Table of Contents

Cardiovascular
- A comparison of central and mixed venous oxygen saturation in circulatory failure ........................................3

Neurosurgical Anesthesia
- Intraoperative brainstem auditory evoked potential observations after trigeminocardiac reflex during cerebellopontine angle surgery .................................................................6

Obstetric Anesthesia
- Mallampati class changes during pregnancy, labour, and after delivery: can these be predicted? ................................9

Pain
- Evaluation of the effectiveness of lumbar interlaminar epidural injections in managing chronic pain of lumbar disc herniation or radiculitis: a randomized, double blind, controlled trial ........12

Regional Anesthesia
- The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty ......15
- Femoral nerve block improves analgesia outcomes after total knee arthroplasty: A Meta-analysis of Randomized Controlled Trials ..17

Respiration & Ventilation
- Prediction of postoperative pulmonary complications in a population-based surgical cohort ...................................21
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Abstract

Purpose This dual-purpose study evaluated whether central venous oxygen saturation (ScVO$_2$) predicted cardiac index (CI) in patients with septic or cardiogenic shock. It also examined whether agreement between ScVO$_2$ and mixed venous oxygen saturation (SVO$_2$) was consistent over changing levels of inspired oxygen concentration and CI.

Background Early diagnosis and aggressive resuscitation to reestablish tissue oxygenation in patients with circulatory failure are sine qua non to improved patient outcomes. The last decade has heralded ScVO$_2$ monitoring as an alternative to pulmonary artery catheter derived SVO$_2$ and CI monitoring for diagnosis and treatment of circulatory failure. However, uncertainty exists about the agreement between ScVO$_2$ and SVO$_2$ measurements across various clinical scenarios. For example, Reinhart’s study is frequently cited as showing consistent agreement between ScVO$_2$ and SVO$_2$ in patients with hypovolemic shock, hypoxia, and hyperoxia. But other studies in patients with septic shock show inconsistent and unsatisfactory agreement. Furthermore, it is unclear whether or not ScVO$_2$ can predict CI. A better understanding of (a) the relationship between ScVO$_2$ and SVO$_2$, (b) the relationship between venous oxygen saturation and CI, and (c) the effect of ScVO$_2$ monitoring on patient outcomes across various clinical scenarios is needed.

Methodology Twenty mechanically ventilated, critically ill patients with an insitu pulmonary artery catheter and requiring inotropic support were recruited. A central vein catheter was inserted into the distal portion of the superior vena cava. Its location, and the location of the pulmonary artery catheter in the proximal pulmonary artery, were confirmed by chest x-ray. Arterial, central venous, and mixed venous blood samples were simultaneously and slowly drawn from the arterial, central venous, and pulmonary artery catheters, respectively. Measurements were obtained at baseline and after the patient was ventilated with 100% inspired oxygen for five minutes. This protocol was repeated if the patient experienced a change in cardiac index $>10\%$ during the 24 hour study period. All cardiac output measurements were performed using an intermittent thermodilution technique (no additional details provided), and all blood samples were analyzed by a co-oximeter.

The authors assessed the agreement between ScVO$_2$ and SVO$_2$ in repeated measurements by the mean bias and 95% limits of agreement (Bland and Altman). They chose 5% as the maximum difference for the limits of agreement that would be clinically unacceptable in the study. Analysis of the relationship between venous oxygen saturation and cardiac index used polynomial regression with a quadratic equation, which took into consideration the curvilinear...
relationship between cardiac index and venous saturation.

**Result** The ScVO$_2$ overestimated the SVO$_2$ by an average absolute difference of 6.9%, and the limits of agreement were large (-5.0% to 18.8%). The difference between ScVO$_2$ and SVO$_2$ appeared to be more significant when SVO$_2$ was <70%.

Both ScVO$_2$ and SVO$_2$ correlated with the cardiac index, and both were comparable in their ability to predict and exclude a low cardiac output state. However, the predictive value of ScVO$_2$ and SVO$_2$ to exclude a low cardiac output state decreased at 100% inspired oxygen concentration.

**Conclusion** ScVO$_2$ and SVO$_2$ values were not interchangeable when assessing cardiac index. Agreement between the paired values can be highly variable; particularly after a drop in cardiac index. The increased difference in measurements observed with an SVO$_2$ <70% is consistent with the fact that ScVO$_2$ does not reflect hepatosplanchnic circulation, a regional circulation that is hypoperfused relative to the heart and brain during circulatory failure. Despite these limitations, the researchers believed that ScVO$_2$ may be useful in guiding hemodynamic resuscitation.

**Comment**
Current opinion on ScVO$_2$ monitoring is mixed, and understanding the debate helps CRNAs make evidence based decisions as to when to incorporate ScVO$_2$ monitoring, as well as how to avoid the pitfalls of inaccurately interpreting its measurements. Proponents of ScVO$_2$ monitoring cite the Surviving Sepsis Campaign guidelines for management of severe sepsis and septic shock$^1$, because the guidelines include a recommendation to maintain ScVO$_2$ or SVO$_2 \geq$ 70%. This recommendation is based on River’s et al. who showed that early goal-directed therapy aimed at maintaining CVP of 8 to 12 mm Hg, a mean arterial pressure $\geq$ 65 mm Hg, and ScVO$_2$ $\geq$ 70% improved short-term and long-term outcomes in patients with sepsis.$^2$ Opponents of ScVO$_2$ monitoring argue that insufficient evidence exists showing the benefits of ScVO$_2$, and that improved outcomes are more likely the result of earlier, more aggressive resuscitation. This study adds to the debate by highlighting two problems associated with ScVO$_2$ monitoring. First, **limits of agreement** show that an ScVO$_2$ measurement of 70% potentially equates to an SVO$_2$ of 56.4% to 73.5%. One can argue that such a large range makes ScVO$_2$ a clinically unreliable treatment parameter, especially given that this finding has been previously reported.$^3$ In addition, **limits of agreement** became more problematic when the SVO$_2$ measurement was <70%. That is to say – as the patient becomes sicker, the ScVO$_2$ becomes less able to herald early decline in global tissue oxygenation. This is no surprise because ScVO$_2$ excludes the lower saturation values in the coronary venous system; values further reduced by increased myocardial oxygen consumption in septic shock. And, ScVO$_2$ excludes the lower saturation values in the hepatosplanchnic region; values further reduced by selective hypoperfusion during circulatory failure. However, despite the limitation that a normal ScVO$_2$ does not guarantee adequate tissue oxygenation, it is reasonable to assume that an ScVO$_2$ $\leq$ 65% in a mechanically ventilated patient under general anesthesia with 100% inspired oxygen is in
need of immediate goal-directed aggressive resuscitation.

The second limitation to ScVO$_2$ monitoring identified in this study was its decreased ability to predict a low cardiac index when the patient was administered 100% oxygen. This finding is consistent with what I have observed in my own practice. A patient under general anesthesia being ventilated with 100% inspired oxygen will have SVO$_2$ values > 70%, despite having a borderline low cardiac index. In addition, SVO$_2$ values directly change with the fraction of inspired oxygen concentration even though hemoglobin, cardiac index, arterial oxygen saturation, and oxygen consumption remain constant. This is important to recognize because normal ScVO$_2$ values could conceal inadequate resuscitation if patients are receiving 100% oxygen. Yet, providing 100% oxygen may be the very thing you want to do in extreme cases, because evidence does suggest tissues benefit from a high arterial oxygen tension.\(^4\)

This study was limited by its sample size, and by the fact that its findings cannot be generalized to patients under general anesthesia. This study is outstanding in its ability to highlight the pitfalls associated with ScVO$_2$ monitoring, areas for future research, and evidence-based issues to consider when each of us makes decisions about how best to use this technology.

Sandra L. Larson, PhD, CRNA, APN


Following is a key study readers may want to read for more information on this topic:

NEUROSURGICAL ANESTHESIA

INTRAOPERATIVE BRAINSTEM AUDITORY EVOKED POTENTIAL OBSERVATIONS AFTER TRIGEMINOCARDIAC REFLEX DURING CEREBELLOPONTINE ANGLE SURGERY

Acioly MA, Carvalho CH, Koerbel A, Lowenheim H, Tatagiba M, Gharabaghi A

Abstract

Purpose The purpose of this study was to look for an association between changes in brainstem auditory evoked potential (BAEP) monitoring of Cranial Nerve VIII and the occurrence of the trigeminocardiac reflex (TCR) during cerebellopontine angle surgery. A secondary purpose was to evaluate the impact of those changes on postoperative hearing function.

Background The TCR is a phenomenon consisting of bradycardia and possibly asystole in conjunction with arterial hypotension and can be elicited by surgical manipulation of the trigeminal nerve during its intra- or extracranial course. The TCR is elicited in 8-14% of cerebellopontine angle tumor surgery patients. It appears that the most important factor involved in the occurrence of the TCR is the stimulation intensity during surgical manipulation of the pathway. The size of the tumor also plays a role, with a higher incidence of TCR in larger tumors. Interrupting the stimulation is usually followed by a rapid normalization of the hemodynamic parameters and additional treatment with vagolytic medication is not generally required. Intraoperative hypotension caused by this reflex has become known to be a negative prognostic factor for hearing preservation, especially during vestibular schwannoma surgery, although the pathophysiologic mechanism remains unclear.

Brainstem auditory evoked potential monitoring (BAEP) is the most widely used electrophysiologic monitoring of cranial nerve VIII during cerebellopontine angle surgery and is minimally influenced by the type or depth of anesthesia. Surgical events that may affect postoperative hearing and are also associated with intraoperative BAEP changes include: direct auditory nerve manipulation, cerebellar retraction, and the drilling of the internal auditory canal. The authors hypothesized that the TCR may be followed by a deterioration of BAEP recordings as well.

Methodology This retrospective study examined 102 consecutive patients who underwent cerebellopontine angle tumor surgery from January 2004 to February 2006. Patients were monitored for the occurrence of TCR. For the purposes of this study, TCR was defined as a decrease in the mean arterial blood pressure of 20% or more associated with bradycardia less than 60 beats/min after direct or indirect stimulation of the trigeminal nerve. Patients having bradycardia without hypotension were not included.

The study looked at the following parameters: patient age and sex; preoperative and postoperative auditory function; tumor type and size; intraoperative BAEP classification; occurrence and frequency of intraoperative TCR; and latency and recovery times of BAEP changes after TCR.
All of the tumors involving the cerebellopontine angle were included except for brainstem tumors. In each case, auditory function was evaluated preoperatively and 7 to 10 days postoperatively. Somatosensory evoked potentials, BAEP, and facial nerve function were monitored continuously. Incidence, time of occurrence, latency, amplitude, and recovery times of BAEP changes after TCR were analyzed and compared with pre-TCR BAEP characteristics.

**Result** Five of the 102 enrolled patients had an occurrence of TCR (4.9%) and were evaluated for intraoperative BAEP changes after TCR and for postoperative auditory function. One of the 5 patients was deaf *preoperatively* and therefore excluded. Of the four patients included, the mean age was 30.7 years, 2 were men and 2 were women, and three of the four had large tumors. Histologically, all 4 cases were different.

In one patient with a small tumor, BAEP responses were stable throughout the entire surgery and after the TCR. This patient’s hearing function was unchanged postoperatively. In the other three cases, intraoperative BAEP acutely deteriorated within 2:04 to 3:27 minutes after the TCR with increased wave latency, decreased wave amplitude, and even wave loss. Two of the three patients had deteriorated BAEP waves until the end of surgery and were deaf postoperatively.

**Conclusion** In this study, BAEP wave deteriorations were identified that were not directly linked to earlier known eliciting events. Although causation has not yet been demonstrated, the authors suggested that the TCR is an additional event that may result in BAEP changes.

**Comment**

In their discussion, the authors remind us that the neurophysiologic changes that may be correlated with BAEP wave deteriorations are believed to be of primary neural or vascular origin. Generally BAEP wave deteriorations that occur within seconds of the eliciting event are likely to indicate neural stretch and those that occur minutes after may have a vascular origin. The BAEP wave deteriorations in this study occurred several minutes after the TCR, suggesting a vascular origin. In addition, the authors reported there were no additional direct eliciting events in the time period between the TCR and the onset of the BAEP changes. However, the same surgical manipulations are known to be eliciting events for both BAEP wave deterioration and the TCR so it is difficult to know if there are two separate pathophysiologic mechanisms or if they are interconnected events.

Of interest is the 4.9% occurrence rate of the TCR in this study. The authors attributed this low occurrence rate to surgical and anesthetic procedures designed to reduce the intensity of cerebellar retraction and increase intraoperative mean arterial blood pressure, thus reducing the incidence of TCR. Additionally, intraoperative factors that may potentiate the TCR should be corrected, such as light anesthesia, hypercapnia, hypoxia, and acidosis. Anticholinergics are ineffective in preventing this reflex and can cause refractory cardiac arrhythmias, so they are not routinely used as a prevention option for the TCR. Since the occurrence of the TCR has been found to be a negative prognostic factor for hearing preservation, the surgeon should be informed of its
occurrence immediately so the eliciting maneuver can be discontinued as quickly as possible. One should anticipate the consequences of TCR in all patients undergoing cerebellopontine angle tumor surgery.

Amy Pfeil Neimkin, DNP, MBA, CRNA

Mallampati Class Changes During Pregnancy, Labour, and After Delivery: Can These Be Predicted?

Br J Anaesth 2010;104:67-70
Boutonnet M, Faitot V, Salomon L, Keita H

Abstract

Purpose The purpose of this study was to describe changes in the airway exam (Mallampati class) before, during and after labor, and to identify any predictive factors in worsening Mallampati classification.

Background Mallampati classification is an easy and reliable measure that is useful in predicting potential difficult airways. Several recent investigations suggest the Mallampati class increases during the course of labor; however no study has described the changes that occur between the 8th month of pregnancy and 48 h after delivery.

Methodology A descriptive, repeated measures design was used to evaluate changes in the Mallampati classification at the 8th month of pregnancy (T1), epidural placement (T2), 20 minutes after delivery (T3), and 48 hours after delivery (T4). Mallampati classification was evaluated with parturients in the semi-sitting position with the head in a neutral position, the mouth wide open and no phonation. At T1 all airway evaluations were evaluated by a single investigator and during the last three evaluations during labor by a second investigator. Potential predictive factors of Mallampati classification change included weight gain between T1 and T2, duration of 1st and 2nd stages of labor, and total intravenous fluid administered during labor. Mallampati classes 3 and 4 were compared at each time point with the McNemar test. Logistic regression was used to identify predictors of changes in Mallampati classification between the time points. Data are presented as the mean (SD) or n (%). A P < 0.05 was considered significant.

Result A total of 87 out of 90 parturients completed the study. The mean age was 31.2 years (5.2). The majority of the subjects were Caucasian females (81.6%) with a pre-pregnancy weight of 64.2 kg (13.2) and a BMI of 23.9 (6.3). The full breakdown of BMI was as follows: <20: 17.2%, 20-25: 49.4%, 25-30: 24.1%, and >30: 9.2%). Table 1 lists obstetrical data. A little over a third of the parturients Mallampati classification did not change between the 8th month of pregnancy and 48 h after delivery (n = 32, 36.8%). Increases in Mallampati classification were noted in a majority of parturients between both T1 and T2 and between T2 and T3; whereas there was a decrease between T3 and T4. The number of parturients with a Mallampati 3 and 4 airway changed significantly between T1 and T2 (10.3% vs. 36.8%, P < 0.0001), between T2 and T3 (36.8% vs. 51.7%, P = 0.0005), between T3 and T4 (51.7% vs. 20.7%, P < 0.0001), and between T4 and T1 (20.7% vs. 10.3%, P = 0.0062) (Figure 1). None of the postulated factors were significant predictors of changes in Mallampati classification.
Conclusion  This study shows that the Mallampati classification worsens over the course of labor, and does not fully reverse by 48 hours after delivery. These results suggest that anesthesia providers need to continually reevaluate the airway during the course of labor.

Comment  A thorough airway evaluation is an essential component to the preoperative evaluation of any patient, especially a parturient. This was an important study because the findings support that changes do occur with the airway (i.e., Mallampati classification) during the course of labor. The implications for this is that anesthesia providers may want to consider reevaluating the airway periodically during the course of labor. This is especially important in parturients who are at risk for a cesarean section or who may require general anesthesia. Anesthesia providers should also consider these findings when caring for a patient presenting for a postpartum tubal ligation the day after delivery because the airway exam may still not have normalized.

The investigators failed to identify any predictors of changes in the airway exam in their study. Factors such as prolonged 2nd stage labor and large amounts of crystalloids have been postulated to be associated with worsening airway exam. The problem with this study is that the investigators did not present any of the statistical results (beta coefficients and/or odds ratio) for the logistic regression analysis so it is difficult to interpret their results. Additionally, no power analysis was presented, so I suspect the study may have been underpowered to find any significant predictors in a logistic regression analysis.

It is important to point out that the mean BMI was only 23.9 so it is difficult to determine from their data if obese parturients have a worsening airway exam over the course of labor. Though given obese parturients may be at increased risk for a difficult airway, one could speculate that a worsening of the Mallampati score in this population could be more problematic. This could be even more of an issue in a severe preeclamptic where airway edema has been reported to be an issue.

Dennis Spence, PhD, CRNA

The views expressed in this article are those of the author and do not reflect official policy or position of the Department of the Navy, the Department of the

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD) or n (%)</th>
</tr>
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<tbody>
<tr>
<td>Gestational Age (weeks)</td>
<td>39.8 (1.2)</td>
</tr>
<tr>
<td>Gestational age at T1 (weeks)</td>
<td>33 (2.2)</td>
</tr>
<tr>
<td>Gestational weight gain (kg)</td>
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</tr>
<tr>
<td>Co-morbidities</td>
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<tr>
<td>Hypertension</td>
<td>5 (5.7%)</td>
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<td>Diabetes Mellitus</td>
<td>10 (11.5%)</td>
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<tr>
<td>Pre-eclampsia</td>
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<tr>
<td>Cervical dilation at T2 (cm)</td>
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</tr>
<tr>
<td>Fluids administered (ml)</td>
<td>1864.9 (709)</td>
</tr>
<tr>
<td>Duration of 1st stage (min)</td>
<td>409.3 (197.2)</td>
</tr>
<tr>
<td>Duration of 2nd stage (min)</td>
<td>17.8 (15)</td>
</tr>
<tr>
<td>Delivery type</td>
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<tr>
<td>Vaginal</td>
<td>58 (66.7%)</td>
</tr>
<tr>
<td>Instrumental</td>
<td>20 (23%)</td>
</tr>
<tr>
<td>Cesarean</td>
<td>9 (10.3%)</td>
</tr>
</tbody>
</table>
Figure 1. Comparison of Mallampati classification at different time points

Note. MP = Mallampati classification. T1: 8 months of pregnancy. T2: prior to epidural placement. T3: 20 minutes after delivery. T4: 48 hours after delivery. Significant increases were found in the incidence of MP3 or MP4 airways between T1 and T2 and T2 and T3 (P <0.001), respectively. The incidence of MP3 and MP4 airways decreased between T3 and T4 (P = 0.0062).

Defense, the Uniformed Services University of the Health Sciences, or the United States Government.
PAIN

Evaluation of the Effectiveness of Lumbar Interlaminar Epidural Injections in Managing Chronic Pain of Lumbar Disc Herniation or Radiculitis: A Randomized, Double Blind, Controlled Trial

Pain Physician 2010;13:343-355
Manchikanti L, Singh V, Flaco F, Cash K, Pampati V

Abstract

Purpose  The purpose of this article was to present a study evaluating the effectiveness of interlaminar epidural injections for disc herniation and radiculitis.

Background  Lower back pain is one of the most common pain problems in the United States. One of the most frequently used treatments for lower back pain has been the administration of an interlaminar epidural steroid. There are other approaches to injecting steroid, such as lumbar transforaminal and caudal, but these appear to have more risk than the interlaminar approach. The literature evaluating the benefits of interlaminar epidural steroid injections for back pain have been largely negative, suggesting that they may help in the short term but lack long term benefits. The mechanism of how these injections are effective in providing pain relief is not well understood. The injection of steroid has long been the standard, but there is emerging evidence that local anesthetics alone may be just as effective as the injection of steroids.

This study evaluated the effectiveness of lumbar interlaminar epidural injections with and without steroids, and local anesthetics for patients with chronic, function limiting low back pain secondary to disc herniation or radiculitis.

Methodology  There were 2 groups of patients, with 35 in each group. Each patient was assigned randomly and blindly to receive a lumbar interlaminar epidural injection by one provider using fluoroscopic guidance. The injections were given between L5 - S1 in 91% of patients, L4 - 5 in 7% of patients, and other levels in 2% of patients. The lidocaine group received 6 mL of lidocaine 0.5%. The betamethasone group received the same anesthetic agent mixed with betamethasone. Patients chosen for this study had disc herniation or radiculitis, were at least 18 years old, and had chronic functioning limiting low back pain for at least 6 months. Patients with previous surgery, spinal stenosis, or uncontrollable medical issues were excluded. Patients were given at least one injection, and follow-up injections were provided as indicated with the average number of injections per group of between 4.2 and 4.3 in a one year period of time.

Result  Outcomes were measured at 3, 6, and 12 months. A numerical rating pain scale (0-10) was used as well as a traditional employer functional assessment (Oswestry Disability Index 0-50 scale). A successful outcome was recorded when a patient had consistent pain relief and functional improvement with the first and second injection lasting at least 3 weeks. At the end of 12 months, 74% of the lidocaine only patients and 86% of lidocaine / betamethasone patients had significant pain relief. Significant functional improvement was found in 69% of
lidocaine only patients and 83% of lidocaine / betamethasone patients at the same 12 month evaluation (P < 0.001 for both groups vs. baseline).

**Conclusion** This study shows that long term pain relief and improved function can be accomplished with interlaminar epidural injections of anesthetic agents, with and without steroids. The inclusion of steroids did appear to provide superior clinical pain relief, but the difference was not statistically significant (P = 0.09 at 12 months). The average number of injections required to provide these results were approximately 4 per year.

**Comment** Just as the authors of this article indicated, the great majority of studies concerning the benefits of interlaminar epidural steroid injections (IESI) have been negative. Most studies indicate that these injections have short term benefits but lack evidence of long term positive results. My clinical experience with interlaminar injections has been much more positive, and is reflective of the results of this particular study. When patients are carefully evaluated and treated, IESI can be an excellent tool in the treatment of lower back pain with radiculitis. I have been concerned about the movement toward the more risky transforaminal approach. There is certainly a place for both methods, but in my opinion the safety and effectiveness of the IESI makes it a superior tool for management of back pain with radiculitis, in most cases. I question whether criticism of the IESI is warranted. Some studies like this one are suggesting that there may be other reasons why IESI has not been as successful as it should be. I suspect that fluoroscopic verification of needle placement may help improve results, especially in those difficult cases where loss of resistance may be questionable and for those practitioners with limited experience. Along with more careful evaluation and patient choice, we may start to see improved outcome studies in the future.

Another issue this article addressed was the use of steroids. It was interesting to note that using no steroid provided similar results as the patients who were given steroids. The side effects of injecting steroids can often be a problem, especially in patients who are diabetic. Most providers limit their injections based on the total dose of steroids over a given period of time. This study suggests that steroids can be limited or eliminated while providing excellent results in most patients. This may allow judicious use of repeated injections over a longer period of time, possibly resulting in improved results as indicated in this study.

It should noted that the comparisons in this study were between lidocaine with, and without steroids. There was no placebo group, so we do not know from this study if normal saline alone would have provided similar pain and functional improvement. In my practice, I have been reducing the amount of steroid and lidocaine, while increasing the amount of saline I am injecting. I am finding that pain relief and functional improvement have remained about the same. My findings would be consistent with this study, but they are of course anecdotal. Could it be that injecting saline into the epidural space provides similar results to steroids? I would be interested in knowing what subscribers to Anesthesia Abstracts are doing with their epidural solutions, and what kind of
results they are seeing short and long term. I will continue to evaluate the use of steroids in epidural injections and modify my practice as scientific and clinical evidence warrants.

Steven Wooden, MS, CRNA

Editor’s Note: to respond to Mr. Wooden’s call for your clinical results log on to Anesthesia Abstracts at www.AnesthesiaAbstracts.com and click on “Discussion Forum.”
Abstract

Purpose The purpose of this secondary analysis was to (1) determine the incidence of falls in patients who received 0.2% ropivacaine continuous peripheral nerve blocks or placebo (perineural normal saline), and (2) to identify factors associated with increased risk of falls during continuous nerve blocks.

Background Total knee and hip arthroplasty is associated with significant postoperative pain. In recent years, continuous peripheral nerve blocks (CPNB) have been used with increasing frequency to provide extended analgesia. However, there is concern that quadriceps weakness secondary to femoral nerve blockade may increase the risk for patient falls.

Methodology Data from 171 subjects was pooled from three previously published multicenter, randomized, triple-masked, placebo-controlled studies. Femoral CPNB catheters were placed for total knee arthroplasty in two studies. In one study posterior lumbar plexus CPNB catheters were placed. Subjects received either a 4-day CPNB with 0.2% ropivacaine or perineural normal saline. In some cases patients were discharged on postoperative day 3 with their CPNB still in place.

The proportion of falls was compared between the groups, and significant covariates were identified to determine those that were associated with increased risk of falls. Descriptive and inferential statistics were used to analyze the results. A P value <0.05 was considered significant.

Result In the three pooled studies n = 85 subjects received CPNB with ropivacaine, whereas n = 85 received normal saline. No significant differences were noted in baseline demographics between the two groups. Subjects in the ropivacaine group had a significantly shorter time until they were discharge ready (ropivacaine: 43 (22) hrs vs. saline: 63 (28) hrs, P< 0.001). Ropivacaine patients could also ambulate a longer distance on the morning of postoperative day 3 (ropivacaine: 106 (83) m vs. 79 (58) m, P = 0.03). No patient in the saline infusion group fell (0%, 95% CI: 0% to 5%), whereas there were 7 falls in 6 patients in the ropivacaine CPNB group (7%, 95% CI: 3% to15%) (P = 0.013). The fall rate in CPNB patients was similar across all three studies (P> 0.05).

The only significant covariate associated with increased falls was a shorter time until actual discharge. Those who did not fall (n = 165) were discharged in an average of 3.4 (1) days vs. those who fell (n = 6), who were discharged in an average of 3.0 (0) days, (P<0.001). Four of the seven falls occurred after patients were discharged home. Of the 7 falls, in 1 patient quadriceps weakness was suspected. In 2 patients quadriceps weakness was unclear. In 4 patients quadriceps weakness was denied. No patient reported an injury associated with a fall. Nevertheless,
two of the 4 subjects who fell at home required readmission.

In 3 of the 6 patients who fell, a lumbar plexus CPNB catheter was used. In the 4 other patients a femoral CPNB was being used for postoperative analgesia. All the falls occurred while the CPNB infusions were still running.

There appeared to be a trend towards subjects falling while ambulating a shorter distance on the afternoon of postoperative day 2 (no fall: 83 (69) m vs. 52 (39) m, P = 0.12) and the morning of postoperative day 3 (no fall: 93 (73) m vs. 53 (40), P = 0.23).

**Conclusion** This analysis suggests that there may be a causal relationship between use of femoral or lumbar plexus CPNB infusions and the risk of falls after total knee or hip arthroplasty. Practitioners who use continuous peripheral nerve blocks for postoperative pain should consider taking steps to reduce the risk of falls and include this as a risk when obtaining informed consent.

**Comment**
Regional anesthesia and CPNB are rapidly emerging as a relatively safe technique for providing extended postoperative analgesia. In some cases, CPNB may help improve functional outcomes. Examples include increased knee range of motion and tolerance of physical therapy. This study is important because it highlights a concern all providers should have when administering a lower extremity peripheral nerve block (continuous or single shot); patients are at increased risk for falls. This is especially important in older patients who may have other comorbidities or be taking medications which may contribute to falling.

Anesthesia providers should inform patients and family members or significant others that there is a risk of falls (approximately 7%) with lower extremity continuous peripheral nerve blocks. Additionally, nursing staff and other providers should understand the increased risk and take appropriate steps to minimize the chances of patients falling. This is especially important if the patient is discharged home before the block has worn off or if they are discharged with the CPNB catheter still running. This last issue is extremely important as increasing workload and productivity pressure on anesthesia providers may limit the amount of time we have to counsel and educate patients having peripheral nerve blocks.

Dennis Spence, PhD, CRNA

The views expressed in this article are those of the author and do not reflect official policy or position of the Department of the Navy, the Department of Defense, the Uniformed Services University of the Health Sciences, or the United States Government.
**Regional Anesthesia**

**Femoral nerve block improves analgesia outcomes after total knee arthroplasty: A Meta-analysis of Randomized Controlled Trials**

Anesthesiology 2010;113:1144-62


**Abstract**

**Purpose** The purpose of this study was to evaluate the efficacy of femoral nerve block (FNB) analgesia versus IV patient controlled analgesia (IVPCA) for three days after total knee arthroplasty (TKA). Femoral nerve block was used with or without continuous FNB and/or sciatic nerve block. IVPCA was used with or without epidural analgesia.

**Background** TKA is one of the most common surgical procedures performed to improve quality of life. However, the surgery is associated with significant postoperative pain, which if poorly managed, can contribute to morbidity, and delay recovery and physiotherapy. Patient controlled analgesia (IVPCA) with opioids, epidural block, FNB, and sciatic nerve block have all been used alone or in combination to decrease postoperative pain and improve outcomes. Unfortunately the need for postoperative anticoagulation makes postoperative management challenging after epidural analgesia. In recent years continuous FNB has been used to extend postoperative analgesia and avoid the risks with epidural analgesia and anticoagulants. Continuous FNB analgesia has been used with increasing frequency to provide extended analgesia.

**Methodology** A systematic review and meta-analysis of randomized controlled trials comparing epidural block or IVPCA opioids versus FNB (single-shot or continuous) with or without sciatic nerve block in adults undergoing unilateral TKA was conducted. Only studies using a nerve stimulator during performance of the blocks were included. This systematic review sought to evaluate the efficacy of these interventions on the following outcomes: (1) pain scores, (2) opioid consumption, (3) knee range of motion, (4) opioid side effects, (5) block side effects, and (6) mobility of the nonoperative leg for 72 hours after TKA. Quality assessments of randomized controlled trials were evaluated with the Jadad 5-point scale. Trials were included regardless of quality assessment ratings. A Meta-analysis technique utilizing Bayesian random effects modeling was used to analyze the results.

**Result** A total of 23 randomized controlled trials with 1,016 patients were included; n = 665 FNB, n = 161 epidural analgesia, n = 190 IVPCA alone. In 14 randomized controlled trials FNB was compared to IVPCA. In 4 trials FNB was compared to epidural block. In 3 trials different types of FNB were compared. Two trials compared FNB with epidural block and IVPCA. The different types of FNB compared are listed in Table 1. The mean Jadad quality scores for the 23 trials was 3.7 (range: 2 to 5), with only 5 of 23 studies being of the highest quality (score = 5).
Compared to IVPCA alone, morphine consumption at 24 h and 48 h was significantly less in the following groups:

- **Single Shot FNB (24 h: -20 mg; 48 h: -38 mg)**
- **Single Shot FNB + Sciatic nerve block (24 h: -31 mg; 48 h: -34 mg)**
- **Continuous FNB (-15 mg; 48 h: -24 mg)**

Morphine consumption was similar at 24 h and 48 h in the single shot FNB, Single Shot FNB + Sciatic nerve block, and Continuous FNB. The use of analgesic adjuncts, such as NSAIDS or gabapentin, did not appear to influence the results.

Pain scores at rest at 24 h were significantly less in the Continuous FNB groups (-1.1) when compared to IVPCA alone. However, at 48 h there were no significant differences between these groups. Pain scores at rest were similar in the Single Shot FNB, Single Shot FNB + Sciatic nerve block, and Continuous FNB at 24 and 48 h.

Pain scores with activity at 24 h and 48 h were lower in Single Shot FNB (24 h: -1.8; 48 h: -1.5), Continuous FNB (24 h: -1.5; 48 h: -1.3), and Single Shot FNB + Sciatic nerve block (24 h: -2.3; 48 h: -2.3) when compared to IVPCA alone. Single Shot FNB, Single Shot FNB + Sciatic nerve block, and Continuous FNB all had similar pain scores with activity at 24 h and 48 h.

Subjects who received a FNB were 0.31 times less likely to have nausea when compared to the IVPCA alone groups. All other side effects were similar (sedation and pruritus). There were no significant differences in knee range of motion at 48 h, patient satisfaction, and hospital length of stay between any of the treatment groups. Degree of motor block between FNB and IVPCA groups or between the operative and nonoperative leg in the FNB groups were similar.

**Conclusion** Single shot or continuous femoral nerve blocks provided superior analgesia and significantly reduced morphine consumption and nausea when compared to IVPCA or epidural alone. However, when compared to a single shot FNB, the addition of a sciatic nerve block or continuous FNB did not significantly reduce pain or morphine consumption. Further high quality studies are needed.

### Table 1. Types of FNB

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>Number of Trials</th>
<th>n = patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSFNB</td>
<td>7 trials</td>
<td>n = 136</td>
</tr>
<tr>
<td>SSFNB + sciatic</td>
<td>3 trials</td>
<td>n = 62</td>
</tr>
<tr>
<td>CFNB</td>
<td>13 trials</td>
<td>n = 352</td>
</tr>
<tr>
<td>CFNB + sciatic</td>
<td>2 trials</td>
<td>n = 43</td>
</tr>
<tr>
<td>SSFNB vs. SSFNB + sciatic or CFNB</td>
<td>2 trials</td>
<td>n = 58</td>
</tr>
<tr>
<td>SSFNB vs. SSFNB + sciatic</td>
<td>1 trial</td>
<td>n = 24</td>
</tr>
<tr>
<td>SSFNB vs. CFNB</td>
<td>2 trials</td>
<td>n = 58</td>
</tr>
</tbody>
</table>

SSFNB = single shot femoral nerve block.
CFNB = continuous femoral nerve block.
Local anesthetic used: in 13 studies bupivacaine, in 13 studies ropivacaine, and in 2 studies lidocaine. 13 of 23 studies used 3-in-1 blocks.
to compare outcomes and complications (i.e., falls due to quadriceps weakness) after Single Shot FNB vs. Continuous FNB (and sciatic nerve block) for TKA.

Comment
The results of this well designed meta-analysis demonstrate what is seen in clinical practice; that peripheral nerve blocks (FNB, CFNB and/or sciatic nerve blocks) provide superior analgesia when compared to IVPCA alone for total knee arthroplasty. What I found interesting was that this systematic review failed to find a significant improvement in outcomes with epidural analgesia. This is probably because far fewer subjects across the studies received epidurals (n = 165) as compared to those who received a single shot FNB or CFNB with or without a sciatic nerve block (n = 665). Also the studies included compared epidurals with or without a FNB making it difficult to detect differences. The difference in group sizes also reflects the changing practice of utilizing lower extremity peripheral nerve blocks as opposed to epidural analgesia alone for postoperative analgesia after TKA. In my clinical practice I find many providers are only using epidurals as the primary anesthetic if the patient’s comorbidities (e.g., severe COPD or OSA) are significant rather than using it purely for postoperative analgesia. I think as more facilities move to regional anesthesia or acute pain services that this trend will continue. I also found it interesting that the addition of a single shot sciatic nerve block did not offer significant benefit over a single shot FNB. Readers should view these findings cautiously for several reasons. Sciatic nerve blocks are more effective in relieving posterior knee pain, and it is sometimes difficult to predict who would most benefit. Additionally, many surgeons like to evaluate lower extremity sensory function after TKA, making it better to place the sciatic nerve block only if needed. At my facility our acute pain service typically errs on the side of caution and preoperatively offers the patient a postoperative sciatic nerve block only if significant posterior knee pain occurs. This review did not include studies which evaluated efficacy of ultrasound-guided FNB with or without a CFNB. In many centers this is becoming almost the standard of care because it allows the provider to see exactly where they are placing the local anesthetic and/or catheter. Many experts believe this may improve outcomes; however further research is needed to confirm this theory. To achieve maximum benefit from ultrasound-guided blocks you need the proper equipment, providers with expertise, and ideally need a team of anesthesia providers to manage patients’ pain throughout their hospitalization. In some centers patients may actually be discharged with continuous FNB infusions after TKA. Given many patients who present for TKA have multiple comorbidities it is critical that effective analgesia be provided to minimize complications. In my opinion, in a large facility having a dedicated acute pain service is the best way to improve outcomes after TKA. Smaller facilities may want to consider how they can provide an acute pain service which utilizes peripheral nerve blocks (ideally with ultrasound) with the option of placing continuous infusion catheters for TKA.
Dennis Spence, PhD, CRNA

The views expressed in this article are those of the author and do not reflect official policy or position of the Department of the Navy, the Department of Defense, the Uniformed Services University of the Health Sciences, or the United States Government.
Prediction of postoperative pulmonary complications in a population-based surgical cohort

Anesthesiology 2010, 113:1338-1350
Canet J, Gallart L, Gomar C et al

Abstract

Purpose The purpose of this study was to evaluate the incidence and characteristics of postoperative pulmonary complications (PPC) in a large population-based sample of patients undergoing a broad range of surgical procedures in southern Europe. The study also sought to develop a scoring system that could be used to predict increased risk for PPC.

Background PPC are a major cause of morbidity and mortality after anesthesia and surgery. The incidence of PPC after noncardiac surgery ranges from 2% and 19%, depending on the study design and population. The American College of Physicians has published a systematic review and guidelines for prevention of PPC after noncardiac surgery; however it would be useful to have a scoring system for identifying patients at increased risk for PPC after both cardiac and noncardiac surgery.

Methodology This was a prospective, multi-center, observational study of a random-sample cohort of patients undergoing nonobstetrical inpatient surgery under general, neuraxial or regional anesthesia was conducted. A total of 59 Spanish hospitals providing public health services to approximately 7.36 million inhabitants of Catalonia participated in the study. At participating centers, all patients undergoing elective or emergency surgery were recruited. Exclusion criteria included: (1) <18 years old, (2) obstetrical procedures, (3) local or peripheral anesthesia procedures, (4) out of the operating room procedures, (5) procedures related to a previous complication, (6) reoperations within 90 days, (7) organ transplant, (8) patients with preoperatively intubated tracheas, and (9) outpatient procedures (< one day stay for a patient alive at discharge).

A standardized questionnaire was administered at each facility and 30 and 90-day mortality rates were collected. The main outcome was a PPC, which was a composite of the inpatient fatal and non-fatal postoperative events. PPC events included (1) respiratory infection, (2) respiratory failure, (3) pleural effusion, (4) atelectasis, (5) pneumothorax, (6) bronchospasm, and (7) aspiration pneumonitis. Any event was counted as a PPC. The secondary outcome was postoperative length of stay and 30-day and 90-day mortality rates.

Predictive logistic regression was used to identify risk factors for PPC and a simplified predictive risk score was calculated. Differences in Length Of Stay were compared based on number of PPC (0, 1, 2-3 and at least 4) and trends in mortality rates between groups based on the number of PPC were determined.

Result A total of 2,464 out of 2,782 eligible patients participated. Approximately half were men (50.8%) with a median (10th-90th percentile) age of 60 years.
Only 20.5% of participants were current smokers and 29.6% were former smokers. Approximately 6% of patients had a respiratory infection in the previous month (with fever and antibiotic treatment). Less than 12% had a diagnosis of COPD and only 20.6% of patients were ASA 3 or 4. Emergency surgeries accounted for 14.9% of all surgeries and over half of all patients received general anesthesia (54.2%). The majority of the procedures were orthopedic (32.4%), followed by general and digestive (29.5%). Cardiac surgery accounted for 2.2% of all surgical procedures. Surgical duration was a median (10-90\textsuperscript{th} percentile) of 1.8 hours (0.8-3.9); Length Of Stay was 3 (1-12) days and 30-day and 90-day mortality was 1.4% and 2.4%, respectively.

A total of 242 PPCs occurred in 123 patients (5% of 2464 patients).Thirty day mortality rates were higher in patients with a PPC (19.5%; 95% CI, 12.5-26.5%) compared to those without a PPC (0.5%; 95% CI, 0.2-0.8%). Characteristics of PPCs are presented in Figure 1. The most common PPC was respiratory failure (2.6%), followed by bronchospasm (1.8%), pleural effusion (1.7%), respiratory infection (1.6%), atelectasis (1.4%), aspiration pneumonia (0.4%) and pneumothorax (0.3%). The median Length Of Stay was significantly longer in patients with at least one PPC (12 days; 10-90\textsuperscript{th} percentile 4-36.8 days).

Mortality rate based on number of PPCs is presented in Figure 2. Cardiac surgery had the highest incidence of patients with at least 1 PPC, although patients...
undergoing general and digestive surgery had higher mortality rates (Figure 1).

Seven independent risk factors of PPC were identified. They included: (1) low preoperative arterial oxygen saturation, (2) acute respiratory infection during the previous month, (3) age, (4) preoperative anemia, (5) upper abdominal or intrathoracic surgery, (6) surgical duration of at least 2 hours and (7) emergency surgery. Independent predictors of risk for PPCs and the calculated risk scores are presented in Table 1.

**Conclusion**  The seven risk factors identified in this study can be used to identify patients at increased risk for postoperative pulmonary complications.

**Comment**  I thought this was an excellent study because it had a large sample size from a heterogeneous population from many facilities and surgical specialties. I believe the results can potentially be used in clinical practice to help identify patients at increased risk for postoperative pulmonary complications. The simple scoring system the authors present is easy to calculate based on the seven risk factors, and cut-off scores can be used to identify patients at the highest risk. This information would be useful to anesthesia providers preoperatively because it may help identify patients who need further workup or optimization (i.e., COPD...
Table 1. Independent Predictors and Risk Score for PPC

<table>
<thead>
<tr>
<th></th>
<th>OR (95% CI)</th>
<th>β Coefficient/ Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤50</td>
<td>1</td>
<td>0.331/ 13</td>
</tr>
<tr>
<td>51-80</td>
<td>1.4 (0.6-3.3)</td>
<td>1.62/ 16</td>
</tr>
<tr>
<td>&gt;80</td>
<td>5.1 (1.9-13.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Preop SpO₂%</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥96</td>
<td>1</td>
<td>0.802/ 8</td>
</tr>
<tr>
<td>91-95</td>
<td>2.2 (1.2-4.2)</td>
<td>2.375/ 24</td>
</tr>
<tr>
<td>≤90</td>
<td>10.7 (4.1-28.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Respiratory Infection Previous Month</strong></td>
<td>5.5 (2.6-11.5)</td>
<td>1.69/ 17</td>
</tr>
<tr>
<td><strong>Preop Anemia (≤10 g/dL)</strong></td>
<td>3 (1.4-6.5)</td>
<td>1.105/ 11</td>
</tr>
<tr>
<td><strong>Surgical Incision</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral</td>
<td>1</td>
<td>1.48/ 15</td>
</tr>
<tr>
<td>Upper Abdominal</td>
<td>4.4 (2.3-8.5)</td>
<td>2.43/ 24</td>
</tr>
<tr>
<td>Intrathoracic</td>
<td>11.4 (4.9-26)</td>
<td></td>
</tr>
<tr>
<td><strong>Duration of Surgery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤2 hrs</td>
<td>1</td>
<td>1.59/ 16</td>
</tr>
<tr>
<td>&gt;2-3 hrs</td>
<td>4.9 (2.4-10.1)</td>
<td></td>
</tr>
<tr>
<td>&gt;3 hrs</td>
<td>9.7 (4.7-19.9)</td>
<td></td>
</tr>
<tr>
<td><strong>Emergency surgery</strong></td>
<td>2.2 (1.0-4.5)</td>
<td>0.768/ 8</td>
</tr>
</tbody>
</table>

Note: OR = odds ratio. Postoperative pulmonary complication (PPC). Simplified risk score is the sum of each \( \beta \) logistic regression coefficient multiplied by 10, after rounding. Risk score intervals for PPC: Low risk <26 points; intermediate risk 26-44 points, and high risk ≥45 points.

patient; correction of anemia). Intraoperatively the information could be used to help tailor the anesthetic to minimize PPC (i.e., place thoracic epidural in patient having a thoracotomy), and postoperatively in planning on what level of care the patient might need (i.e., ICU).

The views expressed in this article are those of the author and do not reflect official policy or position of the Department of the Navy, the Department of Defense, the Uniformed Services University of the Health Sciences, or the United States Government.

Dennis Spence, PhD, CRNA