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Strategie per ridurre il rischio in ALR

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Presentation and management of peripheral nerve injury

Anaesthetists, and their patients, are often unaware of the presence of a peripheral nerve injury in the days and weeks following anaesthesia, since this period is often characterised by the presence of residual anaesthetic agents, postsurgical pain, strong analgesic regimens and a focus on recovery to pre-operative functional levels. Nerve injury may only become apparent days or weeks after anaesthesia/surgery, although many patients are aware of abnormal pain, weakness or sensation immediately following anaesthesia.

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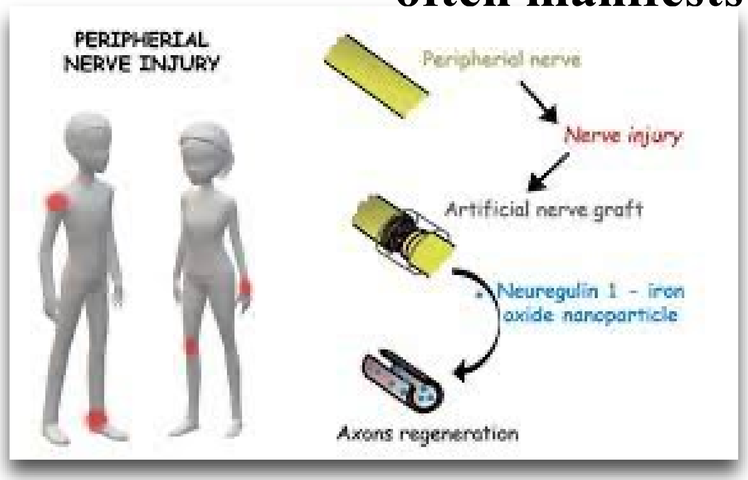
Acute mononeuropathy demands urgent investigation, and patients' concerns regarding motor or sensory abnormalities should be escalated immediately to an experienced anaesthetist, who should synthesise the history and examination findings to determine whether onward referral and investigation is warranted. Patients may present with impaired power or altered sensation (or both). Altered sensation often manifests as paraesthesia, pain or persistent anaesthesia.



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The commonest differential diagnoses to consider in cases where peripheral nerve injury during anaesthesia is suspected are as follows: peripheral neuropathy due to diabetes mellitus; alcohol; hypothyroidism or nutritional deficiency; myelopathy; radiculopathy; spinal cord trauma or infarction; and muscle disease. The prevalence of pre-existing peripheral neuropathy should not be underestimated; this is present in 2–8% of the general population , increasing to 26% of patients with type-2 diabetes mellitus and 58% of patients with established type-1 diabetes mellitus .

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An anaesthetist presented with a suspected perioperative peripheral nerve injury *should document a history of the symptoms, systemic examination and motor and sensory examination of all four limbs and the cranial nerves.*

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If the diagnosis points towards a nerve injury occurring during the peri-operative period, then *it is important to recognise that injury during anaesthesia is not the same as injury caused by anaesthesia (or the anaesthetist)*; the most severe peri-operative nerve injuries are often associated with surgical incision/retraction, rather than anaesthetic technique or patient positioning .

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OTHER PAIN (A KAYE AND N VADIVELU, SECTION EDITORS)

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

Erik M. Helander[1] · Aaron J. Kaye[2,3] · Matthew R. Eng[4] · Patrick I. Emelife[5] · Mark W. Motejunas[5] · Lauren A. Bonneval[3,6] · Justin A. Terracciano[7] · Elyse M. Cornett[8] · Alan D. Kaye[9]

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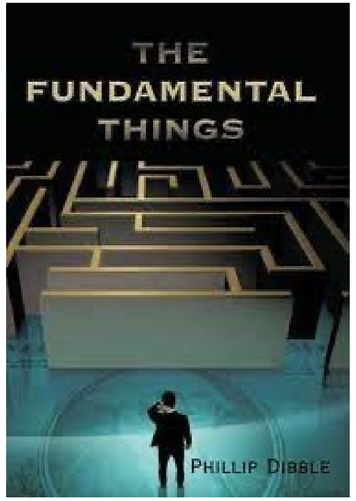
Optimal peripheral nerve blocks should demonstrate sufficient duration of action while minimizing the risk of complications. The utilization of ultrasound technology has contributed to the popularization of regional anesthesia due to its ability to aid clinicians in depositing local anesthetics in precise 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 .The use of ultrasound-guided nerve blocks has demonstrated that intraneural injections do not necessarily result in permanent injury . 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.



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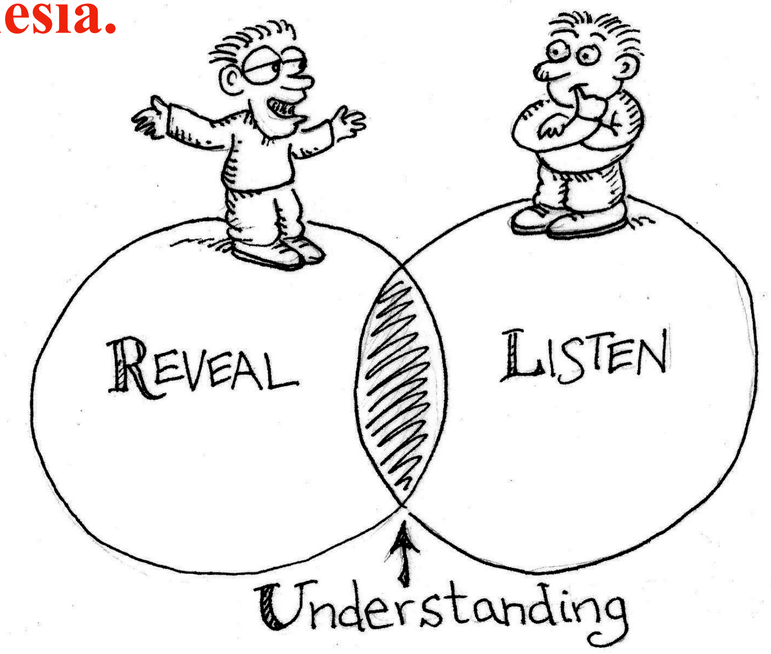
Nonetheless, serious nerve injury is extremely rare, with most injuries being transient—lasting days to weeks—and often subclinical.

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.

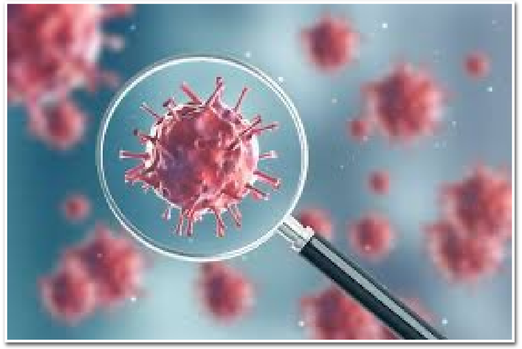


Bleeding

- Prior to block obtain detailed history regarding previous abnormal coagulation events as well as current medications and dietary supplements

- Increased needle size, number of tissue or vascular punctures, and underlying coagulation abnormalities are associated with increased blood loss

- 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



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Infection

- **Overall rare given sterile technique and antimicrobial effects of local anesthetics**
  - Associated with multiple attempts and the use of continuous peripheral nerve catheters
- **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

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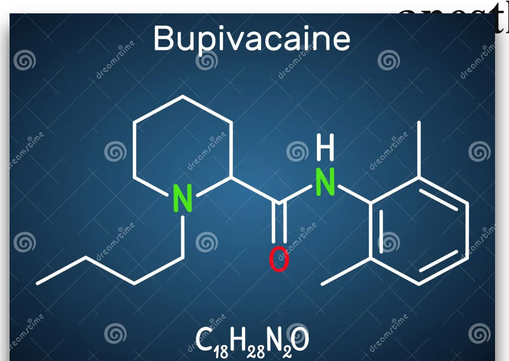
Allergic reaction

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

Drug toxicity

- Toxic dose calculations are effected by patient's body size, age, weight, number of blocks performed, and site of local anesthetic administration

- 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.



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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

- 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

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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

- **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**
- **Contraindications—preexisting neurologic deficit, changing neurologic deficit, or inability to conduct appropriate postop neurologic evaluation**

- 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

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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

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Nerve localisation methods

No nerve localisation technique during needling (i.e. ultrasound guidance, nerve stimulation, elicited paraesthesia) has been demonstrated scientifically to be superior in terms of reducing the risk of nerve injury following peripheral nerve blockade in clinical trials . Peripheral nerve stimulation has a 75% chance to detect needle-to-nerve contact confirmed on ultrasonography , with motor response to currents of 0.2 mA or less reliably indicating intraneural placement of the needle . Paraesthesia elicited by needle advancement has only a 38% chance of detecting needle-to-nerve contact and cannot be relied upon to indicate intraneural placement. Paraesthesia or pain during needling or injection should alert the anaesthetist to cease needle advancement and/or injection and to reposition the needle. A large prospective survey of postoperative nerve injury identified four serious neurological injuries following 21,778 peripheral nerve blocks, but found that in each case, the injury was preceded by either paraesthesia on needling or pain on injection .

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The management of nerve injury following anaesthesia has three aims:

first, to correct the underlying pathology;

second, to alleviate symptoms; and

third, to support, reassure and inform the patient.

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A 2015 review article found that postoperative neurological symptoms suggestive of nerve injury after peripheral nerve blockade occur in 0–2.2% of patients at 3months, 0–0.8% of patients at 6 months and 0–0.2% of patients at 1 year.

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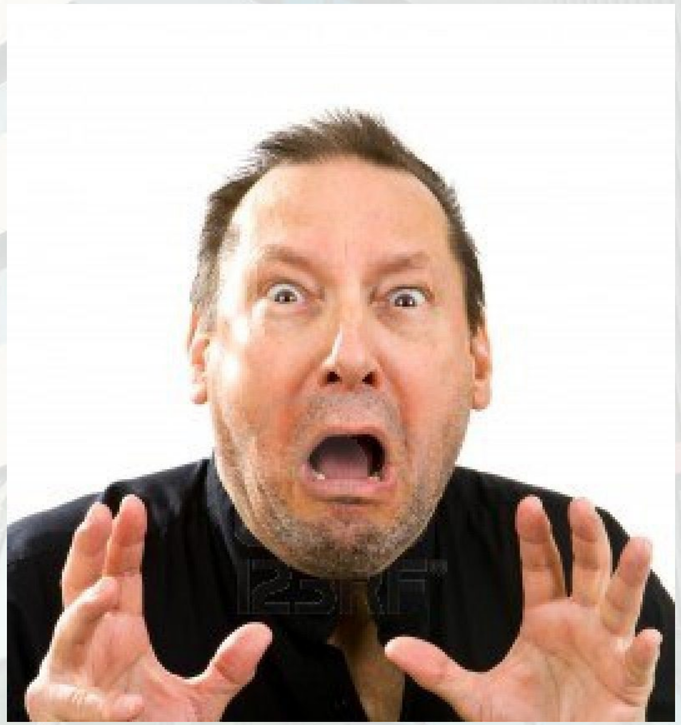
Why peripheral nerve injury ?



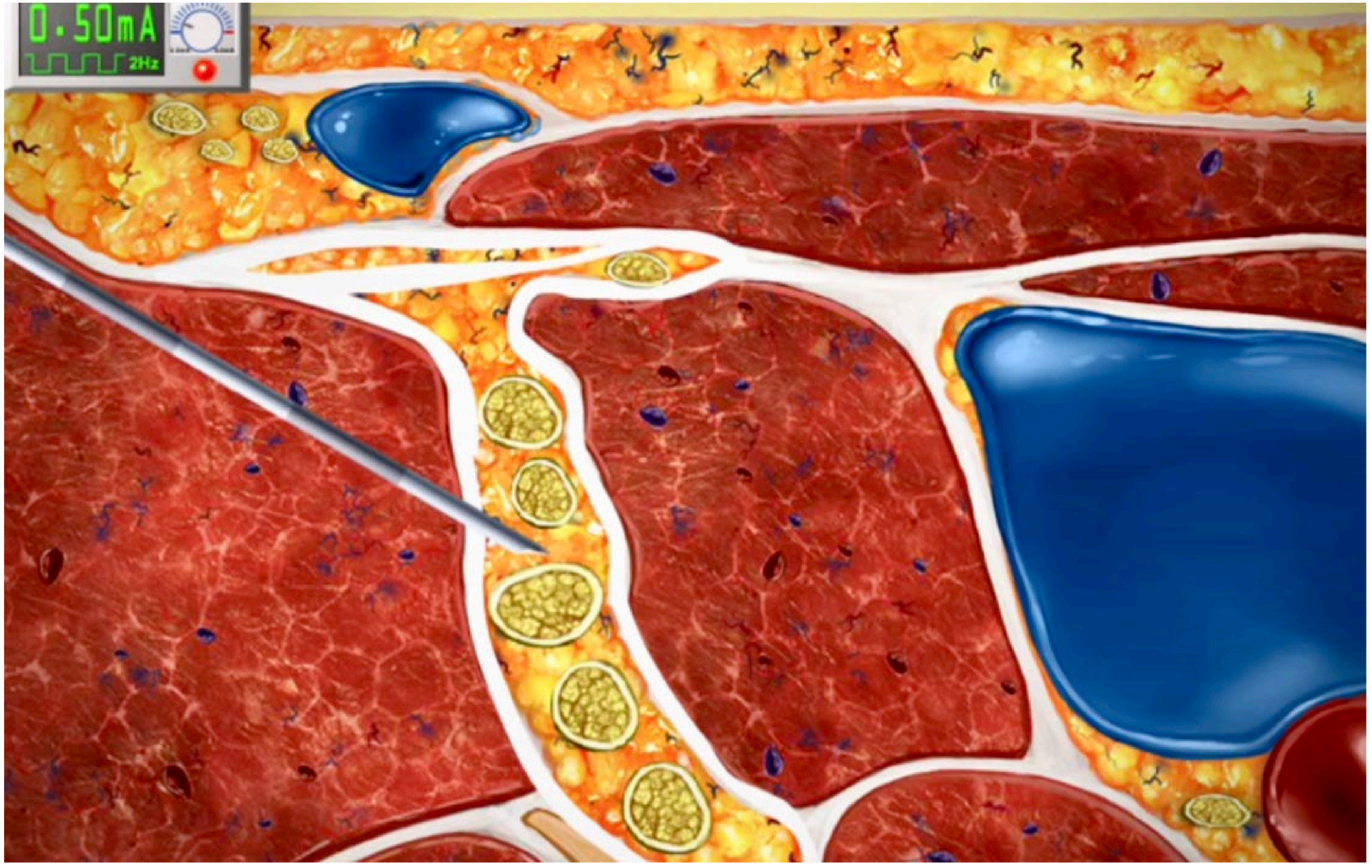
Mechanisms of peripheral nerve injury

1) blunt trauma
2) toxic injury
3) compressive injury
4) stretch injury
5) ischemic injury

TABLE 2. Risk Factors Associated With Perioperative PNI

Patient Characteristics	Perioperative Characteristics
• Preexisting neurologic disease*	• Paresthesia with needle placement
• Diabetes*	• Pain with injection
• Smoker	• Prolonged tourniquet time
• Body mass index extremes	• Positioning—compression or stretch
• Male	• Sedated patient during regional block
• Elderly	• Hypothermia
	• Prolonged hospitalization

*Double crush syndrome.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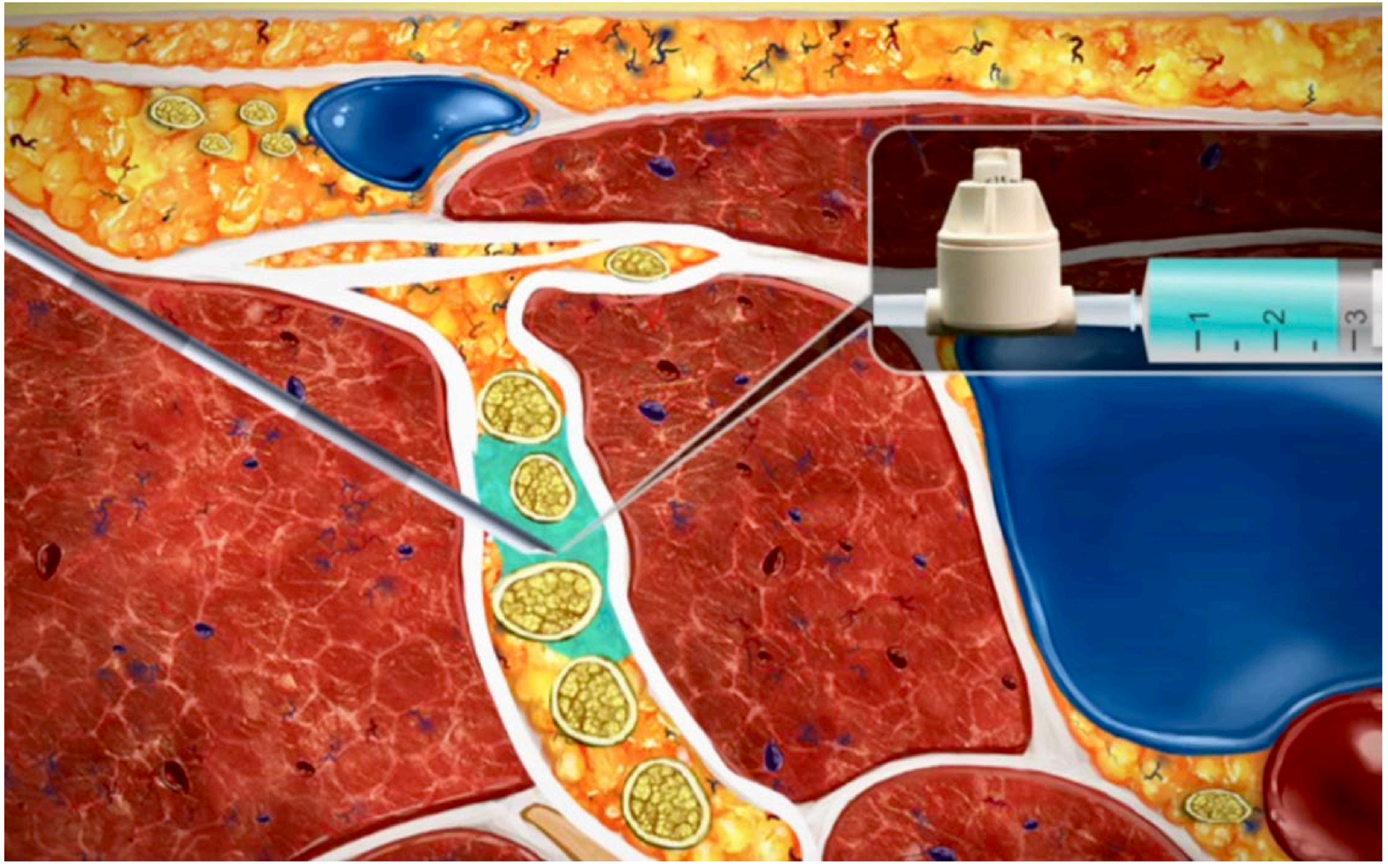
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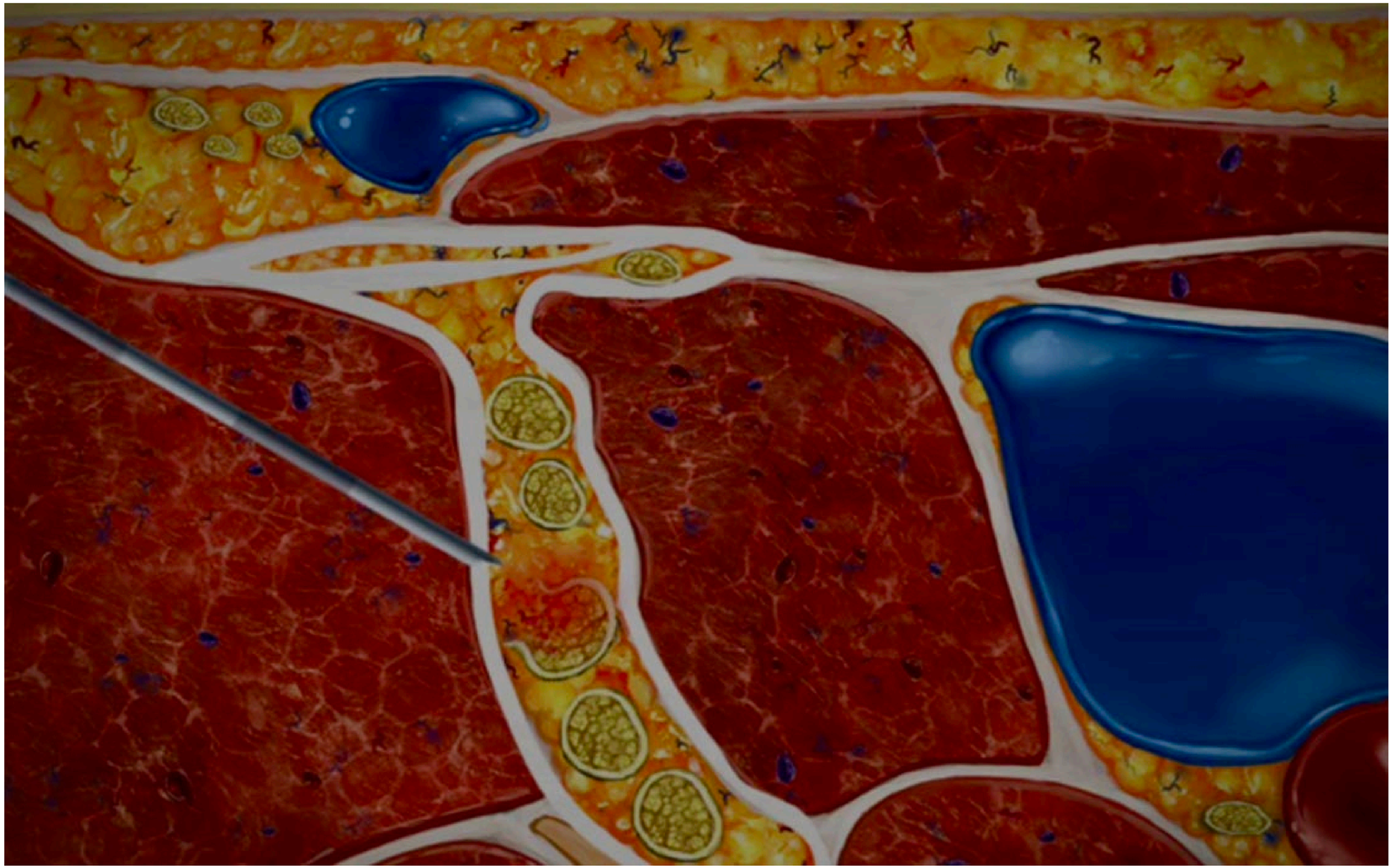

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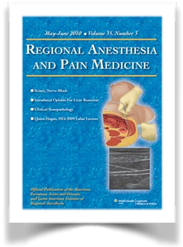
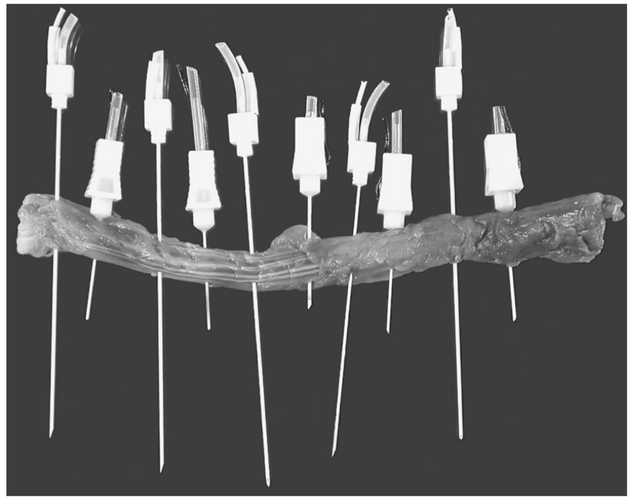
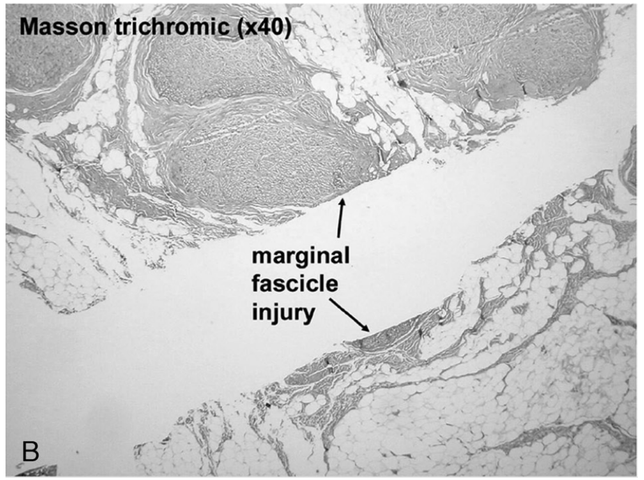


Reg Anesth Pain Med 2009;34: 201Y205

Injury to the Human Sciatic Nerve After Intraneural Needle Insertion

Xavier Sala-Blanch, MD,* Teresa Ribalta, MD, PhD,Þ Eva Rivas, MD,þ Ana Carrera, MD, PhD,§ Albert Gaspa, MD,Þ Miguel A. Reina, MD, PhD,|| and Admir Hadzic, MD, PhD¶





In summary, our experimental data suggest that intraneural needles likely traverse connective tissue rather than fascicular tissue. This is probably due to the differences in consistency between the densely packed, poorly compliant fascicles protected by the perineurium and the surrounding connective tissue within the epineurium. As a result, the advancing needle is more likely to traverse the nerve between the fascicles rather than through the fascicles.

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"…Mechanical injury can result from **forceful needle-nerve contact** from an approaching needle or **injection inside the nerve** itself. "Nerve compression or entrapment may produce a **conduction block** and, if prolonged, a focal **demyelination** of some axons along with an increase in neuropeptide production and dorsal horn activity. Intraneural injection may lead to **sustained high intraneural pressure**, which when exceeding capillary occlusion pressure may lead to **nerve ischemia**. The main source of block-related PNI is **injection of local anesthetic into a FASCICLE** causing direct needle and injection trauma, **rupture of perineurium**, and loss of the **protective environment** within the fascicle with consequent **myelin and axonal degeneration**. Of note, even intrafascicular injection of **saline** can result in axonal degeneration. **Location of the NEEDLE TIP during injection** of the local anesthetic appears to play a crucial role in determining the likelihood and severity of nerve injury…"

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CASE REPORT

Functional Deficits After Intraneural Injection During Interscalene Block

Joshua M. Cohen, MD and Andrew T. Gray, MD, PhD

Objective: We present an occurrence of a severe but transient neurologic complication after intraneural injection during an ultrasound-guided interscalene block.
Case Report: A 36-year-old man underwent ultrasound-guided interscalene nerve blockade before shoulder incision and drainage. On postoperative day 1, he exhibited new-onset arm weakness with dysesthesias. Intraneural injection was recognized based on a retrospective review of the recorded ultrasound imaging. The symptoms persisted for more than 2 weeks and completely resolved by 6 weeks.
Conclusions: Our report suggests that intraneural injection during ultrasound-guided interscalene block carries a risk of neurologic complications.

(*Reg Anesth Pain Med* 2010;35: 397–399)

There are many case reports and even clinical series of intraneural injections visualized with ultrasound imaging. These cases suggest safety for regional block because the follow-up examinations failed to reveal any[1] or minor[2] neurologic symptoms after local anesthetics were injected directly into peripheral nerves. However, here we present a case of functional deficits after interscalene block in which intraneural injection was recognized from the recorded images.

CASE REPORT

The patient was a 36-year-old man scheduled for repeat left shoulder incision and drainage with manipulation for range of motion. He sustained a traumatic shoulder injury before admission and was 5 days status-post an uneventful left shoulder incision and drainage for infection under general anesthesia with a preoperative interscalene nerve block. He was taking no pain medications before his injury, and after the initial incision and drainage, he was taking gabapentin and oxycodone with good analgesia. Before his second procedure, he had normal strength with regard to arm flexion and no history of neuropathy. His medical history was remarkable only for major depressive disorder, treated with citalopram and mirtazapine. The patient gave his written consent for the publication of this report.

A fresh solution consisting of 40 mL 0.375% bupivacaine with 60 μg buprenorphine and 20 mg tetracaine (all preservative-free) was prepared in a 60-mL syringe. A linear ultrasound transducer (L12-5, 50-mm footprint; PHILIPS iU22 platform; Philips, Bothell, Wash) was positioned on the neck at the level of C6, and the brachial plexus was visualized between the anterior and middle scalene muscles (Fig. 1 and Video 1, Supplemental Digital Content 1, http://links.lww.com/AAP/A22). Lidocaine was used to anesthetize the skin, and 30 mL 0.375% bupivacaine with 45 μg buprenorphine and 15 mg tetracaine was slowly injected with intermittent aspiration through a 21-gauge 50 mm echogenic needle (Echotip percutaneous entry needle; bevel angle, 30 degrees; Cook Incorporated, Bloomington, Ind) connected via 60-in microbore intravenous extension tubing (Arrow International, Inc, Reading, Pa) with an in-plane short-axis approach. The block was performed using a multiple-injection technique, with the needle bevel oriented toward the transducer to improve needle-tip visibility. The needle was subsequently removed, and the interscalene groove scanned to ensure adequate deposition of local anesthetic around the superior and middle trunks of the brachial plexus. The transducer and needle were held by an anesthesia resident, while the injection was performed with one hand by an experienced attending. The block was uneventful; no additional sedatives or analgesics were administered, and no paresthesias were reported. Within 5 minutes, the patient described clinical signs suggestive of a successful block, including numbness over his shoulder and weakness with arm abduction.

He underwent surgery for 46 minutes in beach-chair position with intravenous midazolam (total, 2 mg) and fentanyl (total, 100 μg), with range of motion during manipulation noted as 20-degree external rotation at 90 degrees of abduction. Immediately after surgery, he had no pain in the recovery room. However, the following morning, he complained of left arm weakness and numbness below his elbow, with considerable shoulder pain. He described the presence of dysesthesias in the distal forearm. On examination, he had no sensory deficits, but muscle testing revealed 0/5 elbow flexion and supination strength. Whereas sensation to cold temperature was not altered, he exhibited decreased sensation to light touch in the fifth and sixth left cervical nerve distributions. At this point, we reviewed the stored ultrasound images recorded during the interscalene block and noticed that injection had been made intraneurally (Fig. 1 and Video 1, Supplemental Digital Content 1, http://links.lww.com/AAP/A22).

This patient had a prolonged hospital course consisting of further left shoulder irrigation and drainages in the operating room under general anesthesia. By the time of his discharge 2 weeks postoperatively, arm flexion and supination strength were 3/5, and the dysesthesias had nearly resolved. By 6 weeks postoperatively, arm flexion and supination strength were 5/5, and no dysesthesias were reported. Because the patient's symptoms improved during this period, no formal neurology consultation or electromyographic recordings were performed.

DISCUSSION

Our patient had no residual neurologic deficits by 6 weeks postoperatively. Regardless, this case illustrates a significant functional impairment lasting more than 2 weeks after a documented

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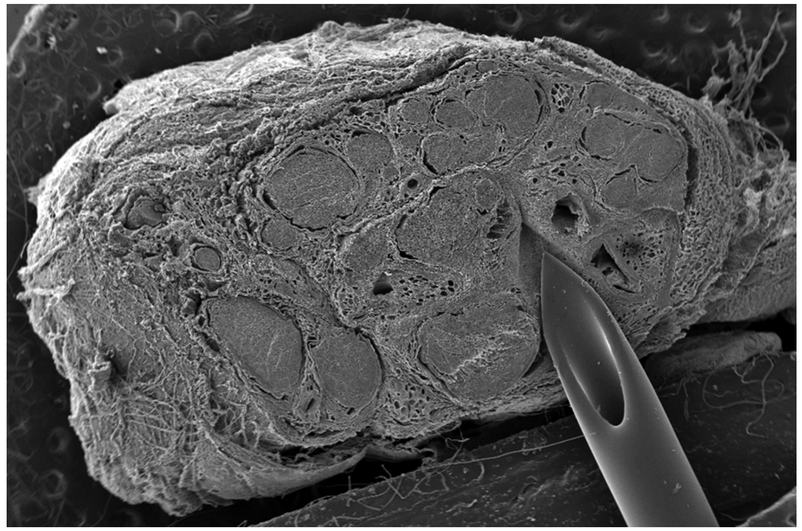
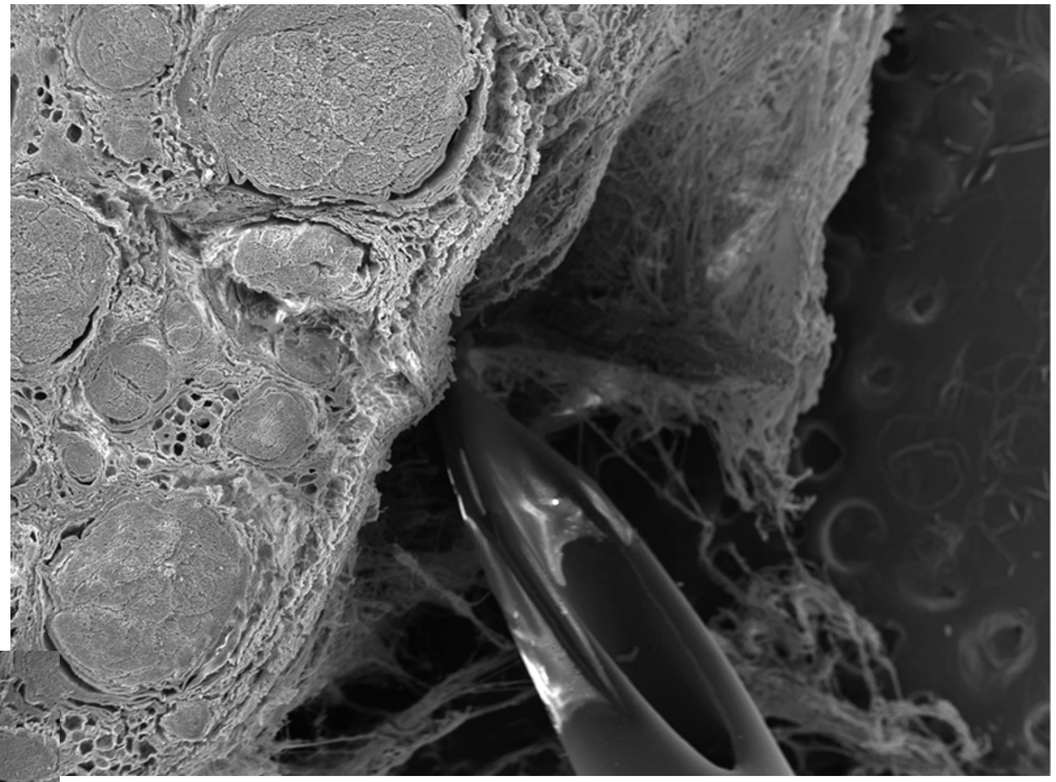
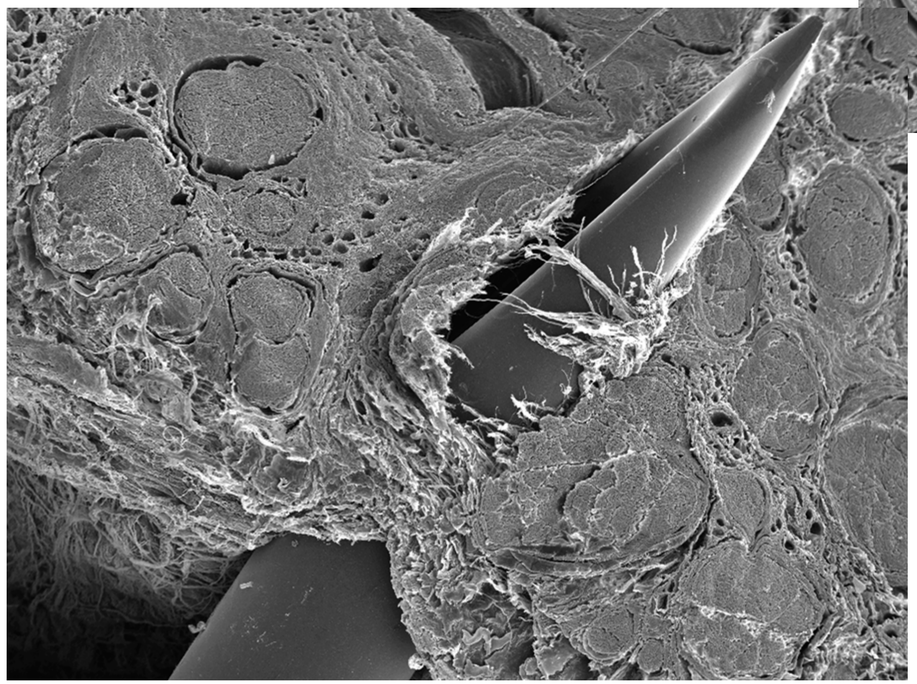
Direct trauma to nerve fascicles during needling accounts for a proportion of nerve injuries following peripheral nerve blockade. In an animal model, needles with 45° (‘short’) bevel angles produce less frequent fascicular damage than needles with 14° (‘long’) bevels . This may be because the nerve fascicle rolls away from a short-bevel needle, rather than being impaled by a long-bevel (sharp) point, and because a short bevel elicits paraesthesia, signifying impending nerve damage, sooner than a cutting, long-bevel needle.







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Mechanisms of peripheral nerve injury

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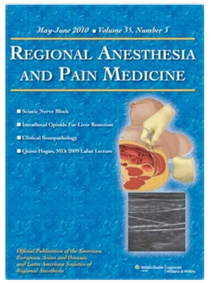

Local Anesthetic Schwann Cell Toxicity Is Time and Concentration Dependent

Sufang Yang, MD, Matthew S. Abrahams, MD,* Patricia D. Hurn, PhD,* Marjorie R. Grafe, MD, PhD,*† and Jeffrey R. Kirsch, MD**

Background: Peripheral nerve blocks with local anesthetics (LAs) are commonly performed to provide surgical anesthesia or postoperative analgesia. Nerve injury resulting in persistent numbness or weakness is a potentially serious complication. Local anesthetics have previously been shown to damage neuronal and Schwann cells via several mechanisms. We sought to test the hypothesis that LAs are toxic to Schwann cells and that the degree of toxicity is directly related to the concentration of LA and duration of exposure. Intraneural injection of LAs has been shown to produce nerve injury. We sought to test the hypothesis that a prolonged extraneural infusion of LA can also produce injury.

Methods: Schwann cells cultured from neonatal rat sciatic nerves were incubated with LAs at different concentrations (10, 100, 500, and 1000 μM), and each concentration was assessed for toxicity after 4, 24, 48 and 72 hours of exposure. Local anesthetics tested were lidocaine, mepivacaine, chloroprocaine, ropivacaine, and bupivacaine. Cell death was assessed by lactate dehydrogenase release measured by optical density.

In a separate experiment, a microcatheter was placed along the sciatic nerves of Sprague-Dawley rats. Rats were randomly assigned to receive either 0.9% saline (n = 8) or bupivacaine (0.5%, n = 4; 0.75%, n = 4) via the perineural catheters for 72 hours. The rats were then killed, and their nerves sectioned and stained for analysis. Sections were stained for myelin and with an antimacrophage (CD68) antibody.

Results: None of the LAs tested produced significant Schwann cell death at very low concentrations (10 μM, or 0.0003%) even after prolonged exposure. With prolonged exposure (48 or 72 hrs) to high concentrations (1000 μM, or 0.03%), all of the LAs tested produced significant Schwann cell death (increased lactate dehydrogenase release relative to control as measured by optical density, 0.384-0.974; all P values < 0.001). Only bupivacaine produced significant cell death (0.482, $P < 0.001$) after prolonged exposure to low concentrations (100 μM, or 0.003%). At intermediate concentrations (500 μM, or 0.015%), cell death was more widespread with bupivacaine (0.768, $P < 0.001$) and ropivacaine (0.675, $P < 0.001$) than the other agents (0.204–0.368; all P values < 0.001). Prolonged extraneural exposure of rat sciatic nerves to bupivacaine caused significant demyelination and infiltration of nerves with inflammatory cells.

Conclusions: Local anesthetics induce Schwann cell death in a time- and concentration-dependent manner. Bupivacaine and ropivacaine have greater toxicity at intermediate concentrations, and prolonged exposure to bupivacaine produces significant toxicity even at low concentrations. Brief exposure to high concentrations of bupivacaine damages Schwann cells. Prolonged extraneural infusion of bupivacaine results in nerve injury.

(*Reg Anesth Pain Med* 2011;36: 444–451)

Anesthesiologists commonly use local anesthetics (LAs) to perform peripheral nerve blocks (PNBs) for surgical anesthesia or to provide analgesia for surgical procedures or other painful conditions. Peripheral nerve blocks have been shown to allow superior early recovery compared with general anesthesia (decreased pain, nausea, vomiting, time to discharge home, rate of unplanned admission),[1–4] provide better pain control than systemic opioid analgesics,[5] and facilitate aggressive rehabilitation, improving long-term functional outcomes.[6–9] However, PNBs may result in nerve damage.[10–13] The effects are usually minor and resolve spontaneously in a few days or weeks. Unfortunately, these injuries are occasionally severe and may be permanent and debilitating.[14,15] Such injuries may be multifactorial, although LA cytotoxicity is likely a major contributing factor.[16] An improved understanding of the effects of LAs on nerve cells may lead to strategies to decrease the risk of nerve injury following PNBs.

In previous studies, injection of LAs within the sciatic nerve sheath has been found to cause demyelination, Schwann cell death, and infiltration of inflammatory cells.[17–20] More recent in vitro studies have demonstrated that clinically used LAs act to uncouple oxidative phosphorylation in mitochondria isolated from rat liver cells.[21] Microarray analysis showed that bupivacaine exposure increased expression of cDNA for heat shock protein 70, c-jun, and c-fos genes and decreased expression of c-myc and poly-ADP ribose polymerase in a promyelocytic leukemia cell line.[22] Lidocaine, bupivacaine, and ropivacaine have been shown to induce apoptosis in neuronal cells in vitro through the activation of enzymes p38 MAPK, ERK, and JNK.[23,24] Local anesthetics (including procaine, mepivacaine, lidocaine, chloroprocaine, ropivacaine, and bupivacaine) have also been shown to cause necrosis of neuroblastoma cells in vitro, as well as apoptosis via activation of caspase.[25] Previous in vitro studies showed that bupivacaine induced apoptosis in Schwann cells through the generation of reactive oxygen species.[26] Unlike this study, however, we used primary rat Schwann cells in our experiments.

The overall goal of the current study was to test the hypothesis that LAs cause injury to Schwann cells. Schwann cells are an important component of the peripheral nervous system. They ensheath the axon and play an important part in axonal growth and regeneration, myelination, and normal electrophysiologic conductivity. Therefore, damage to Schwann cells is likely to have a direct effect on the conductivity of the axon and may cause pathologic changes in neurons or delay the recovery of nerve conduction beyond the pharmacologic duration of action of the LA.[27–29]

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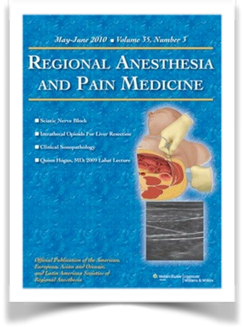

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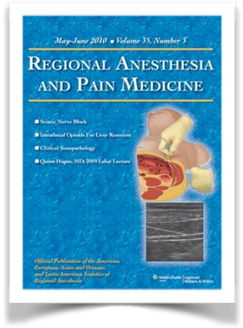
Pathophysiology of Peripheral Nerve Injury During Regional Anesthesia
Quinn H. Hogan, M.D.

After application of local anesthetics outside the perineurium the normally hypertonic endoneural fluid that permeates between the neuronal fibers within the fascicle becomes hypotonic, with the accumulation of edema. High concentrations of extrafascicular anesthetics produce axonal injury independent of edema formation and elevated endoneurial fluid pressure.



Reg Anesth Pain Med 2008;33:435-441.
Pathophysiology of Peripheral Nerve Injury During Regional Anesthesia
Quinn H. Hogan, M.D.

Injection of local anesthetic within a nerve fascicle is clearly neurotoxic.

Together, these various observations lead to the conclusion that the surrounding perineurium plays an important role in protecting the fascicular contents from the cytotoxic effects of local anesthetics.

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High injection pressure (> 170 kPa/25 psi) in animal models indicates, with some reliability, intrafascicular needle-tip placement, whereas low injection pressures indicates extrafascicular needle-tip placement. A similar relationship between injection pressure and needle-to-nerve contact has been described in humans , although the significance of needle-to-nerve contact, as opposed to fascicular penetration, is unclear.

It is pragmatic and reasonable, therefore, to use large volume syringes (i.e. preferably 20 ml or more) for peripheral nerve blockade since these make the requirement for greater force of injection more obvious.

Table 1 Summary of the commonly used local anaesthetic adjuvants

Name of drug	Routes and dosages	Adverse effects	Recommendations for use	Mechanism of action
Morphine[12,22]	Intrathecal: 100-200 μg	Pruritus	Useful in neuraxial blocks	
	Epidural: 1-5 mg	Nausea vomiting	Not recommended for peripheral nerve blocks	
	Peripheral nerve block: 75-100 μg/kg	Respiratory failure		
Fentanyl[23-26,30-35]	Intrathecal: 10-25 μg	Same adverse effects as morphine	Useful in neuraxial blocks	
	Epidural: 2-4 μg/mL	Adverse effect profile slightly favourable in neuraxial use	Not recommended in neuraxial blocks due to inconsistent results	
	Peripheral nerve block	Increased sedation, bradycardia and hypotension		Spinal opioid receptor
Sufentanyl[36-40]	Intrathecal: 1.5-5 μg		Efficacious in neuraxial blocks	Local action in peripheral nerve blocks
	Epidural: 0.75-1.0 μg/mL Not used in peripheral nerve blocks			
Ketamine[203-223]		Neuraxial use associated with nausea, vomiting and hallucinations	Neuraxial use-shortens onset and duration of anesthesia	NMDA receptor antagonists shown to have local anesthetic properties
		PNB use associated with psychomimetic sequelae	Not recommended for PNB use	Cholinergic, adrenergic and 5HT mechanisms
Magnesium[224-238]	Intrathecal: 25-100 mg	Headache	Prolongs analgesia and quality of block by all perineural routes	NMDA receptor antagonism
	Epidural: 50-100 mg	Cardiovascular disturbances	However more studies required to determine minimal effective doses	Voltage gated calcium channel blockade
		Nausea vomiting	Not recommended for routine use	

Clonidine[89-121]	Intrathecal: 15-40 µg Epidural: 25-50 µg Peripheral nerve block: 0.5-5 µg/kg (150 µg is the maximum allowed dose in PNB)	Sedation Bradycardia Hypertension Adverse effects show association with dose	Good quality evidence to support use in neuraxial blocks especially at lower dosages In PNB prolongs block with Bupivacaine but poor efficacy with Ropivacaine and levobupivacaine Additional benefit in Alcohol withdrawal	Activation of post junctional alpha-2 receptors in dorsal horn of spinal cord
Dexmeditomidine[122-147]	Intrathecal: 5-10 µg Epidural: 1 µg/kg Peripheral nerve block: 20-150 µg	Sedation Bradycardia Hypertension Adverse effects show association with dose	Prolongation of neuraxial and peripheral nerve blocks with good efficacy of use	Mechanism similar to Clonidine
Dexamethasone[148-161]	Intrathecal: 8 mg Epidural: 4-8 mg Peripheral nerve block: 1-8 mg	Adverse effects minimal Advantageous to prevent ponv Troublesome paresthesias with PNB use	Efficacious in neuraxial blocks, however better studies required Prolongs nerve blockade in PNB	Local action on nerve fibers
Midazolam[164-184]	Intrathecal: 1-2.5 mg Epidural: 50 µg/kg diluted in 10 mL of saline	Sedation Respiratory depression	Neurotoxicity is a major concern in neuraxial and peripheral nerve routes Not recommended for routine neuraxial and PNB use	GABAergic and opioid receptor mechanisms
Neostigmine[185-202]	Intrathecal: 5-10 µg to 50-150 µg	Neuraxial use associated with bradycardia, restlessness	Lower dosages recommended for neuraxial use	Enhancement of endogenous acetylcholine at nerve terminal

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Buprenorphine, clonidine, dexamethasone, magnesium, and dexmedetomidine are promising agents for use in prolongation of local anesthetic peripheral nerve blocks, and further studies of safety and efficacy are merited. However, caution is recommended with use of any perineural adjuvant, as none have Food and Drug Administration approval, and concerns for side effects and potential toxicity persist.


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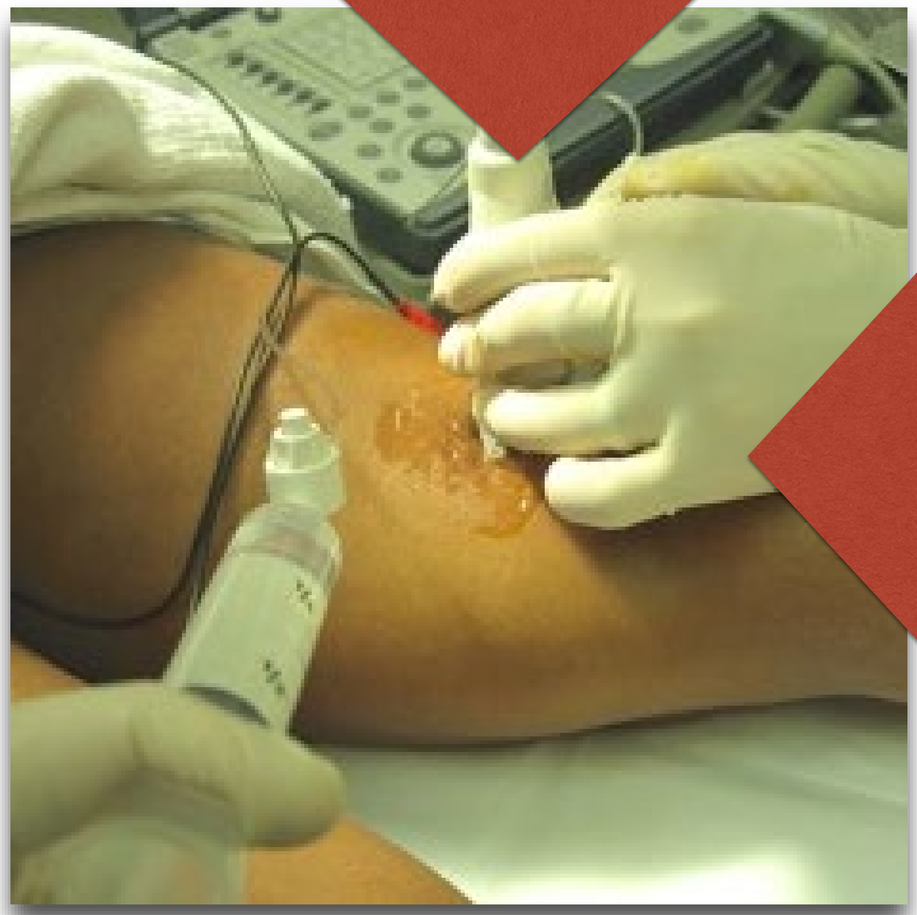

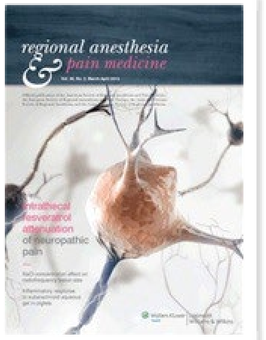

A Checklist for Performing Regional Nerve Blocks

Michael F. Mulroy, MD, Robert S. Weller, MD,† and Gregory A. Liguori, MD‡*

Abstract: Regional blocks are frequently invasive procedures that create the risk of infection, local anesthetic toxicity, and wrong-site performance. National guidelines have been developed by the Joint Commission and the American Society of Regional Anesthesia and Pain Medicine (ASRA) to reduce the potential for each of these risks. Checklists have been shown to reduce errors and complications in medicine: it seems prudent to incorporate the recommended safety steps into a formalized checklist to be reviewed before performance of a regional block. A task force appointed by the ASRA President reviewed available resources and recommendations and performed a survey of RAPM members at the ASRA annual meeting in May 2013 and proposed a 9-point checklist to fulfill this role. Although it is apparent that local modification will be needed, the basic points and principles should be adopted for the performance of regional blocks.

(*Reg Anesth Pain Med* 2014;39: 195–199)

Accidents and errors are inevitable in complex, tightly interconnected systems such as air travel and medical care.[1] The 1999 Institute of Medicine report *To Err is Human*[2] highlighted an alarming incidence of medical errors leading to morbidity and mortality in the US medical system and called for strategies for change. Major sources of error in surgery are wrong-site and wrong-patient procedures, which drew the attention of the Joint Commission as early as 1998. In 2003, the Joint Commission proposed a Universal Protocol that surgical teams could use before any elective surgical intervention to reduce the risk of wrong-site procedures.[3] The revised Universal Protocol, published in 2010, must be performed before any elective invasive procedure, but its application to regional block was not specifically described. Regional blocks also have the potential for wrong-site performance,[4–6] with wrong-side blockade accounting for an increasing percentage of reported wrong-side procedures in recent years (http://patient safetyauthority.org/ADVISORIES/AdvisoryLibrary/2010/Mar7(1)/pages/26.aspx).

Regional block procedures may also be complicated by infection,[7] life-threatening immediate adverse events (local anesthetic systemic toxicity [LAST][8]), respiratory depression from overzealous sedation, and, in the anticoagulated patient, hematoma formation causing paraplegia after neuraxial blocks. The potential for these complications has led several national organizations to develop guidelines and recommendations for safety steps in the performance of regional blocks, including the American Society of Regional Anesthesia and Pain Medicine (ASRA) Guidelines to reduce the risk of infection[7] and sequelae of LAST,[8] the American Society of Anesthesiologists (ASA) Guidelines on appropriate monitoring for sedation,[9] and a recent US Food and Drug Administration (FDA) advisory on determining anticoagulation status before performing a block.[10]

The regional anesthesiologist, then, has a number of safety steps and guidelines to consider before a block, in addition to the Universal Protocol mandated by the Joint Commission for any invasive procedure. Recalling and ensuring compliance with these protocols is challenging for physicians in general, but potentially more so in the setting of "production pressure" to have blocks performed so as not to delay surgery. One tool that has proven indispensable in reducing variability and error in other complex, interconnected systems is a checklist.[11] It has been suggested that adherence to multiple guidelines and advisories can be enhanced by incorporating multiple guidelines into a single checklist.[12] In medicine, the application of checklists has already been demonstrated to reduce the frequency of central line infections,[13] wrong-site surgery,[14,15] and surgical mortality and morbidity.[16] In surgery, the World Health Organization preoperative Surgical Safety Checklist[17] has been proven to reduce surgical complications, but, like the Universal Protocol, it does not address regional anesthesia.

It seems appropriate to attempt to consolidate the recommended safety protocols with the Universal Protocol into a single preblock safety checklist incorporating a "time-out," typically defined as a standardized procedure for final assessment. In March 2013, ASRA President Joseph M. Neal appointed a task force of 3 senior ASRA members experienced in preblock checklist creation and use, asking them to propose a preblock checklist template incorporating existing guidelines in addition to the time-out element and to seek feedback from experts in the area and from the general membership, starting at the ASRA 2013 Spring Meeting.

METHODS

The group pooled experience from their own and other institutions and reviewed published statements and guidelines. The requirements of the Universal Protocol published by the Joint Commission[3] formed the basis of the proposal, incorporating the 3 core principles of the Universal Protocol, namely, preprocedure verification, site marking, and a time out. Similar recommendations from the Safe Anaesthesia Liaison Group of the Association of Anaesthetists of Great Britain and Ireland were also reviewed.[18] Recommendations from the ASRA practice advisory on infectious complications were included (proceduralist uses hand washing, sterile gloves, mask, and removal of jewelry),[19] as well as ASRA recommendations for managing the potential for LAST (appropriate monitoring, ready availability of resuscitation medications including lipid emulsion).[8] The FDA recommendation for preblock review of anticoagulation status was included, as well as basic ASA monitoring and the Joint Commission requirements for drug labeling.

Starting from these basic elements and with checklists already in place at 3 institutions, a Delphic process was used to

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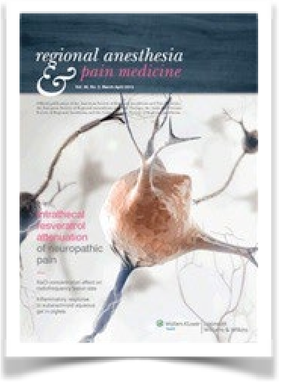
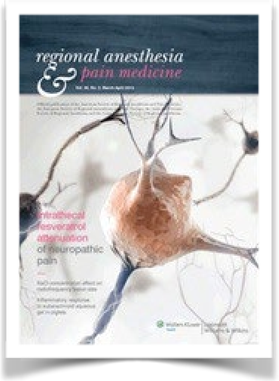


TABLE 2. Final Form of the Proposed Checklist, With Changes in Numerical Sequence and Wording Based on Expert Feedback Enumerated in Table 1

Regional Block Preprocedural Checklist
1) Patient is identified, 2 criteria
2) Allergies and anticoagulation status are reviewed.
3) Surgical procedure/consent is confirmed.
4) Block plan is confirmed, site is marked.
5) Necessary equipment is present, drugs/solutions are labeled.
6) Resuscitation equipment is immediately available: airway devices, suction, vasoactive drugs, lipid emulsion.
7) Appropriate ASRA monitors are applied; intravenous access, sedation, and supplemental oxygen are provided, if indicated.
8) Aseptic technique is used: hand cleansing is performed, mask and sterile gloves are used.
9) "Time out" is performed before needle insertion for each new block site if the position is changed or separated in time or performed by another team.



Ultrasound Guidance and Peripheral Nerve Injury Is Our Vision as Sharp as We Think It Is?

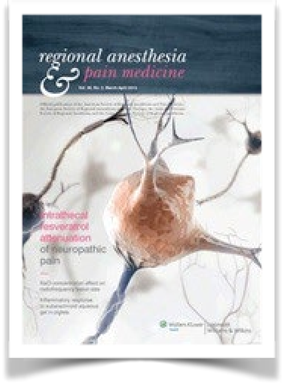
Joseph M. Neal, MD* and Denise J. Wedel, MDÞ

Regional Anesthesia and Pain Medicine & Volume 35, Number 4, July-August 2010

To prove that UGRA could reduce this incidence by 50% (as compared with PNS) would require approximately 3000 patients per group.[4] Although this study may be possible in a busy center, the results might not be as helpful as we would wish for because most of early postoperative nerve symptoms are transient. Indeed, a reasonable estimate is that only 4 of 10,000 patients undergoing peripheral nerve block will have a needle placement-related deficit 12 months afterward.[5,6] Using this number, we calculate that more than 70,000 patients per group would be required to prove a 50% reduction (> = 0.05, A = 0.8). Such a study is unlikely to be undertaken in the resource-limited world of anesthesiology research. In addition, because the frequency of nerve injury varies by block,[3] a well-designed study would be exponentially more difficult if limited to a single block with idealized standardization of local anesthetic concentration and volume, adjuvant, needle type, and so on.

DECALOGO PER NON PROVOCARE LESIONI NERVOSE.

- INTERROMPERE L'INIEZIONE ALLA PRESENZA DI DOLORE
- INIETTARE LENTAMENTE E ASPIRARE SEMPRE
- EVITARE LA FORZA, NON >20 PSI
- NON INIETTARE A<0,20 MA
- CONOSCERE LO STIMOLATORE
- LIMITARE VOLUME, CONCENTRAZIONE E DOSE TOTALE DEGLI ANESTETICI LOCALI
- USARE AGHI APPROPRIATI E CATETERI
- NO BLOCCHI IN PZ.ANESTETIZZATI
- SELEZIONARE I PZ.
- NO IN PZ.CHE NON VOGLIONO E SE IL CHIRURGO NON È CONCORDE.



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The importance of the thought-provoking case reports discussed here is not that they "proved" injury can happen despite the use of ultrasound guidance, but that they remind us that safe and effective practice of regional anesthesia does not reside (and never has resided) in the use of a single piece of equipment. Safety is a mix of proper training, reliable monitors, good judgment, and plain old common sense. We should not expect ultrasound to solve all of our problems, nor should we extrapolate its benefits as justification for pushing the limits of patient safety.

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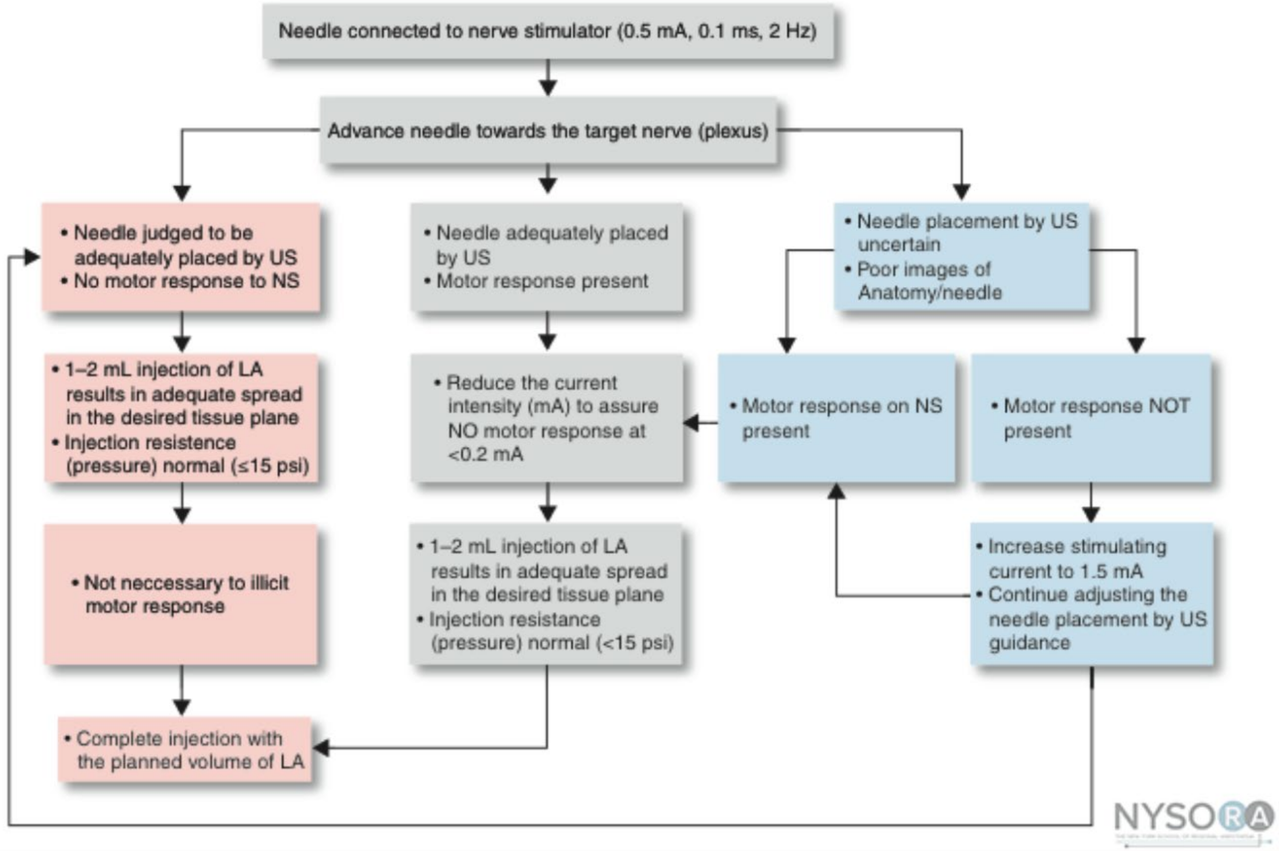
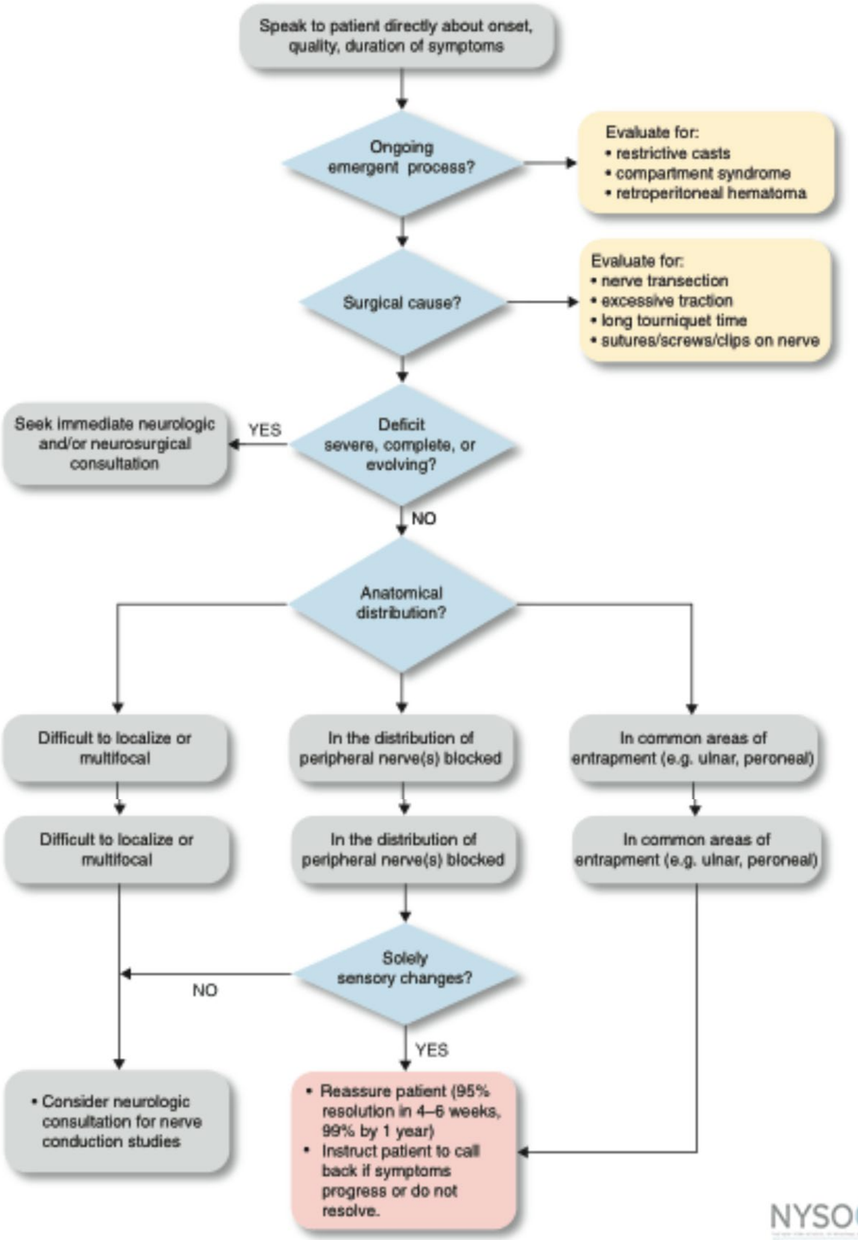
MONITORING DURING NERVE BLOCKS: COMBINING ULTRASOUND (US), NERVE STIMULATION (NS) AND INJECTION PRESSURE MONITORING



Practical Management of Postoperative Neuropathy

PRACTICAL APPROACH TO MANAGEMENT OF A PATIENT WITH NEUROLOGIC DEFICIT AFTER PERIPHERAL NERVE BLOCK



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LAST

Local Anaesthetic Systemic Toxicity

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Hospital fined £100,000 after wrong drug killed new mother

Mayra Cabrera died after giving birth in Swindon when she was accidentally dosed with bupivacaine, a potent anaesthetic

Mayra Cabrera with her newborn son Zac. She died soon afterwards when she was wrongly given a potent anaesthetic. Photograph: Cabrera family/Press Association

Steven Morris
@stevenmorris20
Mon 17 May 2010 18.41 BST

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The highly publicized case in 2004 of Mayra Cabrera, a theatre nurse who died shortly after delivery of her baby boy when her epidural infusion of bupivacaine was mistakenly connected to her i.v. line, reminds us to be vigilant and to learn from such rare events.

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Hospital admits guilt over labour death of Mayra Cabrera

Simon de Bruxelles

Friday March 05 2010, 3.54pm, The Times

A hospital trust has admitted breaches of health and safety over the death of a mother who lost her life when she was mistakenly given epidural anaesthetic instead of saline solution.

Mayra Cabrera, 30, died of a heart attack one hour after giving birth to Zachary, a healthy 8lb baby, in May 2004 at the Great Western Hospital in Swindon, where she worked as a theatre nurse.

While prevention is clearly the most important element in avoiding morbidity and mortality associated with local anaesthetic systemic toxicity (LAST), such cases still occur despite best practice. Knowing how to manage these uncommon events is vital.

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Incidence

LAST has been recognized for more than a hundred years, but the precise incidence is currently unknown. In 1928, the American Medical Association reported 40 deaths attributable to LAs.1 Cocaine was responsible for half of these deaths, but procaine was also implicated. These findings prompted the search for less toxic agents. Lidocaine, first synthesized in 1944, was the first amide LA to be used clinically. However, in1979, the potentially fatal toxicity of amide LAs was highlighted by Albright.2 More recently, studies from 1993 to 1997 reported a rate of LAST for epidural anaesthesia of 1.2–11 per 10 000 anaesthetics.3 The rate of LAST for peripheral nerve block was reported as 7.5 per 10 000 in 1997, 2.5 per 10 000 in 2004,4 9.8 per 10 000 in 2009,5 and when using ultrasound 8.7 per 10 000 in 2013.6

The National Audit Project 3 (NAP3), by the Royal College of Anaesthetists, investigated the major complications of central neuraxial block (http://www.rcoa.ac.uk/system/files/CSQ-NAP3-Full_1.pdf). Eleven cases of wrong-route administration in the UK over a 1 yr period were identified, six involving i.v. bupivacaine injection.

IMMEDIATELY

Give an initial intravenous bolus injection of 20% lipid emulsion

1.5 ml.kg^{-1} over 1 min

AND

Start an intravenous infusion of 20% lipid emulsion at **15 ml.kg^{-1}.h^{-1}**

AFTER 5 MIN

Give **a maximum of two** repeat boluses (same dose) if:

- cardiovascular stability has not been restored **or**
- an adequate circulation deteriorates

Leave **5 min** between boluses

A maximum of **three** boluses can be given (including the initial bolus)

AND

Continue infusion at same rate, but:

Double the rate to **30 ml.kg^{-1}.h^{-1}** at any time after 5 min, if:

- cardiovascular stability has not been restored or
- an adequate circulation deteriorates

Continue infusion until stable and adequate circulation restored or maximum dose of lipid emulsion given

Do not exceed a maximum cumulative dose of 12 ml.kg^{-1}

NRFit™

[redacted]

New Connectors for more Patient Safety

What is NRFit?

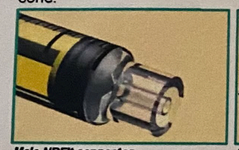
- NRFit is a new type of medical connector in the field of regional anesthesia and is defined by ISO 80369-6.
- Until 2019 NRFit will supersede all Luer connections and Luer hubs of cannulas, catheter connections, filters, patient routes and syringes in regional anesthesia.

NRFit Scope

- Regional anesthesia procedures:
  - Spinal anesthesia
  - Epidural anesthesia
  - Plexus blocks
  - Peripheral single nerve blocks
  - Fascia blocks (e.g. TAP block)
- Continuous wound infusion
- Spinal and cerebral CSF removal

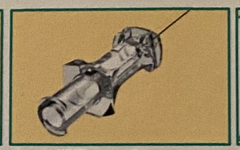
How do you recognize NRFit?

- NRFit connectors are 20% smaller than Luer connectors. The NRFit slip connector is equipped with an additional outer cone.

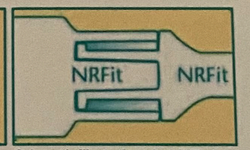


Male NRFit connector, slip version

Male NRFit connector, lock version

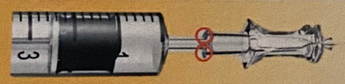


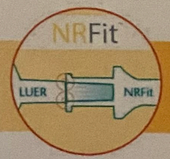
Female NRFit connector



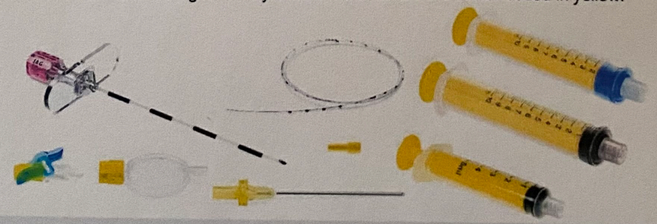
Schematic illustration of a NRFit slip connection

- NRFit connectors can not be connected to Luer connectors.





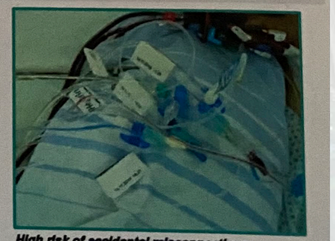
- For a better distinguishability all NRFit connectors are colour-coded in yellow.



Regional anesthesia catheter with catheter adapter, filter and patient line with NRFit connectors.

Why change to NRFit?

- Accidental misconnections of patient lines present a patient risk, which can lead to a fatal outcome in the worst case.
- Reported incidents are often multicausal and arise by a chaining of different, risk-promoting circumstances. (e.g., poor visibility, multiple lines on one patient, high working load).
- The introduction of various types of non-interchangeable connectors for various medical applications is intended to prevent this risk.
- NRFit was initiated by national health authorities, which called for an interdisciplinary solution to the problem.



High risk of accidental misconnections: Several unlabeled tubes on the patient
Source: Aktionsbündnis Patientensicherheit

[redacted]

For further information on NRFit and assistance in conversion planning, please contact PAJUNK®.

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Further aid in the conversion planning can be found in a specific guidance paper of the ISO / Association for the Advancement of Medical Instrumentation

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Conclusions/Summary

Complications from regional anesthesia remain relatively rare. 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 , 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.

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

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.

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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.

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"Regional anesthesia is an art. Remembering that even experts may fail, we should try often and again, observing scrupulously its principles, until we succeed."