Long Beach, Long Beach, CA. Nancy Christiano, 17 S High St, Suite 200 Columbus, OH 43215; (412) 298-8965; email, AVANAA2018meeting@gmail.com; www.vacrna.com.


May 21, 2018 - May 24, 2018, Florida; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” Boca Beach Club, A Waldorf Astoria Resort, Boca Raton, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/bocaratong/18mbr.html.

May 21, 2018 - May 24, 2018, Tennessee; Northwest Anesthesia Seminars - 20 CEC. “Relevant Topics in Anesthesia.” Hilton Nashville Downtown, Nashville, TN. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/nashville/18mma.html.

May 21, 2018 - May 25, 2018, Amsterdam; Northwest Anesthesia Seminars - 20 CEC. “Relevant Topics in Anesthesia.” Renaissance Amsterdam Hotel, Amsterdam, the Netherlands. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/amsterdam/18MAM.html.

May 22, 2018 - May 25, 2018, Louisiana; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine.” JW Marriott New Orleans, New Orleans, LA. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.nwas.com/neworleans/18mnnr.html.

May 28, 2018 - May 31, 2018, Georgia; Northwest Anesthesia Seminars - 24 CEC. “Relevant Topics in Anesthesia.” The Ritz-Carlton Buckhead, Atlanta, GA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/atlanta/18mat.html.

May 29, 2018 - June 5, 2018, Ireland; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” 10-Night Iceland and Ireland Cruise, aboard Celebrity Eclipse, Roundtrip from Dublin, Ireland. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/europe/18mirc.html.

May 30, 2018 - June 2, 2018, South Carolina; Nurse Anesthesiology Faculty Associates - 22 CEC. “32nd Annual Anesthesia Seminar.” Hilton Head Marriott Resort and Spa, Hilton Head, SC. Michael Fallacaro, Box 980226, Richmond, VA 23298; (804) 828-6734; fax (804) 828-0581; email, nafa@vcu.edu; www.nafa-va.org.
June 3, 2018 - June 3, 2018, South Carolina; Encore Symposiums - 8 CEC. “Charleston Harbor-Front Sanctuary Pharmacology CPC Review Course.” The Beach Club at Charleston Harbor Resort & Marina, Mt Pleasant, SC. Nancy LaBrie, 1907 Loch Lomond Ct, Winston-Salem, NC 27106-3608; (336) 768-9095; fax (336) 768-9055; email, nancy@escrnas.com; www.escrnas.com.

June 4, 2018 - June 7, 2018, South Carolina; Encore Symposiums - 23 CEC. “Charleston Harbor-Front Sanctuary 2018.” The Beach Club at Charleston Harbor Resort & Marina, Mt Pleasant, SC. Nancy LaBrie, 1907 Loch Lomond Ct, Winston-Salem, NC 27106-3608; (336) 768-9095; fax (336) 768-9055; email, nancy@escrnas.com; www.escrnas.com.

June 4, 2018 - June 8, 2018, California; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Update.” Tenaya Lodge, Fish Camp (Yosemite National Park), CA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/yosemite/18JYP.html.

June 6, 2018 - June 9, 2018, Washington, DC; Northwest Anesthesia Seminars - 20 CEC. “Current Topics in Anesthesia.” The Westin Georgetown Washington DC Hotel, Washington, DC. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/dct/18jdc.html.

June 11, 2018 - June 14, 2018, Florida; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Update.” Tradewinds Island Grand Resort, St Pete Beach, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/tpetebch/18jps.html.

June 11, 2018 - June 15, 2018, Wyoming; Northwest Anesthesia Seminars - 20 CEC. “Relevant Topics in Anesthesia.” Hotel Terra, Jackson Hole, WY. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/teton/18jwy.html.

June 14, 2018 - June 17, 2018, Florida; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” Margaritaville Key West Resort & Marina, Key West, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/keywest/18kw.html.


June 18, 2018 - June 21, 2018, Nevada; Northwest Anesthesia Seminars - 24 CEC. “Anesthesia Jackpot: Trauma.” The Westin Las Vegas, Las Vegas, NV. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/vegas/18jvn.html.

June 18, 2018 - June 22, 2018, Oregon; Northwest Anesthesia Seminars - 20 CEC. “Clinical Concerns in Anesthesia.” Surlsand Resort, Cannon Beach, OR. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/cannonbeach/18jch.html.

June 20, 2018 - June 23, 2018, South Carolina; UNC School of Medicine - 21 CEC. “31st Annual Carolina Refresher Course: Update in Anesthesiology. Pain & Critical Care Medicine.” Kiawah Island Golf Resort, Kiawah Island, SC. Lynn Craven, UNC Anesthesiology, 208 MacNider Hall, Campus Box 7010, Chapel Hill, NC 27599-7010; (919) 966-0009; fax (919) 966-0009; email, lcraven@uims.unc.edu; http://go.unc.edu/CRC2018.

June 24, 2018 - June 29, 2018, Washington; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” Alaska Explorer via Glacier Bay Cruise, aboard ms Eurodam, Roundtrip from Seattle, WA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/alaska/18jalc.html.

June 25, 2018 - June 30, 2018, South Carolina; Anesthesia Business Seminars - 36 CEC. “Myrtle Beach a la carte: Business of Anesthesia & Beyond.” Island Vista Resort, Myrtle Beach, SC. Laura Moritz, 1080 Ayers Road, Moneta, VA 24121; (336) 577-8490; email, laura@AssociationMeetingPlanners.com; www.AnesthesiaBusinessSeminars.com.

June 26, 2018 - June 29, 2018, Colorado; Northwest Anesthesia Seminars - 24 CEC. “Clinical Anesthesia Update.” St Julien Boulder's Hotel & Spa, Boulder, CO. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/boulder/18jco.html.

June 27, 2018 - June 30, 2018, Florida; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine: Trauma.” Opal Sands Resort, Clearwater Beach, FL. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/clearwater/18emjcw.html.

July 2, 2018 - July 12, 2018, Amsterdam; Northwest Anesthesia Seminars - 20 CEC. “Clinical Concerns in Anesthesia.” 12-Day Scandinavian & Russia Cruise, aboard Celebrity Eclipse, Roundtrip from Amsterdam, the Netherlands. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/europe/18jesr.html.

July 9, 2018 - July 13, 2018, Hawaii; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine.” The Kahala Hotel & Resort, Honolulu, HI. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/hawaii/18emjh0.html.

July 9, 2018 - July 14, 2018, Canada; Northwest Anesthesia Seminars - 20 CEC. “Clinical Concerns in Anesthesia.” Alaska Hubbard Glacier via the Inside Passage Cruise, aboard Celebrity Infinity, Roundtrip from Vancouver, British Columbia, Canada. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/alaska/18jalc.html.

July 11, 2018 - July 14, 2018, South Carolina; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Update.” Marriott Resort & Spa at Grande Dunes, Myrtle Beach, SC. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/myrtlebeach/18jmb.html.


July 16, 2018 - July 19, 2018, Florida; Northwest Anesthesia Seminars - 20 CEC. “Current Topics in Anesthesia.” Opal Sands Resort, Clearwater Beach, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/clearwater/18JCW.html.
July 16, 2018 - July 20, 2018, Montana; Northwest Anesthesia Seminars - 20 CEC. “Current Anesthesia Practice.” The Lodge at Whitefish Lake, Whitefish (Glacier National Park), MT. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/whitefish/18WEhtml.


July 25, 2018 - July 28, 2018, Oregon; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine.” The Nines Hotel, Portland, OR. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/portland/18EMJPO.html.

July 30, 2018 - August 4, 2018, Alaska; Northwest Seminars - 20 CEC. “Current Topics in Emergency Medicine.” 7-Night Alaska Explorer Cruise via Glacier Bay, aboard ms Westerdam, Seward, Alaska to Vancouver, British Columbia, Canada. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/whitefish/18WEhtml.

August 1, 2018 - August 4, 2018, California; Northwest Anesthesia Seminars - 20 CEC. “Relevant Topics in Anesthesia.” Hotel Solamar, San Diego, CA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/sandiego/18asd.html.

August 3, 2018 - August 3, 2018, Florida; GulfCoast Ultrasound Institute, Inc. - 6.75 CEC. “Ultrasound-Guided Vascular Access.” The Plaza Tower & Courtyard Shops, St Petersburg, FL. Lori Green, 111 2nd Ave NE Suite 800, St Petersburg, FL 33701; (727) 363-4500; fax (727) 363-0811; email, lori.green@gcus.com; www.gcus.com.

August 5, 2018 - August 9, 2018, Oregon; Northwest Anesthesia Seminars - 24 CEC. “Current Topics in Anesthesia.” Sunriver Resort, Sunriver, OR. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/vegas/18vs.html.

August 7, 2018 - August 17, 2018, Amsterdam; Northwest Anesthesià Seminars - 20 CEC. “Topics in Anesthesia.” 12-Night British Isles Cruise, aboard Celebrity Eclipse, Roundtrip from Amsterdam, the Netherlands. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/europe/18euc.html.

August 8, 2018 - August 11, 2018, Canada; Northwest Anesthesia Seminars - 24 CEC. “Topics in Anesthesia.” The Algonquin Resort, St Andrews, New Brunswick, Canada. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/standrews/18ac.html.

August 13, 2018 - August 16, 2018, North Carolina; Northwest Anesthesia Seminars - 24 CEC. “Topics in Anesthesia.” The Omni Grove Park Inn Resort, Asheville, NC. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/asheville/18anc.html.

August 13, 2018 - August 17, 2018, Canada; Northwest Anesthesia Seminars - 20 CEC. “Clinical Topics in Anesthesia.” The Rimrock Resort Hotel, Banff, Alberta, Canada. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/banff/18aca.html.

August 19, 2018 - August 24, 2018, Washington; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” Alaska Explorer via Glacier Bay Cruise, aboard ms Eurodam, Roundtrip from Seattle, WA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/alaska/18akl.html.

August 20, 2018 - August 24, 2018, Alaska; Northwest Anesthesia Seminars - 20 CEC. “Current Topics in Anesthesia.” The Lakefront Anchorage, Anchorage, AK. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/alaska/18akl.html.

August 20, 2018 - August 31, 2018, England; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” 14-Night Iceland & Ireland Cruise, aboard Celebrity Silhouette, Roundtrip from Southampton, England. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/europe/18aire.html.

September 4, 2018 - September 7, 2018, Nevada; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” The Palms Casino Resort, Las Vegas, NV. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/vegas/18vs.html.

September 10, 2018 - September 13, 2018, Nevada; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine: Emphasis on Pediatrics.” The Palms Casino Resort, Las Vegas, NV, NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.northwestseminars.com/vegas/18vs.html.

September 10, 2018 - September 13, 2018, North Carolina; Cornerstone Anesthesia Conferences - 20 CEC. “Anesthesia Update.” The Palms Casino Resort, Las Vegas, NV, NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.cornerstoneanesthesiaseminars.com/conferences.com.

September 10, 2018 - September 13, 2018, Washington; Med City Anesthesia Seminars - 20 CEC. “Current Topics In Anesthesia.” Grand Hyatt Hotel, Asheville, NC. Jayne Reuter, PO Box 7214, Houston, TX 77248; (281) 836-0777; email, Info@cornerstoneAnesthesiaConferences.com; www.cornerstoneAnesthesiaConferences.com.

September 10, 2018 - September 13, 2018, California; Northwest Anesthesia Seminars - 20 CEC. “Clinical Anesthesia Update.” Tenaya Lodge, Fish Camp (Yosemite National Park), CA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/yosemite/18YSF.html.

September 17, 2018 - September 20, 2018, Arizona; Northwest Anesthesia Seminars - 20 CEC. “Current Anesthesia Practice.” The Hilton Sedona Resort at Bell Rock, Sedona, AZ. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/sedona/18SAZ.html.
September 20, 2018 - September 23, 2018, South Carolina; Northwest Anesthesia Seminars - 20 CEC.
“Relevant Topics in Anesthesia.” The Westin Hilton Head Island Resort & Spa, Hilton Head Island, SC. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/hiltonhead/18SHH.html.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 7.25 CEC. “2018 Airway on Demand Workshop.” Hynes Convention Center, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 8.5 CEC. “Crisis Resource Management Simulation Course.” Center for Medical Simulation, Charlestown, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 7 CEC. “2018 Neuraxial Regional Anesthesia and Epidural Workshop.” Hynes Convention Center, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 3.5 CEC. “Fundamentals in Perioperative Transesophageal Echocardiogram Workshop-MORNING.” Hynes Convention Center, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 3.5 CEC. “Fundamentals in Perioperative Transesophageal Echocardiogram Workshop-AFTERNOON.” Hynes Convention Center, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 3 CEC. “Writers Workshop: Writing for Professional/Scholarly Publication.” Sheraton Boston Hotel, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 3.5 CEC. “2018 Neuromuscular Block Monitoring Workshop- MORNING.” Hynes Convention Center, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 3.5 CEC. “2018 Neuromuscular Block Monitoring Workshop- AFTERNOON.” Hynes Convention Center, Boston, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 21, 2018, Massachusetts; American Association of Nurse Anesthetists - 6.5 CEC. “Gateway to Debriefing with Good Judgment Courses.” Center for Medical Simulation, Charlestown, MA. (847) 655-8797; email, meetings@aana.com; www.aana.com/meetings.

September 21, 2018 - September 23, 2018, Maryland; Airway Management Education Center - 18 CEC.
“The Difficult Airway Course: Anesthesia.” Hyatt Regency Baltimore Inner Harbor, Baltimore, MD. Registration Office, 333 South State Street, Suite V-324, Lake Oswego, OR 97034; (866) 924-7929; fax (404) 795-0711; email, registrations@theairwaysite.com; www.theairwaysite.com.

September 22, 2018 - October 6, 2018, Hungary; Spieckermann Travel - 20 CEC. “Current Issues in CRNA Practice.” Multiple locations around Hungary, Vienna, and Prague. Michael Rieker, Nurse Anesthesia Program, 523 Vine St, Ste 230, Winston-Salem, NC 27101; (800) 645-3233; fax (586) 775-9556; email, info@mideastrvl.com; http://www.mideastrvl.com/.

September 24, 2018 - September 27, 2018, Arizona; Northwest Seminars - 20 CEC. “Pediatric and Adult Emergency Medicine - Personal and Career Development.” The Hilton Sedona Resort at Bell Rock, Sedona, AZ. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/sedona/18EMS AZ.html.

September 24, 2018 - September 28, 2018, Wyoming; Northwest Anesthesia Seminars - 20 CEC. “Clinical Anesthesia Update.” Hotel Terra, Jackson Hole (Grand Teton National Park), WY. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/tetons/18w wy.html.

September 25, 2018 - October 2, 2018, Spain; Northwest Anesthesia Seminars - 20 CEC. “Clinical Concerns in Anesthesia.” 12-Night Italy and Greek Isle Cruise, aboard Celebrity Eclipse, Roundtrip from Barcelona, Spain. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/europe/18s islge.html.

September 29, 2018 - September 30, 2018, Virginia; Nurse Anesthesiology Faculty Associates - 15 CEC. “4th Annual Anesthesia Crisis Resource Management Course.” Virginia Commonwealth University, Richmond, VA. Michael Fallacaro, Box 980226, Richmond, VA 23298; (804) 828-6734; fax (804) 828-0581; email, nafa@vcu.edu; www.nafa-va.org.

September 30, 2018 - September 30, 2018, Rhode Island; Encore Symposia - 8 CEC. “Newport Mansions Fall Foliage Pharmacology CPC Review Course.” Hotel Viking, Newport, RI. Nancy LaBrie, 1907 Loch Lomond Ct, Winston-Salem, NC 27101-3608; (336) 768-9095; fax (336) 768-9055; email, nancy@escrnas.com; www.escrnas.com.

September 30, 2018 - October 5, 2018, Bonaire; Northwest Anesthesia Seminars - 20 CEC. “Topics in Anesthesia.” Courtyard Marriott Bonaire, Kralendijk, Bonaire, Netherlands. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/bonaire/18oba.html.
October 1, 2018 - October 4, 2018, Rhode Island; Encore Symposia - 23 CEC. “Newport Mansions Fall Foliage Experience 2018.” Hotel Viking, Newport, RI. Nancy LaBrie, 1907 Loch Lomond Ct, Winston-Salem, NC 27101-3608; (336) 768-9095; fax (336) 768-9035; email, nancy@escrnas.com; www.escrnas.com.

October 4, 2018 - October 7, 2018, Tennessee; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Spectrum.” The Park Vista, a Doubletree Hotel, Gatlinburg, TN. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/gatlinburg/18oga.html.

October 6, 2018 - October 6, 2018, Colorado; Colorado Association of Nurse Anesthetists - 10 CEC. “Colorado Association of Nurse Anesthetists Fall Meeting.” Table Mountain Inn, Golden, CO. Kate Jansksy, 9283 Kornhurst Dr, Lone Tree, CO 80124; (425) 765-7922; email, kjanskskycrna@me.com; www.CoANA.org.

October 6, 2018 - October 19, 2018, Israel; Spieckermann Travel - 20 CEC. “Current Issues in CRNA Practice.” Multiple locations around Israel. Michael Rieker, Nurse Anesthesia Program, 525 Vine St, Ste 230, Winston-Salem, NC 27101; (800) 645-3233; fax (586) 775-9556; email, info@mideasttrvl.com; http://www.mideasttrvl.com/.

October 8, 2018 - October 12, 2018, Colorado; Northwest Anesthesia Seminars - 20 CEC. “Clinical Anesthesia Update.” Gateway Canyon Resort, Gateway, CO. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/gateway/18oco.html.


October 16, 2018 - October 26, 2018, Vietnam & Cambodia; Northwest Anesthesia Seminars - 20 CEC. “12-Day Vietnam & Cambodia Land Tour: Anesthesia Update.” Hanoi, Vietnam; Saigon, Vietnam; Saigon, Vietnam; and Phnom Penh, Cambodia. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/vietnam/18vnm.html.

October 22, 2018 - October 26, 2018, Utah; Northwest Anesthesia Seminars - 20 CEC. “Clinical Anesthesia Update.” SpringHill Suites Springdale Zion National Park, Springdale (Zion National Park), UT. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/zion/18out.html.

October 26, 2018 - October 28, 2018, Louisiana; Airway Management Education Center - 18 CEC. “The Difficult Airway Course: Anesthesia.” Hyatt Regency New Orleans, New Orleans, LA. Registration Office, 333 South State Street, Suite V-324, Lake Oswego, OR 97034; (866) 924-7929; fax (404) 793-0711; email, registration@theairwaysite.com; www.theairwaysite.com.

October 26, 2018 - October 29, 2018, New York; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine.” New York Marriott Downtown, New York City, NY. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/newyork/18emoney.html.

October 26, 2018 - November 4, 2018, Argentina and Brazil; Spieckermann Travel - 20 CEC. “Current Issues in CRNA Practice.” Multiple locations around Argentina and Brazil. Michael Rieker, Nurse Anesthesia Program, 523 Vine St, Ste 230, Winston-Salem, NC 27101; (800) 645-3233; fax (586) 775-9556; email, info@mideasttrvl.com; http://www.mideasttrvl.com/.

October 28, 2018 - November 1, 2018, Arizona; Holiday Seminars - 24 CEC. “Scottsdale Anesthesia, 2018.” JW Marriott Camelback Inn Resort & Spa, Scottsdale, AZ. William Smith, PO Box 6145, Snowmass Village, CO 81615; (877) 859-0550; fax (970) 923-9640; email, office@holidayseminars.com; www.holidayseminars.com.

October 28, 2018 - November 2, 2018, Hawaii; Northwest Anesthesia Seminars - 20 CEC. “Anesthesia Topics.” Hyatt Regency Maui, Lahaina, HI. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/mauii18ohi.html.

November 1, 2018 - November 4, 2018, Arizona; Arizona Association of Nurse Anesthetists - 20 CEC. “AZANA Sun in Sedona Anesthesia Conference.” Poco Diablo Resort, Sedona, AZ. Laura Moritz, 1080 Ayers Rd, Moneta, VA 24121; (336) 577-8450; email, laura@AssociationMeetingPlanners.com; www.AZCRNA.com.

November 1, 2018 - November 4, 2018, Florida; Northwest Anesthesia Seminars - 20 CEC. “Keys in Anesthesia.” Margaritaville Key West Resort, Key West, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/keywest/18kw.html.

November 1, 2018 - November 9, 2018, Spain; Northwest Anesthesia Seminars - 20 CEC. “Clinical Concerns in Anesthesia.” 12-Night Western Mediterranean Cruise, aboard Celebrity Eclipse, Roundtrip from Barcelona, Spain. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (309) 547-1265; email, info@nwas.com; www.nwas.com/europe/18ewmc.html.


November 3, 2018 - November 17, 2018, South Africa; Spieckermann Travel - 20 CEC. “Current Issues in CRNA Practice.” Multiple locations around South Africa. Michael Rieker, Nurse Anesthesia Program, 523 Vine St, Ste 230, Winston-Salem, NC 27101; (800) 645-3233; fax (586) 775-9556; email, info@mideasttrvl.com; http://www.mideasttrvl.com/.


November 4, 2018 - November 9, 2018, Turks & Caicos Islands; Northwest Anesthesia Seminars - 20 CEC. “Current Topics in Anesthesia.” Beaches Resort and Spa, Providenciales, Turks & Caicos Islands. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/turks/18ntc.html.


November 5, 2018 - November 8, 2018, Florida; Med City Anesthesia Seminars - 20 CEC. “Current Topics In Anesthesia.” TradeWinds Island Grand Resort, St Pete Beach, FL. Karissa Goodrich, PO Box 711, Saint Charles, MN 55972; (800) 538-0217; email, mail@medcityanesthesiaseminars.com; www.medcityanesthesiaseminars.com.

November 9, 2018 - November 11, 2018, California; Airway Management Education Center - 18 CEC. “The Difficult Airway Course: Anesthesia.” Hyatt Regency San Francisco, San Francisco, CA. Registration Office, 333 South State Street, Suite V-324, Lake Oswego, OR 97034; (866) 924-7929; fax (404) 795-0711; email, registrations@theairwaysite.com; www.theairwaysite.com.

November 9, 2018 - November 11, 2018, Florida; Frank Moya Continuing Education Programs - 20 CEC. “47th Annual Refresher Course for Nurse Anesthetists.” The Hilton Hotel, Disney Springs Resort Area, Orlando Lake Buena Vista, FL. Frank Moya, MD, 1828 SE First Avenue, Ft Lauderdale, FL 33316; (954) 763-8811; fax (954) 762-9111; email, info@currentreviews.com; www.currentreviews.com.

November 11, 2018 - November 16, 2018, Jamaica; Northwest Anesthesia Seminars - 20 CEC. “Reviews for Anesthesia Professionals.” Casa Maria Hotel, Port Maria, Jamaica. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/jamaica/18nja.html.

November 12, 2018 - November 16, 2018, Hawaii; Northwest Seminars - 20 CEC. “Topics in Pediatric Emergency Medicine.” Hyatt Regency Maui, Lahaina, Maui, HI. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/maui/18EMNHL.html.

November 15, 2018 - November 18, 2018, Florida; Northwest Seminars - 20 CEC. “Topics in Emergency Medicine.” Margaritaville Key West Resort, Key West, FL. NWS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@northwestseminars.com; www.northwestseminars.com/keywest/18emnkw.html.

November 19, 2018 - November 29, 2018, Florida; Northwest Anesthesia Seminars - 24 CEC. “Clinical Concerns in Anesthesia.” 12-Day Southern Caribbean Cruise, aboard Celebrity Silhouette. Roundtrip from Fort Lauderdale, FL. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/caribbean/18nsc.html.

November 27, 2018 - November 30, 2018, California; Northwest Anesthesia Seminars - 20 CEC. “Recent Topics in Anesthesia.” Napa Valley Marriott Hotel and Spa, Napa, CA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/napa/18nca.html.

December 3, 2018 - December 6, 2018, Bahamas; Northwest Anesthesia Seminars - 20 CEC. “Current Topics in Anesthesia.” Grand Hyatt Baha Mar, Nassau, Bahamas. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/bahamas/18nbb.html.

December 4, 2018 - December 7, 2018, Georgia; Northwest Anesthesia Seminars - 24 CEC. “Current Topics in Anesthesia.” Hyatt Regency Savannah, Savannah, GA. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/savannah/18DGA.html.

December 11, 2018 - December 19, 2018, China; Northwest Anesthesia Seminars - 24 CEC. “Topics in Anesthesia.” 10-Day East Asia Cruise, aboard ms Westerdam, Roundtrip from Hong Kong, China. NWAS, 1412 N 5th, Pasco, WA 99301; (800) 222-6927; fax (509) 547-1265; email, info@nwas.com; www.nwas.com/china/18dpc.html.

January 23, 2019 - January 26, 2019, Cayman Islands; destinationCME - 24 CEC. “Anesthesia Camp Grand Cayman 2019.” The Ritz-Carlton, Grand Cayman, Grand Cayman, Cayman Islands. John E Ellis, MD, 1700 East 56th Street, Suite 3801, Chicago, IL 60637; (773) 417-0075; fax (847) 301-8148; email, info@destinationcme.com; http://destinationcme.com/.


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