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Regional Nerve Blocks—Best Practice Strategies for Reduction in Complications and Comprehensive Review

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Abstract

Purpose of Review Understanding the etiologies of the complications associated with regional anesthesia and implementing methods to reduce their occurrence provides an opportunity to foster safer practices in the delivery of regional anesthesia.

Recent Findings Neurologic injuries following peripheral nerve block (PNB) and neuraxial blocks are rare, with most being transient. However, long-lasting and devastating sequelae can occur with regional anesthesia. Risk factors for neurologic injury following PNB include type of block, injection in the presence of deep sedation or general anesthesia, presence of existing neuropathy, mechanical trauma from the needle, pressure injury, intraneural injection, neuronal ischemia, iatrogenic injury related to surgery, and local anesthetic neurotoxicity.

Summary The present investigation discusses regional blocks, complications of regional blocks, risk factors, site-specific limitations, specific complications and how to prevent them from happening, avoiding complications in regional anesthesia, and the future of regional anesthesia.

Keywords Regional anesthesia · Pain · Nerve blocks · Analgesia · Ultrasound

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Introduction

Peripheral nerve blocks are utilized to provide anesthesia and postoperative analgesia for surgeries of the upper and lower extremity, the trunk, and the chest. This form of regional anesthesia provides a safer perioperative experience, improves pain control, and reduces opioid consumption. It has also been shown to improve patient satisfaction and expedite patient discharge home [1, 2•].

Optimal peripheral nerve blocks should demonstrate sufficient duration of action while minimizing the risk of complications. The utilization of ultrasound technology has contributed to the popularization of regional anesthesia due to its ability to aid clinicians in depositing local anesthetics in precise proximity to peripheral nerves of interest. However, regional anesthesia still presents serious complications such as nerve injury, catheter infection, and local anesthetic systemic toxicity (LAST). Additionally, patients with preexisting sensory or motor deficits are more likely to develop new deficits following a nerve block [3].

The use of ultrasound-guided nerve blocks has demonstrated that intraneural injections do not necessarily result in permanent injury [4, 5]. Although the use of ultrasound guidance has increased in popularity, this technique has not been associated with a reduction in postoperative neurologic symptoms or long-term peripheral nerve injury compared to peripheral nerve stimulation [6••]. Nonetheless, serious nerve injury is extremely rare, with most injuries being transient—lasting days to weeks—and often subclinical [7•]. If significant injury is suspected, a neurologic consultation with neurophysiologic testing is indicated.

Benefits of continuous peripheral nerve blocks include prolonged analgesia, increased postoperative patient satisfaction, and faster functional recovery of operated limbs. However, undergoing regional anesthesia using peripheral nerve catheters carries its own risks and challenges. While rare, infection associated with placement of a peripheral nerve catheter may cause significant morbidity, including permanent nerve injury [8]. Other complications associated with peripheral nerve catheters include inadvertent catheter removal; catheter kinking, knotting, and looping; and block failure.

Local anesthetic systemic toxicity continues to be a major source of morbidity and mortality associated with regional anesthesia. LAST is usually a consequence of intravascular injection or rapid systemic absorption of local anesthetic; it is effectively treated with lipid emulsion therapy, which theoretically acts as a lipid shuttle for the local anesthetic [9••].

Understanding the etiologies of the complications associated with regional anesthesia and implementing methods to reduce their occurrence will foster a safer practice of regional anesthesia. Thus, this manuscript details the specific complications associated with neuraxial anesthesia and peripheral nerve blocks, evidence-based strategies to prevent such complications, and the future directions of regional anesthesia.

Complications of Regional Blocks

Risk Factors

Neurologic injuries following peripheral nerve block (PNB) and neuraxial blocks are rare, with most being transient. However, long-lasting and devastating sequelae can occur with regional anesthesia. Risk factors for neurologic injury following PNB include type of block, presence of existing neuropathy, mechanical trauma from the needle, pressure injury, intraneural injection, neuronal ischemia, injection under deep sedation or general anesthesia, iatrogenic injury related to surgery, and local anesthetic neurotoxicity [6••, 10]. The size and type of needle can also be a factor. There is a higher incidence of fascicular invasion with long-beveled needles compared to short-beveled needles, but injuries sustained with short-beveled needles tend to be more severe [11]. The elicitation of a paraethesia as a risk factor for peripheral nerve injury (PNI) is controversial [12–15]. Performing blocks on pediatric patients that are heavily sedated or under general anesthesia has not been associated with additional risk as has been demonstrated in adults [6••]. The ability of the patient to report pain or paraethesia may be a valuable monitor for intraneural needle placement, but sedation can increase patient comfort and improve patient satisfaction [16, 17].

Risk factors cited in complications of neuraxial anesthesia include type of neuraxial technique with epidural bearing higher risk than spinal, coagulopathy (pathologic or pharmacologic), female sex, advanced age, preexisting neurologic disease, and spinal stenosis. In addition, risks for complications have been shown to be higher in orthopedic compared to obstetric patients [6••].

Peripheral Nerve Injury

The incidence of PNI is difficult to determine due to the heterogeneity of studies and varying definitions of what constitutes a PNI [18]. The incidence of long-lasting PNI ranges from 2 to 4 per 10,000 patients [19]. In a study by Urban et al., mild parasthesias were not uncommon on postoperative day 1, occurring in 19% of axillary blocks and 9% of interscalene blocks. After 2 weeks, the incidence of neuropraxia fell to 5% in the axillary group and 3% in the interscalene group. After 4 weeks, only 0.4% of patients experienced symptoms [14]. Overall, transient deficits lasting up to 2 weeks are not uncommon and can range from 8.2 to 15% [10, 12].

A retrospective study of 380,680 cases found an incidence of all causes of perioperative nerve injury to be at 0.3%. Type of surgery (neuro, cardiac, general, ortho), hypertension, tobacco use, diabetes, and general and epidural anesthesia were all associated with nerve injuries. Peripheral nerve blocks trended toward, but did not reach, a statistical significance for PNI [20]. Two other retrospective studies both with over 12,000 patients undergoing total knee and total hip arthroplasty found no association between PNB and PNI [21, 22]. Another study revealed that an interscalene nerve block for total shoulder arthroplasty did not increase the risk of PNI [23].

Where local anesthetic is deposited may also contribute to the development of PNI, and intrafasicular injections are thought to carry the highest risk. Selander et al. showed that axonal degeneration from intrafasicular injection was similar using saline or 0.5% bupivacaine and increased with increasing concentrations of bupivacaine and with the addition of epinephrine [24]. In a canine model, higher injection pressures were associated with persistent neurologic deficits and were considered indicative of an intrafasicular injection [25, 26]. However in a porcine model, intraneural injections of clinically relevant volumes of local anesthetic resulted in histological changes but no functional deprivation [4].

Peripheral nerve injury in the perioperative period can be caused by factors outside of regional anesthesia, and most nerve injuries are unrelated to regional blockade. Other factors that can lead to peripheral nerve injury include positioning, use of tourniquets, direct damage to the nerve from traction, transection, stretching, and metabolic and environmental factors [27]. The incidence of PNI following PNB is extremely low with both nerve stimulation and US techniques. Inadvertent intraneural injection can still happen with the use of ultrasound, and its use has not be shown to reduce the risk of long-term PNI when compared to nerve stimulation [12, 28, 29].

Anatomic Considerations

Axons are surrounded by the endoneurium, a layer of connective tissue containing mostly collagen fibers. A group of axons are bound together by the perineurium forming a fascicle. A tough layer of tissue, the epineurium, encases a group of fascicles in connective tissue forming the overall structure of a nerve [15, 30]. An advancing needle will tend to push a nerve away rather than penetrate the tough epineurium. When a needle does penetrate the epineurium, it is more likely to be in the adipose or interfasicular space. It is thought that sites with higher concentrations of non-neural connective tissue (distal sites) will have a higher chance of the needle being intraneural, but extrafasicular [6••]. In light of these differences, no clinical evidence exists that there is an increased risk of PNI when blocks are performed at more proximal sites [15].

Preexisting Conditions

Diabetes, hypertension, severe peripheral vascular disease, and cigarette smoking can disrupt the microvascular integrity to nerves lending them more susceptible to injury [15]. Patients with hereditary peripheral neuropathies, acquired peripheral neuropathies, Guillain–Barre syndrome, amyotrophic lateral sclerosis, postpolio syndrome, multiple sclerosis, and neural tube defects warrant careful consideration and discussion with the patients before performing regional anesthesia. [31]. Further care should be taken in patients with spinal stenosis as there is evidence that they may be at increased risk for neurologic injury following neuraxial anesthesia [6••, 32, 33].

Local Anesthetic Systemic Toxicity

LAST can be a dire complication of regional anesthesia. LAST can occur from unintentional vascular injection or through excessive systemic absorption. High concentrations of local anesthetic in the systemic circulation can lead to life-threatening side effects such as hypotension, arrhythmias, cardiac arrest, seizure, and loss of consciousness. Intravascular injection during caudal and epidural anesthesia is often the source of increased serum local anesthetic levels. Mild symptoms of local anesthetic toxicity include tinnitus, metallic taste, circumoral numbness, and agitation. These can often be treated with supportive measures and close observation. CNS symptoms of seizure, coma, and respiratory arrest often precede cardiovascular collapse but may not be evident in a deeply sedated or fully anesthetized patient. Hypertension, hypotension, tachycardia, bradycardia, ventricular arrhythmias, and cardiac arrest can all occur [34, 35].

Diagnosis is clinical with signs and symptoms of agitation, auditory changes, metallic taste, tinnitus, and the aforementioned severe side effects. Lipid emulsion is the treatment of choice, and advanced cardiac life support should be started if cardiac arrest occurs. Prevention involves aspiration of the needle before injection, application of test doses of medication, incremental injection of local anesthetic during neuraxial anesthesia administration, and observation for early signs and symptoms of toxicity. Finally, less cardiac toxic local anesthetic agents may be selected.

Severe cases should be treated according to the ASRA Checklist for Treatment of Local Anesthetic Toxicity (Table 1) [9••]. The use of ultrasound has been estimated to reduce the incidence of LAST by up to 65% [19]. In a study of 7156 PNBs in 6069 patients Barrington et al. reported the incidence of LAST to be 0.98 per 1000 PNBs [36].

Studies have shown that local anesthetic systemic toxicity is rare. The incidence was 1.04 per 1000 in one study from the National Inpatient Sample in the USA where 710,327 patients underwent total joint arthroplasty with an adjunctive peripheral nerve block between 1998 and 2013. Major adverse complications occurred in 21% of those patients [37].

Site-Specific Limitations

Site-specific limitations for regional blocks must be taken into consideration with type of surgery, patient risk factors, and

Table 1 ASRA checklist for treatment of LAST (adapted from Neal et al. [9])

Risk reduction	Detection	Treatment
Identify at risk patients Consider LA dose as part of time-out Use lowest dose of LA Consider using test dose (epi 2.5–5 mcg/ml) Aspirate prior to injection Use incremental injection while observing for signs of toxicity	Use standard ASA monitors Monitor patient during and after injection Toxicity can be delayed for > 30 min Sedation may impede detection of LAST Watch for cardiovascular instability, altered mental status, or neurologic symptoms CNS signs: excitation, depression, non-specific (metallic taste, tinnitus, circumoral numbness) CV signs can be only manifestation of severe toxicity	Stop injection Get help Administer lipid emulsion at first signs of severe toxicity 100% FiO2 Avoid hyperventilation CPR if pulseless Benzos for seizures Decreased dose of epi (≤ 1 mcg/kg) Avoid Propofol if hemodynamically unstable Monitor: > 2 h for CNS event, 4–6 h for CV event

comorbidities. If a patient is coagulopathic, it is prudent to choose a block site where direct pressure can be held if vascular puncture is committed. Patients undergoing upper extremity surgery with underlying lung pathology will benefit from sparing of the phrenic nerve. Interscalene, supraclavicular, and infraclavicular blocks can all result in phrenic nerve palsy [38, 39]. A more distal or peripheral site can possibly be chosen providing it will have adequate analgesic coverage for the expected surgery. Motor weakness is another consideration when choosing a site for blockade as femoral nerve blocks can result in significant quadriceps weakness when compared to more distal sites targeting the saphenous nerve [40, 41].

Specific Complications

Postdural Puncture Headache

Postdural puncture headache (PDPH) is a common complication of neuraxial blocks with an overall incidence around 7% [42]. PDPH can occur following any opening in the dura mater. This may occur through spinal anesthetics, epidural wet tap, lumbar puncture, or migration of an epidural catheter. The mechanism of PDPH is thought to occur through transdural leakage, which causes decreased CSF volume and pressure. This decreased pressure, along with gravity in the upright position, causes traction on the meninges and pain-sensitive intracranial vessels, which refer pain to the frontal, occipital, neck, and shoulder region via trigeminal, glossopharyngeal, vagus, and upper cranial nerves [43]. PDPH diagnosis is clinical, characterized by a positional headache worse in the upright position and improved in the supine position.

Initial management includes conservative measures such as bed rest, intravenous hydration, caffeine supplementation, recumbent positioning, and analgesic medication. More than 85% of PDPH resolve with this approach [44]. Patients who do not respond to conservative management within 48 h require more aggressive treatment. The epidural blood patch is considered the standard therapy for moderate and severe PDPH [45].

Prevention of PDPH includes proper neuraxial block technique, use of needles with smaller diameter, bevel positioning parallel to dual fibers rather than perpendicular, use of atraumatic needles, replacement of stylet, and reducing the number of puncture attempts [44].

Backache

Backache is a frequent ailment of neuraxial anesthesia. Incidence of backache resulting solely from neuraxial blocks is difficult to estimate because of the high occurrence of postanesthesia backache and high prevalence of chronic back pain in the general population. Estimates show that up to 25–30% of patients receiving general anesthesia complain of backache [46].

The main mechanism of neuraxial backache stems from trauma to skin, subcutaneous tissues, muscle, and ligaments as the needle is inserted. Non-steroidal anti-inflammatory medications and warm or cold compresses are suitable treatments for postneuraxial block backache. Although post block backache is usually benign, it may be a sign of serious complications such as epidural abscess or spinal hematoma [47].

Transient Neurological Symptoms

Transient neurologic symptoms (TNS), a painful ailment of the buttocks and thighs with radiation to the lower extremities, can occur after spinal anesthesia. Schneider first detailed TNS in 1993 with four cases of severe radicular back pain occurring after administration of hyperbaric lidocaine spinal anesthesia in lithotomy position. No sensory or motor deficits were discovered on exam, and the symptoms resolved spontaneously in several days [48]. Studies have estimated the incidence of TNS after neuraxial anesthesia ranges between 0 and 37%, and is dependent on a variety of anesthetic, surgical, and probably undetermined patient factors [49–51].

In a review by Zaric and Pace, the risk of developing TNS after spinal anesthesia with lidocaine was significantly higher than when using bupivacaine, prilocaine, or procaine. Further, consideration of body positioning in addition to local anesthetic choice may play a role in prevention of TNS [52]. Many studies have been performed in an attempt to discover the etiology, clinical significance, and risk factors associated with TNS. However, our understanding of this condition is incomplete [53].

Total Spinal Anesthesia

Total spinal anesthesia is a life-threatening complication of neuraxial anesthesia that occurs through the placement of local anesthetic into the intracranial subarachnoid space. It involves applying some level of anesthesia to the brainstem and central nervous system. It is a clinical diagnosis which presents with loss of consciousness and signs of cardiovascular collapse in the form of hypotension, bradycardia, and respiratory dysfunction that may or may not require intervention. These signs and symptoms can appear within minutes of the application of spinal anesthesia.

Treatment involves prompt recognition and prevention of hypotension and hypoxia. Important measures include patient placement into the Trendelenburg position to increase venous return, fluid bolus, and ionotropic medications such as phenylephrine to support blood pressure, and respiratory interventions such as mask ventilation or endotracheal intubation [47]. Precautionary techniques include cautious aspiration, application of a test dose, and incremental injection of local anesthetic during epidural and caudal neuraxial anesthesia.

Epidural Abscess

An epidural abscess is a possibly fatal condition caused by infection and ultimately, a buildup of pus in the epidural space. It is a rare, but severe complication of neuraxial blocks and occurs with an incidence from 0.015 to 0.7% according various reports [54, 55]. Patients usually display signs and symptoms of fever, malaise, leukocytosis back pain, and signs of spinal cord compression. Epidural abscess is diagnosed with gadolinium-enhanced MRI.

Treatment involves rapid neurosurgical consultation for decompression through abscess drainage. The microorganism at fault must also be eliminated, and duration of parenteral antibacterial treatment is typically for 4–6 weeks [56]. Prevention relies on proper use of full aseptic technique when placing neuraxial blocks, including the donning of a surgical mask. The occurrence of epidural abscesses may also be reduced by minimizing needle trauma during placement [57].

Spinal or Epidural Hematoma

Spinal hematoma is a dangerous complication of neuraxial block that occurs when there is bleeding within the central nervous system. This complication is rare and has been estimated to be about 1:150,000 for epidural blocks and 1:220,000 for spinal anesthetics [58]. Patients with a spinal hematoma typically present with complaints of new onset sharp back and leg pain with numbness and weakness. They may also present with bladder and bowel dysfunction. Diagnosis should be made in a timely manner with imaging in the form of MRI and CT scan. Neurologic consultation should also be obtained. Treatment occurs through surgical decompression, usually with laminectomy. Improved neurologic outcomes are seen when surgery occurs within 12 h of symptom onset [59]. Limiting the risk of hematoma involves avoiding neuraxial blocks in patients who are at an increased risk of bleeding. Therefore, the risks and benefits of these procedures must be considered when patients with coagulopathy, severe thrombocytopenia, and anti-coagulation therapy are involved.

Meningitis

Subarachnoid space infection can occur as a result of neuraxial block. Exogenous contamination of equipment or medications or endogenous bacteria seeding by needles may be the source of infection. Therefore, sterile technique is crucial in prevention of meningitis as a complication of neuraxial block.

Incidence of meningitis following neuraxial anesthesia is rare. There were no cases of CSF infection in a prospective study by Dripps and Vandam of 8460 normal risk patients undergoing spinal anesthesia. [60] In two retrospective studies of high-risk obstetric patients in labor who received extradural blocks, only two patients out of 27,000 and 505,000, respectively, had CSF infections [61, 62]. Early clinical signs and symptoms are fever, headache, emesis, and lethargy. Diagnosis is made with lumbar puncture. Treatment involves intravenous antibiotics.

Cardiac Arrest

The mechanism of cardiac arrest is not fully understood. Theories involve shifts in cardiac autonomic balance toward the parasympathetic nerves and activation of various receptors in the heart. Intravascular fluid support, the use of mixed alpha and beta agonists, and vagolytic agents have been utilized to decrease the frequency of and improve the survival outcomes of cardiac arrest during neuraxial anesthesia [47]. The incidence of cardiac arrest during regional anesthesia has been estimated to range from 1.5–6.4/10,000 cases [63–65].

Urinary Retention

Neuraxial anesthesia with local anesthetics can lead to urinary retention through blockade of the S2 through S4 nerve root fibers. This causes a decrease in urinary bladder tone and inhibits the voiding reflex. Epidural opioid administration may also lead to urinary retention.

Urinary retention is common after anesthesia and surgery with reports of an incidence between 5 and 70% [66]. The diagnosis of neuraxial block induced urinary retention is often arbitrary, and its incidence is not known because of a lack of standard criteria. However, by identifying patients at risk, practicing appropriate techniques, and monitoring bladder volume with ultrasound, urinary retention, and its complications may be prevented.

Avoiding Complications in Regional Anesthesia

Although with an overall benign safety profile with an estimated complication rate of 5 in every 10,000 patients, regional anesthesia is not without risks [67]. Invasive instrumentation places patients at risk for bleeding, infection, and damage to surrounding structures. While practitioners work to mitigate these risks both through extensive training as well as with the

Table 2 Avoiding complications in regional anesthesia

Bleeding	- Prior to block obtain detailed history regarding previous abnormal coagulation events as well as current medications and dietary supplements [67] - Increased needle size, number of tissue or vascular punctures, and underlying coagulation abnormalities are associated with increased blood loss [67] - Non-compressible bleeding sites - Active pharmacologic anticoagulation - Bruising and oozing blood at needle insertion site are to be expected - Hematoma formation with potential compressive complications [67]
Infection	- Overall rare given sterile technique and antimicrobial effects of local anesthetics - Associated with multiple attempts and the use of continuous peripheral nerve catheters [67] - Sterile technique reduces the risk of infection (using betadine or chlorhexidine, and sterile needles and gloves). There has been no association between sterile gown use and infection risk. - Active infections including sepsis or cellulitis may place patients at higher infection risk. Active infectious sites should be avoided during needle puncture. - There is no evidence to support prophylactic antibiotic therapy [67]
Allergic reaction	- Obtain thorough drug and allergy history prior to procedure - Reactions to local anesthetics themselves is uncommon - Preservative compounds found in local anesthetics such as paraaminobenzoic acid, methylparaben, and metabisulfite are often found to be the culprit of allergic reactions [67]
Drug toxicity	- Toxic dose calculations are effected by patient's body size, age, weight, number of blocks performed, and site of local anesthetic administration [68] - CNS toxicity—related to both total dose and injection site. As little as 0.5–1 mL of local anesthetic injected inappropriately has demonstrated seizure activity. - Myotoxicity—complications associated with continuous regional anesthesia with long-term muscle injury [68]
Equipment	- Ultrasound imaging—inexperience associated with increased complications - Pressure manometers—evaluate injection pressure during performance, high pressure at the onset may indicate intraneural needle placement leading to fascicular injury and neurologic deficits [67]
Operator factors	- Having a thorough understanding of anatomy including anatomical variations is critical for reducing complications associated with operator error - Reported errors associated with excessive needle depth include spinal cord injuries during interscalene blocks, pneumothoraxes during thoracic paravertebral blocks, and kidney hematoma's during lumbar paravertebral blocks [67] - Patient feedback is critical in minimizing adverse outcomes and the practitioner should pay special attention to patient reported pain or paresthesia's throughout the procedure
Patient factors	- Performing regional blocks on patients with peripheral neuropathies due to diseases such as diabetes may require stronger nerve stimulator currents putting the patient at risk for additional neurologic injury [68] - Successful blocks in obese individuals or trauma patients are increasingly more difficult due to complications in identifying landmarks and anatomical variations respectfully. In the setting of traumas out of the concern for developing compartment syndrome, alternative anesthetic techniques should be considered [67] - Contraindications—preexisting neurologic deficit, changing neurologic deficit, or inability to conduct appropriate postop neurologic evaluation [67] - Deep sedation or general anesthesia in adults adds risk of unintended intraneural injection without the patient having the capacity to communicate that the needle is placed in the wrong position [6]

utilization of real-time imaging via ultrasound technology, these risks remain present and must be considered prior to any regional anesthetic [67, 68] (Table 2).

The Future of Regional Anesthesia

As regional anesthetic techniques are utilized to care for patients with a variety of comorbidities, the advantages that have been demonstrated include decreased hospital length of stay, improved pain and satisfaction scores, and increased safety when utilized at greatest benefit [69]. Ultrasound guided imaging has become the primary technique of performing a nerve block. Since employing ultrasound-guided techniques, block success rate is improved, intravascular injection rate is decreased, and other complications are reduced such as an iatrogenic pneumothorax [70, 71]. It is imperative that training today and in the future includes a comprehensive ultrasound-guided regional anesthesia curriculum for the safety and quality metrics described [72].

Conclusions/Summary

Complications from regional anesthesia remain relatively rare. However, anesthesia providers should be aware of some of the risks associated with these procedures. Serious complications of peripheral nerve blocks include nerve injury, catheter infection, bleeding, and LAST. Advancements in ultrasound technology and availability were thought to result in a reduction of these some of these complications. While large-scale studies have yet to be performed, current data has not demonstrated a signification difference in complication rates using ultrasound-guided techniques. These studies utilizing ultrasound have nonetheless provided valuable insight into some of the mechanisms of nerve injury. It was previously believed that intraneural injections increased the risk of damage to the targeted nerve. The ability to visualize anatomy via ultrasound has demonstrated that intraneural injection occurs, but it is rarely associated with nerve injury. Further, it should be noted that most but not all nerve-related injuries are temporary and present as mild mononeuropathies. There are many documented cases of prolonged and even permanent nerve injury from intraneural injury.

In recent years, an ASA Closed Claims study revealed an increased rate of injury in patients undergoing certain interventional pain while under deep sedation or general anesthesia and for similar reasons, an inability of the patient to communicate seems likely to increase risk of intraneural injection and potential complications. Thus, patients must be alert enough during a pain procedure to be able to effectively communicate with the anesthesiologist in the chance for an unanticipated procedural complication or an acute reaction to medications, which includes the potential for life-threatening allergic reactions with loss of airway, cardiovascular collapse, and even death. Best practice strategies should include regional block placement under a level of sedation in which the patient can effectively communicate with the clinician during the procedure [6••, 73–75].

While rare, anesthesiologists administering nerve blocks should be able to recognize the signs of LAST and the appropriate treatment. Patients with LAST can exhibit signs of toxicity within seconds of local anesthetic injection. The presentation of LAST is variable, but patients commonly experience seizures, bradycardia, hypotension, and arrhythmias. In addition to supportive care, lipid emulsion therapy has been shown to be effective in treating severe LAST. Providers should have lipid emulsion therapy readily available when performing nerve blocks for this reason. Cardiopulmonary bypass may be necessary in some cases.

Overall, regional anesthesia remains a safe option for many patients. Peripheral nerve blocks provide many advantages for patients and providers including improved pain control, reduced opioid consumption, and decreased length of stay. The increased availability of ultrasound technology has grown the field of regional anesthesia, and today's practicing anesthesiologist should be comfortable administering the more common nerve blocks. This makes awareness of the potential complications and how to avoid them essential for anesthetists. Any general or regional anesthetic technique must always be tailored to both the individual patient and the operation, considering the potential benefits and risks. The contribution of the individual anesthetist in managing the RA (or GA) technique effectively and safely in order to achieve a good outcome must not be underestimated.

Compliance with Ethical Standards

Conflict of Interest Erik M. Helander, Aaron J. Kaye, Matthew R. Eng, Patrick I. Emelife, Mark W. Motejunas, Lauren A. Bonneval, Justin A. Terracciano, and Elyse M. Cornett declare no conflict of interest. Alan D. Kaye serves on the Speakers Bureau of Depomed and Merck.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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