

ANESTHESIOLOGY™ 2014

OCTOBER 11-15 | NEW ORLEANS, LA

Session: L008
Session: L066

Nerve Injury/Dysfunction and Peripheral Nerve Blockade: Fact or Fiction

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Disclosures: This presenter has no financial relationships with commercial interests

Stem Case and Key Questions Content

56-year old attorney was an unrestrained driver in a head-on motor vehicle accident and sustained a traumatic injury to his left hand and wrist (positive loss of consciousness). He is also complaining of transient “tingling sensations” only to tips of fingers on the left hand. He is scheduled for open reduction and internal fixation of left hand and wrist.

Medical disease and preoperative evaluation

Patient’s medical history is significant for asthma and he reports of dyspnea with exertion. Asthma is treated with cromolyn sodium and albuterol inhaler. 1. What is the etiology/prevalence of asthma and pathogenesis? 2. Are there predisposing factors of asthma and what preoperative work-up would you order? He has a 12-year history of insulin dependent diabetes mellitus. 3. If regional anesthesia with a peripheral nerve block is chosen, should epinephrine be added to prolong blockade effect? He was hospitalized 2 months previously to treat his shortness of breath symptoms and to rule out pneumonia. He recently had an upper respiratory infection and completed a 10-day course of at-home antibiotics. Surgeon wishes to urgently proceed with this open fracture. 4. How long would you postpone or would you not postpone surgery in a patient with a recent upper respiratory infection and asthma? His past surgical history is significant for both cervical (1989) and lumbar posterior fusion (2000) and he has a documented difficult intubation during his lumbar fusion surgery requiring an awake fiberoptic intubation. 5. What anesthetic options should be discussed? Should a peripheral nerve block be considered secondary to report of peripheral nerve dysfunction versus general anesthesia (GA)? Additional medications include daily baby aspirin (81 mg) and atorvastatin (Lipitor) 80 mg daily. 6. Should regional anesthesia be contraindicated in patients taking aspirin? He smoked 1 pack-per-day for 40 yrs and quit 4 yrs ago. Patient was anxious to receive a peripheral nerve block and indwelling catheter for pain management in order to avoid a general anesthetic (GA). He did not want to repeat an “awake intubation” and wanted to avoid a foley catheter. 7. What anesthetic options should be discussed with this patient and what are the advantages and disadvantages of axillary, infraclavicular, supraclavicular and interscalene blocks?

Intraoperative/perioperative anesthesia management

Discussions between the intraoperative teams decided to proceed with surgery (concern for status and type of fracture). 8. How would you pre-medicate an asthmatic patient for surgery. Physical exam shows normal airway, distant breath sounds at bases bilaterally (no wheezes, rales or rhonchi), and heart exam with regular heart sounds. Preanesthesia assessment vitals:

heart rate 78 bpm, respiratory rate 22 bpm, and blood pressure 110/68 mmHg. Gross neuro exam reveals normal motor function of upper extremities and equal bilaterally into the hands. Decreased sensation to touch on the finger tips (distal phalanx) to the index, middle, ring and baby fingers of the left hand. Patient had tests performed, neurology consult requested and was premedicated with diphenhydramine, atropine, droperidol, hydroxyzine hydrochloride, and treated with glucocorticoid replacement therapy. 9. Would you order preoperative steroid(s)? The intraoperative anesthesiologist consulted the regional anesthesia/pain management service for advice/consultation on the optimal anesthetic plan for the patient. 10. What pulmonary function changes may occur subsequent to an interscalene or supraclavicular block and any concerns in a patient with pulmonary disease? Intraoperative anesthesiologist consults with the regional anesthesia/acute pain medicine service and requests a nerve/nerve plexus block be placed for intraoperative anesthesia. They further inquiry about nerve block placement and any concerns about sensory deficits in the fingertips of the left hand. 11. What local anesthetic should be used in this patient and should any adjuvant(s) be added to the chosen local for this patient? Should a single shot nerve block be placed and/or catheter inserted in this patient, and when should the catheter be used/bloused with local. The intraoperative anesthesiologist wishes the regional anesthesia team to come into the OR for nerve block placement. 12. Should preoperative, intraoperative, or postoperative placement of a peripheral nerve block be performed and any advantages? Intraoperative anesthesiologist is also inquiring if the regional anesthesia team can select the most appropriate technique since a tourniquet is likely to be needed. 13. Describe the formation of brachial plexus and which areas of the plexus need to be covered for planned surgery? 14. What nerves may be missed with an interscalene or axillary nerve block and would an interscalene block be indicated for postoperative analgesia in this patient? During peripheral nerve block placement, the intraoperative anesthesia team recalls that the sedated patient complained of "tingling sensations" to the operative hand and wanted the regional team to reconsider proceeding with the regional technique. 15. Can ultrasound (US) guided regional anesthesia provide advantage over other techniques for peripheral nerve block placement? Can use of US decrease complications such as nerve injury or systemic local anesthetic toxicity?

Postoperative management

Upon arrival to the post anesthesia care unit (PACU), the nurses are concerned that the patients saturation is 90 percent and he has slow and rapid respirations at a rate of 33-35 bpm. 16. What to do if a patient has dyspnea in the PACU following interscalene block and intraoperative GA? Prior to patient discharge to the floor from the PACU, the surgical team is planning for continued pain management during the remaining hospital course. 17. What means of regional anesthesia provide postoperative pain management and any potential advantages/complications?

Model Discussion Content

Differential diagnosis of dyspnea (and wheezing) can include a host of diagnosis, but to differentiate asthma from other diseases is usually not difficult to determine (triad of wheezing, dyspnea and coughing along with history of periodic attacks is characteristic along with a family history of allergic disease(s) as complimentary evidence). In addition, patients with long-standing asthma may develop chronic obstructive lung disease and suffer from exertion shortness of breath and even orthopnea (1). Etiology of asthma may be difficult to define, but asthma is heterogeneous with a common denominator of nonspecific hyper-irritability of the

tracheal-bronchial tree and is clinically divided into 2 groups: idiosyncratic (intrinsic) and allergic (extrinsic). Idiosyncratic asthma is theorized to be due to abnormality of the parasympathetic nervous system. Allergic asthma is associated with history of allergic disease, increased levels of immunoglobulin E within serum and positive skin reactions to extracts of airborne antigens (1). There are predisposing factors to initiate and aggravate an asthmatic attack and preoperative work-up of the asthmatic patient should include a battery of tests. Attention to the baseline cardiopulmonary function should be established and anesthetic preoperative evaluation to include a plan to minimize and/or prevent obstruction to expiratory outflow.

Acute exacerbation of asthma are evoked by respiratory infections. Subsequent to a viral infection, airway responsiveness of even healthy subjects is increased and can last from 2-8 weeks following remission of the infection in both healthy and asthmatic subjects. Risk of respiratory complications is increased following an upper respiratory infection (URI) along with an increased risk of laryngospasm and bronchospasm. Therefore, it is recommended to delay elective surgery for 2 to 3 weeks following submission of clinical URI symptoms in asthmatic patients (1). Anesthetic options should be discussed with this patient and a peripheral nerve block considered even with reports of questionable nerve injury. However, there are only a few published reports of anesthesia-related nerve injury associated with peripheral nerve blocks (PNBs). The commonly cited incidence (0.4%) of neurologic injury may be underestimated owing to underreporting. Therefore, the risks for the development of neuropathy in neurologically compromised patients undergoing regional blockade remains unknown. No study to date has been able to determine the answer, however, predicting the incidence in a non-impaired patient population may be possible and lead to additional insight for the patient with a pre-existing neurological impairment. Anesthetic options to discuss with this patient could include, but not limited to, general anesthesia (GA) and regional anesthetic or combination. Postoperative pain management issues also need addressed and a plan developed. Some anesthetic possibilities include:

- a.) GA and patient controlled analgesia (PCA),
- b.) Brachial plexus block (approaches: interscalene, supraclavicular, infraclavicular, axillary and individual nerve branches),
- c.) GA in addition to nerve plexus block,
- d.) Continuous nerve plexus catheter(s) for anesthesia/analgesia and
- e.) Bier Block.

Patients that have been treated with glucocorticoids for asthma within the previous year are suspected to have an element of adrenocortical suppression (2), but what about the asthmatic patient who had less than a week of steroid therapy longer than 6 months prior? Preoperative consideration of the routine use of systemic steroid preparation should be discussed with the surgical service secondary to any concerns of (single day of high dose or continued perioperative administration) steroid(s) administration and affect on wound healing in the circumstance of ongoing wheezing and surgery.

Subsequent to discussion(s) with the surgical service and intraoperative anesthesia team, the decision to proceed with surgery was made. Patient had tests performed, neurology consult requested and pre-medicated with glucocorticoid replacement therapy (2).

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Intraoperative anesthesiologist consulted regional anesthesia service for advice on optimal anesthetic plan. Each case of a patient with a preexisting neuropathy should be evaluated individually as there are no absolute methods that exist for predicting how the patient with such a disposition will fare with a regional block technique. Whether the neuropathy will remain static or become exacerbated remains uncertain. Therefore, a full appraisal of the risks and benefits associated in a patient with preexisting neuropathy along with alternatives to regional anesthesia should be provided to the patient. In addition, reliance on retrospective reviews may also provide insight as to any potential unfavorable consequences of regional blockade to patients interested in disclosure of how their disease process may be influenced by regional anesthesia. Secondary to history of loss of consciousness during/from the accident, the intraoperative anesthesiologist inquires about placement of a brachial plexus block to reduce further compromise of patient cognitive dysfunction/confusion. Intraoperative anesthesiologist wishes regional team to come into the operating room (OR) for peripheral nerve block placement if nerve blockade is chosen. Intraoperative anesthesiologist also requested the regional team to use a long acting local anesthetic (versus an intermediate acting local; lidocaine or mepivacaine) and to also consider adding epinephrine into the long acting local (bupivacaine or ropivacaine) to prolong anesthesia for surgery that could take several hours to complete.

The upper extremity is innervated by the brachial plexus formed by ventral primary divisions of cervical and thoracic nerve roots. These roots join to form an anatomical orientation of the brachial plexus that further innervates the upper extremity. There are four nerve branches that innervate the upper extremity and consideration should be provided for coverage of the arm if a tourniquet is anticipated. Therefore, consideration of nerve block placement (+/- a catheter) should be considered for preoperative (pre-emptive), intraoperative, or postoperative placement to gain any potential perioperative advantage(s).

Can ultrasound (US) guided regional anesthesia provide advantage over other techniques (paresthesia or nerve stimulation) for peripheral nerve block placement and can use of US, compared to nerve stimulation, decrease complications such as nerve injury or systemic local anesthetic toxicity? Introduction of US has rejuvenated interest in regional anesthesia. Benefits of direct visualization of nerves and surrounding anatomy, continual observation of needle tip and spread of local make US-guided regional anesthesia/analgesia appealing. Use of US may reduce the incidence of intraneural needle tip placement and/or local injection compared to nerve stimulation secondary to ability to image peripheral nerves. In addition, situations where less local anesthetic can be injected secondary to real-time US imaging of local surrounding target nerves...a process not possible with use of a nerve stimulator. However, in a cost-conscious health-care setting and to convince skeptics, there also needs to be evidence of increased benefits and reduced complications. An additional option for consideration of technique to use (US- or nerve stimulation-guided) would be to combine US along with use of a nerve stimulator with the theory that an added benefit may be obtained as a result of US imaging of the intended target and potential for nerve stimulation as the block needle is being advanced that may diagnose aberrant anatomy.

US is a rapidly developing area of technology and there is growing evidence to support the benefits of its use in nerve and nerve plexus blocks, especially prevention of intraneural block needle tip placement.

Common complications associated with nerve blocks [see below] may be avoided with US, but problems/compromise have still been reported. Anatomical variants have been demonstrated by US and US has proved to be useful in performing regional anesthesia/analgesia in difficult situations or where peripheral nerve stimulation is unsuccessful or inappropriate (3).

Despite growing interest in use of US imaging to guide performance of regional procedures, controversy still exists as to whether US is superior to previously developed nerve localization techniques such as a peripheral nerve stimulator (PNS). No hard evidence has shown US-guided versus alternative nerve localizing techniques are superior in regional anesthesia/analgesia (4). Abrahams investigated this by performing a review and meta-analysis of randomized controlled trials that compared these two methods (5). Some results from the meta-analysis indicated that blocks performed using US were more likely to be successful [risk ratio (RR) for failure 0.41, 95% confidence interval (CI) 0.26-0.66, $P=0.001$], took less time to perform (mean 1 min less to perform with US, 95% CI 0.4-1.7 min, $P=0.003$), faster onset time (29% shorter, 95% CI 45-12%, $P=0.001$), and longer duration (mean difference 25% longer, 95% CI 12-38%, $P=0.001$) than with PNS guidance. US use also decreased risk of vascular puncture during block performance (RR 0.16, 95% CI 0.05-0.47, $P=0.001$) along with improved efficacy of nerve blocks compared with techniques that use PNS.

Regional techniques, despite well-known clinical benefits, has not gained the same popularity as that of general anesthesia, especially for patients. This is secondary to multiple shortcomings such as a defined failure rate, lack of simplicity, and potential for patient discomfort/injury. Many negative aspects of regional procedures evolved from reality that nerve-localization techniques are unreliable (great variation in human anatomy). Use of US imaging for nerve localization is an innovative application of an old technology that addresses many of the shortcomings of current techniques. Specifically, US allows operator to see neural structures, guide the needle under real-time visualization, navigate away from sensitive anatomy, and monitor the spread of local anesthetic. US technology may represent an ideal mechanism by which the anesthesiologist can attain safety, speed, and efficacy over general anesthesia (6).

Ultimately, it is the correct perineural spread of local anesthetic around a nerve that provides safe, effective, and efficient anesthetic conditions. Many of the challenges and clinical failures of RA techniques are attributed to the fact that neurovascular anatomy is highly variable and current nerve localization techniques provide little or no information regarding the anatomical spread of local anesthetics, but US technology has been utilized in an attempt to minimize many of the drawbacks of traditional nerve block techniques. US can provide an evidence-based context to further expand use in regional anesthesia/analgesia, but limitations of US including learning curve issues, costs, and artifact generation may prove to be preventable limiting factors (7).

There are pulmonary function changes that may occur subsequent to an interscalene or supraclavicular block and such concerns in a patient with pulmonary disease need to be appreciated. Placement of interscalene blockade almost ensures a 100% incidence of a hemidiaphragm paresis and decreasing the dosage does not seem to reduce the likelihood of this event or lessen pulmonary effects. Supraclavicular blockade has a lower incidence of ipsilateral hemidiaphragmatic paresis, and infraclavicular along with axillary blockade usually have no effects on hemidiaphragmatic function (8, 9).

Other adverse pulmonary function changes and chest wall mechanics can occur subsequent to an interscalene block (8). Therefore, patients with preexisting pulmonary disease may require consideration of the brachial plexus blockade technique given the undesirable changes in pulmonary function and if it has been determined that they will not tolerate the pulmonary mechanic changes or reductions in pulmonary function.

Local anesthetic selection and concentration choices should be strategized in this patient as well as consideration of adding any adjuvant(s) to the chosen local. A single shot nerve block and/or a peripheral nerve catheter in this patient are alternatives as well as consideration of when the catheter should be used/bloused with local.

In addition, certain nerve branches of the brachial plexus may be missed with an interscalene or axillary nerve block as well as concern that a selected nerve block provide for optimal postoperative analgesia. There are maneuvers that may direct local toward a more proximal distribution, but a better approach may be to block the nerve branches independently or chose an alternative nerve block approach.

Extremity tourniquet pain is not completely understood, but in theory is mediated by somatic and sympathetic nerves. Tourniquet pain may be refractory to usual management, but there are a host of measures that can be employed to provide anesthesia to the area.

Anesthetic assessment and patient education that dyspnea in the PACU following interscalene/supraclavicular block and intraoperative GA could occur is necessary to reduce patient anxiety. Adverse respiratory symptoms may occur after GA or following an interscalene or supraclavicular block along with altered respiratory sensations. An additional risk that always needs to be addressed with each patient candidate is that of peripheral nerve injury. Effective regional anesthesia blockade can provide postoperative pain management, but may also expose patients to potential complications.

Any orthopedic surgery using GA with or without peripheral nerve/nerve plexus blockade for multimodal analgesia can be associated with, but not limited to: 1) multiple nursing interventions for pain management, PONV and other opioid related side-effects; 2) PACU and same-day surgery discharge delays; 3) unplanned hospital admissions or readmissions for pain management; 4) increasing opioid requirements following resolution of the nerve blockade; and 5) side-effect profiles from escalating perioperative opioid needs (10-13).

It has been suggested that neural blockade with local anesthetics before a surgical insult may prevent nociceptive input from altering excitability of the central nervous system by preemptively blocking the N-methyl-D-aspartate induced wind-up phenomena and subsequent release of inflammatory mediators (14). However, relevance of preemptive analgesia has been questioned and only a small number of clinical studies have shown any benefit of pre- vs. post-incision pain management (15,16). A review by Moinich stated that evidence is lacking to support the claim that timing of single-dose or continuous postoperative pain treatment is critically important in the management of postoperative pain (17).

Consideration for the doses of local used during block placement and continuous catheter infusion are necessary (18). History of any preexisting peripheral neurologic dysfunction should

be followed throughout the perioperative period and consideration provided toward any reported postoperative complication(s) and/or neurovascular dysfunction. In addition, there may be an incidence of persistent paresthesia following extremity surgery as a possible result of surgical dressings, a nerve block or surgically placed diffusion catheter into a joint (19).

The amount of scientific published data on preexisting neuronal injury currently makes it impossible to define specific guidelines for the use of regional anesthesia in the patient with such potentially compromising conditions and/or neuromuscular disease. There can also be instances with several neurologic and neuromuscular disorders where there may be an advantage(s) to performing regional anesthesia versus a general anesthetic. However, a study of significant size to confirm or support the safety of regional anesthesia in these patients is scarce. It has also been suggested that patients with preexisting chronic neurologic deficits due to mechanical, ischemic, toxic or metabolic derangements may be placed at increased risk with regional anesthesia/analgesia. In addition, an axon with a preexisting underlying disease process (toxic, metabolic, ischemic) may have impaired axonal flow throughout the neuron (may or may not be symptomatic) and predisposes the axon to distal denervation following another, even minor neural insult (i.e. double-crush). Another final aspect to consider is that taking the most conservative legal approach would be to avoid regional anesthesia in patients with preexisting neurologic-disorders and that the decision to proceed with regional anesthesia in these patients should be made on a case-to-case basis along with risk-to-benefit analysis. Common and potential serious complications associated with upper extremity peripheral nerve blockade

1. Infection

- Use of strict aseptic techniques should be incorporated in all peripheral nerve blockade techniques.
- Catheters at various locations (axilla) are more difficult to keep clean/sterile and risk-to-benefit should be incorporated (esp. catheter removal when no longer needed).

2. Hematoma formation

- Attempt to reduce multiple needle passes/insertions (esp. in anti-coagulated patients).
- Advancement of block needle through muscle may lead to bleeding and hematoma development.
- If blood vessel puncture is witnessed/observed, the procedure should be interrupted and pressure applied over the site (several minutes before proceeding with the block).

3. Nerve Injury

- Use of a nerve stimulator and slow needle advancement may help to reduce such risks.
- Paresthesia with nerve stimulation may not be necessary and may also reduce needle penetration of peripheral nerves.
- Injections should be stopped when a patient complains of pain or when high injection pressures are met.
- Peripheral nerve blocks may have a predisposition for nerve injury (mechanical and pressure) and nerve stimulation along with slow needle advancement may reduce such events.
- Nerve stimulation obtained with a current intensity of 0.5-0.2mA before injecting local anesthetic may reduce likelihood of intraneural injection.

4. Local anesthetic toxicity

- Systemic toxicity during and immediately following local anesthetic injection is always possible (aspirate bolus doses frequently and inject local anesthetic slowly when injecting large volumes).

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- Potential for absorption of local anesthetic may exist. Therefore, large volumes of long-acting anesthetics should always be considered (especially in older patients).

5. Other

- Instruct patients on the inability to coordinate any blocked extremity

- Instruct the patient on the care of the insensate extremity and explain the need for frequent body repositioning (may avoid stretching and prolonged ischemia of anesthetized nerves).

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