3 Avoiding Complications in Regional Anesthesia

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There is widespread conviction among anesthesiologists that regional anesthesia offers significant advantages over general anesthesia in certain settings. At the same time, there is a fear of complications related to the performance of regional anesthetic techniques that is held with almost equal intensity. Complications related to regional anesthesia have been described by many authors, although our understanding of the numerous factors leading to these complications is limited. Auroy et al.[1] described the risk of complications related to regional blocks as lower than 5 in 10,000 patients in their series, which included spinal, epidural, and peripheral nerve blocks. In the case of spinal or epidural hematoma, the relative risk has been described as 1:220,000 and 1:150,000, respectively, a rate that approaches the risk of routine general anesthesia.[2] However, the risk of neurologic complications after central neuraxial block can be markedly elevated (1:1,800) in patients with risk factors such as female sex, osteoporosis, or concurrent use of anticoagulants.[3] Despite the relatively infrequent occurrence of complications related to regional anesthesia, the fear of complications exceeds their actual occurrence. This may be attributable in part to widespread misperceptions regarding the role of regional anesthesia in producing neurologic injury on the part of patients, surgeons, anesthesiologists, and other healthcare providers. The absence of a clear understanding often leads to blame being assigned to the regional anesthetic without careful assessment and diagnosis of the neurologic deficit to determine its etiology. These misconceptions have also led to "chart wars," in which written statements assigning blame before establishment of a clear diagnosis are placed in the medical record. These statements often obscure the truth and serve as a barrier to effective communication between physicians caring for patients with neurologic deficits after surgery. They may also serve as fodder for the malpractice attorney and make it difficult to defend a physician practicing within the "standard of care," regardless of their specialty. Although it is impossible to prevent all neurologic injuries related to regional anesthesia, it may be possible to reduce their occurrence by avoiding well-defined risk factors and using meticulous technique at all times.

Scope of the Problem

Lee et al.[4] described the "Injuries Associated with Regional Anesthesia in the 1980's and 1990's" based on a closed claims analysis of 134 cases. Axillary blocks made up 44% of claims, intravenous regional block 21%, interscalene blocks 19%, and

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supraclavicular blocks 7%. The damaging event was related to the block in 51% of peripheral block claims. Death or brain damage was present in 11%. The damaging event in high-severity claims was variable and included block technique (n = 3), wrong drug or dose (n = 3), allergic reactions (n = 2), inadequate ventilation (n = 2), high block (n = 1), difficult intubation (n = 1), no event (n = 1), and unknown (n = 1). Permanent nerve damage was present in 29% of peripheral block claims and temporary injury in 58% of claims.

Bleeding

The potential risk of bleeding complications resulting from the performance of regional anesthesia is readily apparent given the almost universal association of nerve plexuses with vascular bundles including an artery and a vein. Complications related to bleeding include minor issues such as oozing or bruising at the site of needle insertion. In addition, the potential for significant blood loss is present as well. Small amounts of oozing or minor bruising at the needle insertion site are common and should not be considered complications, but rather an expected part of the procedure. There is also a risk for significant hematoma formation or blood loss. This may be related to vascular puncture or injury related to needle insertion. The degree of concern for this complication is directly related to size of the needle, the number of times the vascular structure or tissues are punctured, the ability to compress the vessel, and any underlying coagulation abnormalities. Major bleeding complications related to the performance of regional anesthesia have been reported and include persistent Horner's syndrome, peripheral nerve injury, hematoma formation, and blood loss requiring transfusion. The potential for significant blood loss is increased by the presence of inherent anticoagulation abnormalities or medically administered anticoagulants. Ekatodramis et al.[5] reported two cases of prolonged Horner's syndrome caused by hematoma formation after continuous interscalene block.[5] Several authors have reported peripheral nerve or brachial plexus injuries related to hematoma formation during axillary brachial plexus block.[6–9] A case report by Nielsen[10] describes bleeding after a series of intercostal nerve blocks performed for analgesia after cholecystectomy in a patient receiving heparin. After the fourth set of blocks, the patient's hematocrit decreased from 33–40 to 20 and eventually to 15. Transfusion of eight units of packed red blood cells was required to maintain a hematocrit above 30. The small hematoma present after the third set of blocks expanded to cover a 30 × 65 cm area. The patient had no long-term sequelae, but had pain in the right flank and hip for 4 weeks in the area of the hematoma. In the case of lumbar plexus blocks, numerous case reports of psoas hematoma with and without neurologic complications and with and without anticoagulants have been reported.[11–14] In addition, renal subcapsular hematoma in association with lumbar plexus block has been reported.[15] Although there is sparse literature to support this, some authorities have suggested that the *ASRA Consensus Guidelines for the Performance of Neuraxial Anesthesia in the Presence of Anticoagulants* be applied to the performance of peripheral nerve blocks as well.[2] In the case of deep nerve blocks in noncompressible sites such as cervical, thoracic, and lumbar paravertebral, there may be merit to this approach. However, some degree of latitude may be appropriate in those situations in which a block is performed in an area that is readily compressible such as the femoral or axillary region. However, this cannot be recommended as entirely safe, because case reports of neurologic injury related to hematoma formation in association with axillary block have been published. It is vitally important that preblock history determine if there is a history of coagulation abnormality or if medications or oral dietary supplements are being taken that can affect coagulation.

Infection

The potential for infection associated with the performance of regional anesthesia is an obligatory part of every regional anesthesia discussion (see Chapter 19). The usual

maxims to avoid performing blocks in patients with sepsis, placing needles through an obvious skin infection, or avoiding the performance of blocks in infected extremities have been conventional wisdom. The occurrence of infection related to the performance of single-shot peripheral nerve blocks is rare, which may reflect the relatively low infectious risk of sterile needle insertion and/or the antimicrobial effects of local anesthetics.[16] There is a greater risk associated with the performance of continuous peripheral nerve block techniques. When indwelling catheters are present, it is common for these catheters to become colonized.[17,18] However, if left in for short periods of time, progression to frank infection or sepsis is uncommon. The most common organisms encountered are staphylococcus species although enterococcus, other gram-positive cocci, gram-negative bacillus, and others are found as well.[16] The risk of infection can best be reduced by using meticulous technique including careful cleansing of the skin before needle insertion, using agents such as Betadine or chlorhexidine, using sterile needles, and using sterile gloves if palpation of the site or contact with the needle is anticipated. In the case of indwelling catheters, the routine use of a hat, mask, and sterile gloves is warranted. The use of a sterile gown may not be required in all cases, but if contact with the catheter during insertion is likely, this extra precaution is recommended. Attempts to demonstrate a difference in infection rate between catheters inserted with and without the use of a sterile gown during epidural catheter insertion have not been successful in demonstrating any significant change in outcome.[18] There is no evidence to support the routine use of preblock antibiotics for single-shot blocks and little to support the use of preinsertion antibiotics in the case of continuous nerve blocks, although they do reduce the incidence of colonization. Colonization seems to be increased by frequent dressing changes. Efforts should be made to dress catheters well initially and minimize the total number of dressing changes or breaks in the integrity of infusions.[18]

Allergic Reaction

Allergic reactions to local anesthetics are uncommon and avoiding this complication is something that should be accomplished by taking a thorough drug and allergy history. A history of prior allergic reaction to local anesthetics or a history of allergic reaction to paraaminobenzoic acid–containing compounds should be recorded. In this setting, ester local anesthetics should be avoided. It is also possible that allergic reactions may be attributable to preservatives such as methylparaben or metabisulfite in the local anesthetic solution.[19–21]

Drug Toxicity

There are several types of toxicity associated with the use of local anesthetics for peripheral nerve blocks. These include central nervous system (CNS) toxicity related either to the total dose administered or the site of injection, cardiac toxicity, neurotoxicity, and myotoxicity.

The risk of CNS toxicity related to injection of local anesthetic may be reduced by careful aspiration of the needle before injection of local anesthetic, injection of a test dose of local anesthetic containing epinephrine and looking for mild signs of CNS toxicity or effects of intravenous epinephrine, injection of small volumes of local anesthetic followed by frequent aspiration and allowing sufficient time for drug to circulate before administering additional local anesthetic. In the case of blocks such as interscalene in which the carotid or vertebral arteries may be encountered, seizure activity may be produced by a large injection or as little as 0.5–1 mL of local anesthetic.[22,23] This is significantly different from CNS toxicity, that results from administering doses of local anesthetic too large for an individual's body size, age, weight, or general state of health.[24–28] Information about the patient's age, weight, general state of health, number of blocks to be performed, and site of local anesthetic administration should be taken into consideration when choosing a total dose of local anesthetic.

It is well established that local anesthetics have neurotoxic effects. These effects have been much more prominent and well studied within the subarachnoid space in association with spinal anesthesia where both concentration and dose seem to have a role in the observed changes.[29-31] There is little direct evidence to correlate the use of local anesthetic for peripheral nerve block with significant direct neurotoxicity.[32] However, the combination of local anesthetic with or without adjuvants and peripheral nerve injury or intraneural injection may be related to worsened outcome.

Myotoxicity is a well-known side effect of local anesthetics.[33] It has been used with theoretic advantage in the treatment of myofascial trigger points, but complications related to the myotoxicity resulting from local anesthetic used in the performance of peripheral nerve block have been rare.[34,35] The performance of single-shot peripheral nerve blocks has not been associated with significant myotoxicity. However, significant complications related to the performance of continuous regional anesthesia with resultant long-term muscular injury have been reported. Marginal block performance and the need for multiple large boluses of local anesthetics should be carefully evaluated to avoid repeated intramuscular injections. The potential for drug toxicity related to other drugs inserted via indwelling peripheral nerve catheters exists and may lead to catastrophic consequences. However, there are no reports in the peer-reviewed medical literature regarding this complication.

Equipment

Regional anesthesia techniques have been enhanced by the use of various types of equipment. This includes the nerve stimulators, ultrasound imaging devices, and pressure manometers. Nerve stimulators have been used to facilitate the location of peripheral nerve bundles transcutaneously, which aids in selecting the correct needle insertion site.[36] They have had more widespread use as a means of providing visual cues to needle location and have become commonplace in this setting. Once a needle has been advanced toward a peripheral nerve, the presence of motor or sensory pulsations may be used as an indicator of needle-tip location. It has been assumed that there is a direct correlation between the current required to elicit a motor response and the distance of the needle tip away from the nerve structure. It is widely accepted that performance of peripheral nerve blocks with currents of 0.5 mA or less is more likely to result in a favorable outcome than nerve blocks performed with higher currents. There are many under the false assumption that the presence of a motor response at a reasonable current not only indicates proximity, but also indicates the absence of needle insertion to the nerve with a resultant increase in safety. Although a motor response at an extremely low current may indicate intraneural needle placement, this is not always true. The converse is also not true. Studies comparing the response of patient-reported paresthesias to nerve stimulation and nerve stimulation to ultrasound have demonstrated that reliance on current alone is insufficient to prevent nerve injury.[37,38] Perlas et al.[39] have demonstrated that paresthesias may be perceived by patients in the absence of a motor response even at currents as high as 1.5 mA. Although nerve stimulators are excellent tools, their use alone does not confer an automatic safety advantage with respect to the avoidance of nerve injury. However, if motor stimulation is present at an extremely low current, it is prudent to withdraw the needle until the twitch disappears and then increase the current to see if the twitch may be reestablished. Avoiding injection in the patient with a motor response at an extremely low current may help to avoid complications, although this cannot be guaranteed.

Recent years have seen an explosion in the use of imaging techniques for the performance of regional anesthesia. The largest growth in this area has been in the use of ultrasound. These devices allow the imaging of bones, soft tissue structures, nerves, vascular bundles, and the needle approaching the nerve. In addition, they demonstrate the flow of local anesthetic either around the nerve in the desired manner

or away from the nerve, allowing time to reposition the needle to facilitate greater success in the block. They may also demonstrate intraneural injection.[40] These techniques have the significant advantage of allowing direct visualization of the important structures and may provide greater safety in years to come. At present, the size, expense, and overall lack of experience in the larger community of regional anesthesiologists has limited application of these techniques. However, the explosion of courses and the rapidly advancing ultrasound technology and reduced costs of new devices will help to increase their acceptance and use.

It is also a widely held belief that there is a certain "feel" to the syringe during the injection of local anesthetic associated with a normal injection. If this normal feel is not apparent and the injection requires markedly increased pressures, it may be because the needle tip is either against or within the nerve. Early work has been reported outlining the use of pressure manometers to evaluate injection pressure during the performance of nerve injections in animal models.[41] The authors contend that high injection pressures at the onset of injection may indicate intraneural needle placement and lead to severe fascicular injury and persistent neurologic deficits. This is strictly experimental at the present time and its future applicability in the clinical setting is yet to be determined.

Operator Factors

Although the patient is the one who experiences the complication, there should be no doubt that the practitioner handling the needle has an intimate and critical role in the development of complications. Although many attempts have been made to simplify the performance of regional anesthesia with the use of various surface landmarks, mnemonics, peripheral nerve stimulators, and imaging devices, the simple fact remains that regional anesthetic techniques are more readily performed by those who have a solid understanding of the anatomy. This includes knowledge of anatomy that goes beyond the simple surface landmarks drawn to facilitate needle insertion and extends to the three-dimensional anatomy of the nerves, muscles, and blood vessels below the surface of the skin. This anatomic knowledge should incorporate not only the standard understanding of various nerves and their plexuses, but should also include a simple understanding of various anatomic variations that may be present. These variations may lead to either altered nerve location or motor and sensory responses, which although different from the standard, are nonetheless valid. A sound knowledge of anatomy also helps to prevent errors related to excessive needle insertion depth. This error is frequently observed during the early stages of learning regional anesthesia and results from the desire on the part of that person performing the technique to encounter the targeted nerve, believing that if only they will go deeper they will sooner or later encounter what they are looking for. This is a dangerous way of thinking and has produced many devastating complications. Interscalene blocks have been a far too frequent example of this complication. In this block, the nerve plexus is typically 1–1.5 cm below the surface of the skin. Evidence of needles inserted too far with this particular technique have been reported in the literature in the form of spinal cord injuries.[42] Other examples include pneumothorax during thoracic paravertebral block and kidney hematoma and peritoneal catheter insertion during lumbar paravertebral blocks.[15,43,44] The accomplished regional anesthesia practitioner must also learn to listen to the patient. Patient reports of unusual paresthesias or pain during needle insertion or injection should be noted and evaluated. They may be reporting the pain that occurs with direct nerve contact, needle insertion into the nerve, or intraneural injection. The ability to use the patient as a source of information for the practitioner has created great controversy, especially surrounding the performance of regional anesthetics on patients who are awake, heavily sedated, or asleep. In most cases, performance of regional anesthetic techniques should not be excessively painful, and reassurance and a gentle hand should allow the procedure to be performed on the

awake or mildly sedated patient without difficulty.[45,46] In the case of young children, the mentally unstable, or the patient with an unstable fracture who is unable to tolerate positioning or nerve stimulation, the use of heavy sedation or general anesthesia may be necessary and should be discussed at the time that consent is obtained. Finally, the practitioner should carefully evaluate the indications for selecting a given block for a given patient. If there are significant contraindications to the performance of a block such as preexisting neurologic deficit, changing neurologic deficit, or inability to conduct appropriate postoperative neurologic evaluation, choice of another technique may be appropriate. Performance of regional anesthetics on the wrong limb has been an ongoing problem. This requires care on the part of all involved to reconfirm correct limb selection. Attempts to reduce the incidence of error have stimulated the use of preanesthetic site verification and the "time-out" process.[47]

Finally, the importance of appropriate education and training in regional anesthesia techniques cannot be overemphasized. This should occur during residency training and at continuing medical education courses on an ongoing basis, in order to stay current with contemporary techniques.

Patient Factors

There are numerous patient factors that may contribute to complications associated with the performance of regional anesthesia. Preexisting disease such as diabetes may change neuroconductivity and result in the need for higher nerve stimulator currents to produce the desired effect.[48] The underlying nerve dysfunction in these patients may also predispose them to additional neurologic injury. This is not an absolute contraindication to doing blocks in these patients, but rather should be taken into consideration during the performance and the discussion of risks related to the procedure preoperatively. The same is true of other causes of peripheral neuropathy. Patient factors such as morbid obesity in which landmark identification may be challenging must be taken into consideration.[49] In some patients, this may prevent successful performance of the block. Other patient factors, such as trauma resulting in anatomic abnormality or the potential for complications such as compartment syndrome, may prevent the performance of blocks, and in this setting, altered anesthetic and postoperative analgesic techniques may be more appropriate.

Conclusion

Numerous factors contribute to the development of complications related to the performance of peripheral nerve blocks. A thorough knowledge of anatomy, indications and contraindications for block performance, meticulous attention to preparation and performance of regional anesthetic techniques, careful selection of local anesthetic drug and dose, and use of available technical devices to facilitate performance of regional anesthesia will help to minimize long-term complications related to these techniques.

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