# Table of Contents

## General
- Surgical space conditions during low-pressure laparoscopic cholecystectomy with deep versus moderate neuromuscular blockade: A randomized clinical study ............................................. 3

## Pain
- Safeguards to prevent neurologic complications after epidural steroid injections........................................................................................................... 6

## Pediatric Anesthesia
- Are Caudal Blocks for Pain Control Safe in Children? An analysis of 18,650 Caudal Blocks from the Pediatric Regional Anesthesia Network (PRAN) Database .............................................................. 9

## Pharmacology
- Efficacy of ketamine as an adjunct to lidocaine in intravenous regional anesthesia........................................................................................................ 12
- Residual neuromuscular block in type II diabetes mellitus after rocuronium: a prospective observational study ....................................................... 15
- Postoperative opioid-induced respiratory depression ......................... 17
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Surgical space conditions during low-pressure laparoscopic cholecystectomy with deep versus moderate neuromuscular blockade: A randomized clinical study

Anesthesiology 2014;119:1084-92

Abstract

Purpose The purpose of this study was to compare surgical conditions for laparoscopic cholecystectomy with low insufflation pressure (8 mm Hg) and either deep or moderate neuromuscular blockade with rocuronium.

Background Laparoscopic cholecystectomy is typically performed with insufflation pressures of 12 to 15 mm Hg. But some studies suggest that keeping insufflation pressure <12 mm Hg is associated with decreased postoperative pain and improved respiratory function. Laparoscopic cholecystectomy requires neuromuscular block to optimize surgical conditions. It is not known if a “moderate” level of rocuronium neuromuscular blockade will provide optimal operative conditions compared to “deep” neuromuscular blockade with propofol and remifentanil total intravenous anesthesia and low-pressure insufflation (8 mm Hg). The authors hypothesized that operative conditions would be better in the deep block group.

Methodology This was a single-blind, randomized controlled trial comparing operative conditions with moderate vs. deep neuromuscular block during laparoscopic cholecystectomy. Abdominal insufflation pressure was 8 mm Hg in all patients. Moderate block was defined as rocuronium 0.3 mg/kg on induction with no maintenance dosing. Deep block was defined as rocuronium 1 mg/kg on induction with an infusion to maintain the post-tetanic count at 0 to 1 twitch. A standardized propofol and remifentanil total intravenous anesthetic was used for all patients. During induction of anesthesia each subject received 0.3 mg/kg rocuronium. Patients in the deep group received an additional 0.7 mg/kg (total dose = 1 mg/kg), and the moderate block group received an equal volume of saline. In the deep block group neuromuscular blockade was maintained at a post-tetanic count of 0 to 1 twitch with a rocuronium infusion of 3-4 mg/kg/hr. The moderate block group received a saline infusion. Insufflation pressure was initially set at 12 mm Hg, then decreased to 8 mm Hg. Sugammadex 2 to 8 mg/kg IV was given at the end of surgery to antagonize neuromuscular block if the Train-of-4 ratio was less than 0.90.

Operative conditions were evaluated by one of two experienced surgeons blinded to group assignment, using a 0 to 4 likert scale:

- 1 - optimal = optimal surgical conditions
- 2 - good = nonoptimal conditions - intervention not needed
- 3 - acceptable = intervention considered to improve surgical conditions
- 4 - poor = inadequate conditions - intervention necessary
If the surgeon reported inadequate surgical conditions the insufflation pressure was increased to 12 mm Hg. If that did not work, rocuronium 0.6 mg/kg was administered to patients in the moderate block group. Sample size calculations and statistical analysis were appropriate. A P < 0.05 was significant.

**Result**  A total of 48 patients completed the study; 25 in the deep block group and 23 in the moderate block group. No significant differences were found in baseline demographics or surgical characteristics. Median surgical duration was 40 minutes in the deep block group and 36 minutes in the moderate block group (P = NS).

Less than half of surgeries (48%) could be completed at 8 mm Hg insufflation pressures. Only 60% of patients in the deep block group and 35% of patients in the moderate block group had their surgery completed at an insufflation pressure of 8 mm Hg (P = NS; Figure 1). Optimal surgical conditions were more frequent in the deep block group both overall (28% of deep block vs. 4% of moderate block) and at the time of gallbladder dissection (36% of deep block vs. 24% of moderate block). These differences were not statistically significant (Figure 1).

**Conclusion**  Surgical conditions were slightly better with deep neuromuscular blockade compared to moderate neuromuscular blockade with rocuronium during low-pressure laparoscopic cholecystectomy. However, approximately half the surgeries required an increase in the insufflation pressures to achieve optimal surgical conditions.

**Comment**  The authors of this study found that a deep block with rocuronium provided slightly better surgical conditions. The problem the authors discovered was that the lower insufflation pressures resulted in poorer operative conditions for the surgeon. This required an increase in the insufflation pressure in 40% of patients in the deep block group and 65% in the moderate block group. Also the authors reported at the start of this study their surgeons had no experience operating with such low insufflation pressures. I understand the
rationale for lower insufflation pressures, but my concern would be that this could increase the risk of serious complications because the surgeon cannot see what they are doing.

A limitation of this study is that the scale they used to rate the operative conditions has not been validated, and the authors did not report inter-rater reliability; meaning two raters consistently reporting the same scores. Also these results may not be generalizable to patients who receive a balanced anesthetic which includes volatile anesthetics. I suspect the addition of volatile anesthetics may have improved operative conditions.

So what can we take from this study? Well, I think if you happen to work with a surgeon who uses low insufflation pressures you should be prepared to keep the patient deeply blocked and be prepared to administer a full reversal dose.

**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.
Pain

Safeguards to Prevent Neurologic Complications After Epidural Steroid Injections

Anesthesiology 2015; 122:published ahead of print
Rathmell JP, Benzon HT, Dreyfuss P, et al

Abstract

Purpose  The purpose of this article was to present the findings of a collaborative effort to identify methods which would help prevent complications after epidural steroid injection.

Background  Although the incidence of complications from epidural steroid injections is low, they can be catastrophic. The U.S. Food and Drug Administration (FDA) facilitated an effort to identify methods which would prevent complications from epidural steroid injections. The effort was part of the “Safe Use Initiative” conducted by the FDA and included a review of the current scientific evidence along with input from 13 physician stakeholder societies representing specialists in pain management. The goal of the FDA Safe Use Initiative was to reduce preventable harm by the identification of risks and then developing, implementing, and evaluating solutions in cooperation with stakeholders.

Methodology  Preventable risks associated with steroid use in epidural pain management were identified by an FDA workgroup. Clinical considerations were formulated which focused on prevention of catastrophic neural injury associated with epidural steroid injections. Representatives from 13 national pain organizations were asked to consider each preventative strategy and provide their opinion concerning the validity of each strategy. After the initial consideration, additional study material was added, and the strategies were then brought before each organization to be reconsidered. Final votes on each consideration were tabulated.

Result  All 13 organizations agreed that the following statements focused on the reduction of epidural steroid injection risks were valid.

1. Cervical interlaminar epidural steroid injections (ESI) are associated with risk of catastrophic neurologic injury
2. Particulate steroid use was associated with catastrophic risk when used with a cervical transforaminal approach
3. Cervical interlaminar ESIs should not be performed higher than C6-7
4. Prior imaging should be used to demonstrate adequate epidural space at the target level before performing a cervical ESI at any level
5. Particulate steroids should not be used for transforaminal cervical ESIs
6. Particulate steroids may be used for transforaminal lumbar ESIs
7. The use of image guidance with contrast is necessary in all ESIs regardless of location, unless contraindicated
8. If image guidance with contrast is not used, only a non-particulate steroid without preservatives should be used
9. Face mask and sterile gloves must be worn during ESI
10. Moderate to heavy sedation is not recommended, and if sedation is used at all, the patient should be able to communicate pain during the procedure
Among the remaining considerations, there was some dissent about requiring the use of digital subtraction imaging because the technology is not readily available. There was also disagreement about whether or not non-particulate steroids should be used in lumbar injections because the therapeutic benefit of these steroids has not been adequately demonstrated.

**Conclusion** These recommendations for minimizing catastrophic injury after epidural steroid injection focused on the root causes of such injuries. Those causes include direct trauma to the spinal cord and infarction due to inadvertent intravascular injection of particulate steroids. Both of these events are preventable. The article provides recommendations, which if followed, should significantly minimize the risks.

**Comment**
The use of interventional strategies for the treatment of neuraxial pain has become commonplace. The increased use of epidural steroid injections has exposed more patients to risks, some of which are catastrophic. Those catastrophic risks include stroke, spinal cord injury, and death. This effort by the FDA and pain management organizations has provided some simple clinical considerations which should help every provider reduce patient risk. The two major issues surrounding catastrophic injury appear to be spinal cord trauma and intravascular injection of particulate steroids. Spinal cord trauma is unlikely to take place in the lumbar region. Reports of such injuries have been isolated to cervical and thoracic needle placement. Those who perform cervical ESIs need to be very cautious with interlaminar needle placement and consider seriously the recommendations of never placing the needle higher than C6/7. The epidural space above that level is very narrow, or even absent in some patients, and dural penetration and spinal cord injury is much more likely. When performing cervical interlaminar ESIs, I have been placing the needle in one of the interspaces between C-7 and T-2 and then threading a catheter up to the desired cervical level. This approach provides more room in the epidural space for safer needle placement, allows me to better identify with contrast that I am actually in the epidural space, and directs the injectate to the ideal location with minimal volume. All of these benefits reduce patient risk while maximizing therapeutic value.

The risk of inadvertent intravascular particulate steroid injection can be eliminated by using non-particulate steroids. However, studies have not adequately demonstrated a reasonable therapeutic benefit for these types of steroids. Particulate steroids continue to be the standard for pain management, but high-risk situations where there is doubt about the potential for intravascular injection need consideration of either abandoning the procedure or using non-particulate steroids. The use of imaging with contrast is the standard of care for cervical and transforaminal ESIs, and should be used if possible with all ESIs unless contraindicated, according to these recommendations. Recommendations from other sources have suggested that “blind” (without the use of imaging) interlaminar lumbar ESIs are not inappropriate but have demonstrated a lower success.
rate. Increased risk using a blind technique in the interlaminar lumbar ESI approach does not appear to be an issue.

Cervical ESIs carry unique risks that should be considered. Vascular penetration and injury risks are much higher in this area, and some experts recommend against using a transforaminal approach for cervical ESIs. I abandoned the transforaminal approach in my practice a few years ago when I realized that the risks of this approach were higher than the interlaminar catheter approach while my patient outcomes were about the same.

It is obvious to most people that the practice of anesthesia in any situation carries significant risks. Those of us who practice pain management have the same duty as those who practice surgical anesthesia; to properly evaluate each situation and minimize patient risk whenever possible. I think these recommendations are sound and should be considered for every pain management practice.

Steven Wooden, DNP, CRNA, NSPM-C
Are Caudal Blocks for Pain Control Safe in Children? An Analysis of 18,650 Caudal Blocks from the Pediatric Regional Anesthesia Network (PRAN) Database

Abstract

The purpose of this study was to evaluate the safety profile of caudal regional anesthetic blocks in children. Additionally, the authors investigated patterns of local anesthetic dosing for caudal blocks.

Background

The caudal block is the most commonly performed regional anesthetic in pediatric surgical patients. Pediatric neuraxial blocks are typically performed while the patients are under general anesthesia as compared to the blocks typically being performed on adult patients who are awake or lightly sedated. This difference allows for the potential risk of neurologic complications in the pediatric population.

Caudal blocks have been performed since 1933. The latest systematic reviews have yet to address safety concerns raised by previous reports. Further, a large safety analysis has yet to be performed producing providers and parents with crucial risk information which is vital when deliberating the performance of caudal blocks in children.

Methodology

This study was performed using the Pediatric Regional Anesthesia Network (PRAN) database. Data were collected from 2007 through 2012. Demographic data included patients’ age, ASA status, and gender. Block performance data included level of consciousness during the block (awake, sedated, or general anesthesia), as well as block performance techniques; landmark or ultrasound-guided. Local anesthetic type, dose, and volume were retrieved and recorded.

The following were defined as complications from a caudal block:

a) block failure (unable to place, difficult to inject, subcutaneous injection)
b) vascular puncture (blood with aspiration)
c) positive intravascular test dose
d) dural puncture (CSF with aspiration)
e) seizure
f) cardiac arrest
g) sacral pain
h) other neurologic symptoms

Complications were recorded as either temporary or permanent.

Blocks performed using ropivicaine were converted to equipotent doses of bupivicaine using the following equivalency: 1mg ropivicaine = 0.7 mg bupivicaine.

Logistic regression analysis examined the association between the type of anesthesia (general versus awake) on the development of complications.

Result

The analysis included 18,650 children who received a caudal block. Before 2010, 3% of caudal
blocks were performed with ultrasound guidance compared to 2% in the following years. Caudal blocks performed while awake and/or sedated took place in the younger subjects, 2-18 months, compared to older patients, 7-29 months, who had their blocks performed during general anesthesia.

Overall, the estimated rate of complications from the placement of a caudal block was 1.9%. Complications were most prevalent in younger patients (median 11 months) while the older patients (median 14 months) were more likely to be complication free. No significant difference was noted in complication rates between males and females. Further, the rate of complications did not differ when ultrasound-guidance was used compared to blocks placed without ultrasound-guidance. Complication rates in patients who were awake for the block were higher (4%) compared to patients who were under general anesthesia (2%). Complication rates were far less (1.2%) when a test dose was used compared to blocks that omitted a test dose (2.2%). The most common complications were:

- block failure 1%
- blood aspiration 0.6%
- intravascular injection (a positive test dose) 0.1%

Rates of other studied complications were as follows:

- dural puncture 0.08%
- cardiac arrest 0.005%
- seizure 0.005%
- sacral pain and muscle spasm 0.005%

No reported adverse events resulted in long-term complications. The rate of complications with any sequela was 0.005%.

The median bupivacaine equivalent local anesthetic dose was 1.4 (0.78-2.51) mg/kg. Local anesthetic dose per kilogram weight was increased when epinephrine was used as an adjunct. Children who had a caudal block performed with ropivacaine received a larger total local anesthetic dose than those who had received a caudal with bupivacaine even after adjusting for the difference in drug potency, 1.66 mg/kg ropivacaine (in bupivacaine equivalents) vs. 1.34 mg/kg bupivacaine.

A total of 4,406 patients (24%) received a large, potentially unsafe dose of more than 2mg/kg bupivacaine equivalent. And, 968 children (5%) received a potentially toxic dose of more than 2.5 mg/kg of bupivacaine. The children who received the potentially unsafe dose were younger than those who did not receive a potentially unsafe dose of caudal bupivacaine (11 months and 15 months respectively).

**Conclusion**  A review of the PRAN database determined caudal blocks performed in over 20 different pediatric hospitals had an extremely low rate of complications. The severe complications of cardiac arrest and seizure were found to be 0.005%, and the most common complication was block failure at 1%. No cases of long-term sequelae were recognized. However, a large variation in local anesthetic doses used for caudal anesthesia, including some potentially toxic and unsafe doses, were noted.

**Comment**  Regional anesthesia is a pillar of anesthetic practice, offering remarkable efficacy. While the efficacy of
caudal blocks has not been in question; some recent studies have presented safety concerns in pediatric surgical patients. This large and well-performed study debunks the majority of the previously proposed concerns, especially since 18,450 of the blocks were performed while the child was under general anesthesia. Additionally, the study highlights the importance of performing a test dose of local anesthetic prior to bolusing which was directly associated with lower complication rates.

There were some serendipitous findings during the study necessitating discussion. First, while adequately addressing the potential safety issues, the authors unmasked the large variability in dosing of both bupivicaine and ropivicaine. Secondly, the study highlighted the decreasing trend to implement ultrasound-guidance during caudal block placement.

Even with caudal bupivicaine administration reaching the potentially unsafe 2 mg/kg and potentially toxic 2.5 mg/kg doses, the study found no complications directly associated with the consistently high doses. Total local anesthetic dose and patients’ weight had a linear relationship; however, patient weight was not the sole factor explaining such variability. A quality improvement (QI) project should be focused on determining the reason for such high local anesthetic doses. The QI project’s conclusion will assist providers in avoiding unsafe local anesthetic doses for caudal anesthesia. Safe local anesthetic dosing is especially important in younger children who have been found to be the most “at-risk” for injury and toxicity.

Lastly, throughout the study, the use of ultrasound-guidance steadily declined, while the rate of caudal anesthetics consistently increased. A total inverse of the implementation of ultrasound-guidance for peripheral regional anesthesia in adults. The study suggested that ultrasound-guidance provides no increase to the safety profile of caudal anesthesia. Therefore, this finding should not be terribly surprising.

Caudal blocks in pediatric surgical patients are safe and effective. Providers should be vigilant with correct local anesthetic dosing and confident in the evidence supporting the safety profile of regional anesthesia.

Kenneth J. Taylor, DNP, CRNA
Efficacy of Ketamine as an Adjunct to Lidocaine in Intravenous Regional Anesthesia

Reg Anesth Pain Med 2014;39:418-422
Abdel-Ghaffar HS, Kalefa MA, Imbaby AS

Abstract

Purpose  The purpose of this study was to compare the efficacy of ketamine 50 mg added to 40 mL of 0.5% lidocaine for intravenous regional anesthesia (IVRA; Bier block). Both intraoperative and postoperative analgesic requirements, onset and recovery times, tourniquet pain, and side effects were observed in patients undergoing surgery of the hand or forearm.

Background  IVRA is one of the oldest regional anesthesia techniques for surgeries of the hand and forearm lasting less than 90 minutes. Unfortunately, tourniquet pain is a common problem when an upper arm tourniquet is used. Numerous adjuncts have been used to hasten block onset and duration, and decrease tourniquet, intraoperative, and postoperative pain. Ketamine is an N-methyl-D-aspartate (NMDA) antagonist, which is purported to decrease intraoperative pain by blocking peripheral NMDA receptors on C-fibers in the forearm.

Methodology  This was a prospective, randomized, double-blind study of 40 adult patients, aged 20 years to 50 years, ASA I-II, undergoing surgery of the hand or forearm with a Bier block. Patients were randomized to receive either IVRA with 40 mL lidocaine 0.5% with 50 mg of ketamine (lidocaine + ketamine) or 40 mL lidocaine (lidocaine alone). The anesthesia provider, surgeon, and patient were blinded to group assignment. After exsanguination of the arm, a double cuff was applied to the upper arm and inflated to 250 mm Hg. The local anesthetic solution was then injected. After satisfactory anesthesia the distal cuff was deflated. All surgeries were done by the same surgeon.

Sensory and motor block onset were assessed every 30 seconds. Intraoperative pain and tourniquet pain were evaluated before tourniquet inflation and every 15 minutes using a verbal rating scale (VRS), with

1 = mild pain
2 = moderate pain
3 = severe pain
4 = excruciating pain

If the patient reported a VRS of 2 or greater, then fentanyl 0.5 µg/kg was administered. Diclofenac 75 mg IM was administered for postoperative pain scores of 2 or greater. Time to first analgesic request and total analgesic consumption during the first 24 hours were recorded. Statistical analysis and sample size calculation were appropriate.

Result  No significant differences were found in demographics, surgical characteristics, or total tourniquet time. The average dose of ketamine was 0.68 mg/kg in those who received it.
Ketamine group). Sensory and motor onset and recovery times were similar. Three patients (15%) in the Lidocaine only group required supplemental fentanyl (mean = 43 µg) for tourniquet pain compared to no patients in the lidocaine + ketamine group (P = NS). Patients in the lidocaine + ketamine group required significantly less postoperative pain medication, had a longer time to first request for pain medication, and required less diclofenac than those in the lidocaine alone group (P < 0.05; Table 1).

Five patients in the lidocaine alone group complained of CNS symptoms at the time of tourniquet deflation. Two patients complained of tinnitus and three complained of perioral numbness compared to none in the lidocaine + ketamine group (25% vs. 0%). In the lidocaine + ketamine group, five patients complained of excessive salivation and diplopia compared to none in the lidocaine alone group (25% vs. 0%). All patients (100%) in the lidocaine + ketamine group reported being very satisfied with analgesia at 24 hours compared to only 60% in the lidocaine alone group (P = 0.006).

**Conclusion**

The addition of ketamine to lidocaine for IVRA with an upper arm tourniquet significantly decreased the amount of postoperative analgesic requirements and time to first pain medication request. Tourniquet pain frequency and intraoperative analgesic requirements were higher in the lidocaine alone group; however, this difference was not statistically significant [concluding editor’s note: the investigators concluded that intraoperative analgesic requirements were significantly less; however, no difference was reported].

**Comment**

I thought this was a novel study because I would have never thought to add ketamine to a Bier block local anesthetic solution. It was hypothesized that ketamine might bind to peripheral NMDA receptors on peripheral C-fibers to reduce tourniquet and intraoperative pain. Only 3 patients required intraoperative fentanyl in the lidocaine alone group compared to none in the lidocaine + ketamine group. These results suggest it may do this, but the sample size was too low to confirm this hypothesis.

<table>
<thead>
<tr>
<th>Table 1. Bier Block with and without Ketamine</th>
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<td><strong>Lidocaine alone</strong> <code>&lt;br&gt;</code> <em>(n = 20)</em> <code>&lt;br&gt;</code></td>
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<tr>
<td><strong>Recovery of sensory block, min</strong></td>
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<tr>
<td><strong>Tourniquet pain</strong></td>
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<tr>
<td><strong>Post-op pain medication</strong></td>
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<tr>
<td><strong>Time to pain medication request, h</strong></td>
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<tr>
<td><strong>Post-op diclofenac consumption, mg</strong></td>
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**Note:** Results presented as mean ± standard deviation.
I am not surprised the time to first analgesic request was longer in the ketamine group. Most of the time patients will need an analgesic immediately after the tourniquet is deflated. However, I would not have expected the lidocaine + ketamine group to take almost 15 hours longer than the lidocaine alone group before requesting their first postoperative pain medication. I found this pretty amazing and much longer than the expected analgesic duration of ketamine. This suggests there may be some peripheral effect. Or it could be the ketamine was taken up into the muscle tissue and slowly released over the next 24 hours.

I think this technique might be particularly useful in settings where you cannot give or do not have any opioids or other analgesics to administer after a Bier block, for example humanitarian missions, operational settings, or a physician’s office.

**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.
Residual neuromuscular block in type II diabetes mellitus after rocuronium: a prospective observational study

Eur J Anaesthesiol 2014;31:411-416
Armendáriz-Buil I, Lobato-Solores F, Aguilera-Celorrio L, Morros-Diaz E, Fraile-Jiménez E, Vera-Bella J

Abstract

Purpose The purpose of this study was to compare differences in time to recovery of neuromuscular blockade in patients with type II diabetes vs. healthy control patients after administration of 0.6 mg/kg rocuronium.

Background Diabetes mellitus can result in motor nerve dysfunction and degeneration. This may lead to alterations in the response to neuromuscular blockade. Previous investigations have found prolonged neuromuscular blockade recovery time after administration of vecuronium in type II diabetes patients when compared to healthy controls. Prolonged blockade was found despite type II diabetes patients reporting no history of diabetic neuropathy or altered renal function. Unfortunately, no studies have examined differences in type II diabetes neuromuscular blockade recovery profiles after administration of a single dose of rocuronium 0.6 mg/kg.

Methodology This was a prospective case-control study of 62 adult ASA I-III patients undergoing general anesthesia who required a single dose of rocuronium 0.6 mg/kg to facilitate intubation (n = 31 type II diabetes and n = 31 healthy controls). Control patients were matched on weight, age, and gender. Both diabetic and control patients had to be free of neurological or neuromuscular disease and have no kidney dysfunction. A standard induction technique was used for all patients: midazolam 10-20 µg/kg, propofol 1-2 mg/kg, and after calibration of the neuromuscular block monitoring device, rocuronium 0.6 mg/kg. Anesthesia was maintained with sevoflurane 1.5% in air/oxygen (FiO₂ = 40%). Temperature was maintained with a warming blanket.

The primary outcome of this study was the time after administration of 0.6 mg/kg rocuronium until a train-of-four ratio of 0.9 (DurTOF90). The study ended when a TOF of 0.9 was achieved even if the surgery was not complete. Secondary outcomes included time to achieve a TOF of 0.7 (DurTOF70). The time between a 2/4 TOF and a TOF ratio of at least 0.9(T2-TOF90) was also tracked. Statistical analysis and sample size calculations were appropriate.

Result There were 32 patients in the type II diabetes group and 39 in the control group. No significant differences were found in demographics or clinical characteristics, with the exception of blood glucose levels on the day of surgery which were higher in the type II diabetes (127 mg/dl vs. 90 mg/dl, P < 0.05). The time to reappearance of each twitch, DurTOF90, DurTOF70, and T2-TOF90 were all significantly longer in patients with type II diabetes (P < 0.05; Figures 1 & 2). On average, it took 25 minutes longer for the diabetic patients to achieve a TOF of 0.9 after administration of a single dose of 0.6 mg/kg rocuronium compared to healthy controls. A TOF ≥ 0.9 indicates the patient has adequate
of a single dose of 0.6 mg/kg rocuronium compared with healthy controls. These findings suggest diabetic patients have an increased risk of residual neuromuscular blockade than do healthy patients.

**Comment**

Diabetes is a devastating disease that increases a patient’s risk for perioperative complications. In this study the investigators confirmed that with rocuronium, like vecuronium, neuromuscular blockade is prolonged in patients with type II diabetes. These results are clinically useful because they tell us it takes healthy, older patients (average age 60 years) an average of 85 minutes to recover fully from a single dose of 0.6 mg/kg rocuronium; you can add approximately 25 minutes to this time for a similarly aged adult with type II diabetes.

I think the take-home message from this is that you should always monitor neuromuscular function and realize that a diabetic patient may take longer to recover from a nondepolarizing neuromuscular blocking agent.

**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.
Abstract

Purpose The purpose of this study was to identify clinically relevant aspects of respiratory depression recorded in malpractice insurance claims. The data source was the ASA closed claims project database.

Background Previous studies have identified a wide range for the incidence of respiratory depression during the first 24 hours postoperatively, 0.1% to 37%, depending in part upon the definition of “respiratory depression.” When respiratory depression was defined as the administration of naloxone, the incidence was low. When respiratory depression was defined in terms of respiratory rate or oxygen saturation, the incidence was much higher.

A JCAHO review spanning eight years of data associated “wrong dose” medication errors with half the cases of respiratory depression. The JCAHO subsequently recommended five steps to reduce the risk of postoperative respiratory depression in patients receiving opioids, largely based upon expert opinion:

- identify patients at high risk for opioid-induced respiratory depression
- use non-opioid analgesics
- emphasize assessment of patient sedation, ventilation, & oxygenation
- educate healthcare providers who monitor for respiratory depression
- institute a quality improvement process for respiratory depression incidents

Methodology Investigators evaluated 9,799 records from the ASA closed malpractice claims database. Claims involving acute pain management and respiratory depression occurring between 1990 and 2009 were collected, 138 in all. The certainty that respiratory depression was present was defined using the following criteria:

Definite respiratory depression:
- patient received naloxone and respirations improved
- respiratory arrest
- resuscitation

Probable respiratory depression:
- respiratory rate < 8/min
- somnolence
- oxygen saturation < 90% (unless abnormal baseline)
- high opioid dose in patient not previously taking opioids
- snoring, airway obstruction, cyanosis

Possible respiratory depression:
- cardiac arrest not due to another cause and
- risk factors for respiratory depression

Patients who experienced respiratory depression received opioids via a spinal or epidural, IVPCA, or IM/IV bolus. Each case was examined for factors that may have contributed to respiratory depression, such as:

- Obstructive Sleep Apnea (diagnosed or high risk)
- opioids given by multiple routes
- multiple opioid prescribers simultaneously
- history of chronic opioid use
- time between last patient check and discovery of respiratory depression
Inclusion criteria were met by 92 records. Respiratory depression was classified as “definite” or “probable” in 73% of patients. In general, patients with respiratory depression had a mean age of 50 years old and were obese; fully two-thirds had a BMI $\geq 30 \text{ kg/m}^2$. Obstructive Sleep Apnea was either diagnosed or a high risk in a quarter of the patients. About half of patients received opioids by more than one route of administration, and about half were receiving a continuous infusion of opioids. The vast majority of events involving respiratory depression occurred within the first 24 hours post-op.

Prior to a respiratory depression event, nursing assessments noted somnolence in 62% of patients and heavy snoring in 15% of patients. The time between the last nursing check and discovery of a respiratory depression event was not known for all patients. When it was known, the time between the last nursing check and discovery of a respiratory depression event was as brief as 15 minutes. It was 60 minutes or less in over half of patients. In the remainder of patients it was between 1 hour and 5 hours (with one exception in which the patient was discovered in respiratory depression 8 hours after the last nursing check). Nursing checks were judged by the panel of investigators as “inadequate” in about one-third of patients based upon missing the importance of clinical signs (e.g. oxygen desaturation) or length of time between nursing checks. In one case a patient was discovered obtunded and with an SpO2 of 49%. The only action taken was to apply oxygen.

When respiratory depression occurred the severity of injury was high, death in 55% of patients and permanent brain damage in 22%. Only 23% of patients recovered with temporary effects. The anesthesia care provided was classified as “less than appropriate” by the investigators in 40% of patients. Almost all were likely preventable with improved care.

The vast majority of respiratory depression events in this study resulted in death/brain damage, occurred within 24 hours post-op, and were preventable. Somnolence was usually observed prior to the respiratory depression event.

Respiratory depression that puts the patient at risk is difficult to study. This closed insurance claims study was a reasonable effort, but it is important to point out that it does not tell us how often respiratory depression occurs or in how many patients. It is only able to identify commonalities amongst patients who experienced a problem sufficient to result in a malpractice insurance claim. Most of us probably believe that respiratory depression that results in significant risk to patients is relatively rare; whether or not that is true is unknown. I do think we could demonstrate that respiratory depression resulting in the deadly outcomes reported in this study is fairly rare. In anesthesia we have thankfully reached a time when most of our quality improvement effort is directed at making uncommon complications even more uncommon. We have an opportunity to do that when we consider respiratory depression. Why should we apply our efforts to make respiratory depression
even less common? Most cases of respiratory depression included in this study were preventable using well-known principles. Is it even an anesthesia problem? The anesthesiologists who conducted this study judged inappropriate anesthesia care to be a factor in 40% of the respiratory depression, so, yes, it is an anesthesia problem.

The authors did a good job of identifying procedures that can reduce the risk of respiratory depression, such as identifying at-risk patients, using multimodal analgesia, improving patient assessment (monitoring by a person rather than just a machine), and avoiding the administration of opioids by multiple routes simultaneously. I want to add one more factor. I think in addition to assessing the patient we need to assess the abilities of those who care for our patients in the PACU, the ICU, and on the ward. When I say “assess the abilities,” I’m not saying assess their intelligence, rather their knowledge and how much time they have to apply that knowledge to the patient. Here is a story to illustrate my point, the story that taught me this lesson.

I once did a long case that I knew would require high levels of analgesia for postoperative pain. To provide that analgesia I used a sufentanil infusion as the basis of the anesthetic with enough inhalation agent to ensure amnesia and a muscle relaxant. I had done many cases that way at a previous institution and had the timing down so patients would wake up and breathe but have no pain. But this was the first time I’d done one in the OR I worked in at the time. The patient had received enough sufentanil that I knew it wasn’t going to wear off for 2 - 3 hours. I took the patient to the PACU well oxygenated and breathing deeply. In report, I told the PACU nurses about the technique I’d used and warned them that if they gave any opioids in the PACU the patient would stop breathing. Everything was fine. I left and started my next case. The PACU nurses gave the patient IV morphine. He had a respiratory arrest and was reintubated and placed on a ventilator without harm. These PACU nurses were not dumb. They had simply not seen a case done as I had done that one. They were unfamiliar with the pharmacokinetics of a sufentanil infusion. They knew all the patients who had that surgery needed morphine in the PACU. I had failed to assess their knowledge, and I had not taken their experience and the PACU culture into consideration. Fortunately, the patient suffered no harm.

Postoperative respiratory depression can be all but eliminated if we will be careful to consistently apply what we know about preventing it. That includes taking time to educate the nursing staff and restraining ourselves from using techniques that depend upon the nursing staff having knowledge and procedures they’ve not yet gained.

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