

Regional Anesthesia Complications: Protecting Your Patient and Yourself

Shane Garner, CRNA

Disclosures

- None

Review regional anesthesia evidenced-based practice advisories for:

- Ultrasound guidance, neurologic complications, anticoagulation medications, infectious complications, pediatric regional anesthesia, local anesthetic systemic toxicity

Discuss current trends and controversies in regional anesthesia

- Preprocedure checklist, acute compartment syndrome, closed malpractice claims

Timeout

- ***Wrong-site nerve blocks are a sentinel event***
 - More common than wrong-site surgery (~10x) - likely underreported
- Rectify any discrepancies between consent, case posting, or patient expectations
- ***Involve patient in timeout***
 - Name, DOB, procedure, side

< Restart	Checklist
☐	Patient Is Identified - 2 criteria
☐	Allergies Confirmed
☐	Anticoagulant Confirmed ⓘ
☐	Surgical Procedure/Consent Verified
☐	Block Plan Confirmed
☐	Block Site Marked
☐	Necessary Block Equipment Present
☐	Drugs/Solutions Labeled
☐	Resuscitation Equipment Available ⓘ
☐	ASRA Recommended Monitors Applied
☐	IV Access Functioning
☐	Sedation Given, If Needed



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Regional Anesthesia and Pain Medicine

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Advisories & guidelines

Trust ASRA – the gold standard in scientific advisories and guidelines related to anesthesia, analgesia, and acute and chronic pain.

Practice advisories and guidelines represent the opinions of the respective authors. Readers are advised to analyze and apply this information in their own practices.



State of the Art Safety Standards in RA
THE EUROPEAN SOCIETY OF REGIONAL
ANAESTHESIA & PAIN THERAPY



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Practice Advisories

- Provide synthesis of scientific literature and analysis of expert opinion, clinical feasibility data, open forum commentary, and consensus surveys
- Not intended as standards or guidelines
- Not intended to replace local institutional policies

The Second American Society of Regional Anesthesia and Pain Medicine Evidence-Based Medicine Assessment of Ultrasound-Guided Regional Anesthesia

Executive Summary

Joseph M. Neal, MD, Richard Brull, MD,† Jean-Louis Horn, MD,‡ Spencer S. Liu, MD,§
Colin J. L. McCartney, PhD, MBChB,|| Anahi Perlas, MD,† Francis V. Salinas, MD,* and Ban Chi-ho Tsui, MD¶*

- Nerves have a variety of ultrasound (US) appearances
- Limitations of machines with regard to acoustic resolution
- **1/3 of fascicles are not visible on a US image**
- No good understanding of what constitutes safe vs dangerous perineurial injection
- **Conservative USG nerve localization techniques**

Ultrasound advantages

- Faster sensory block onset
- ***Fewer vascular punctures***
- Faster performance time
- Fewer needle passes
- ***Decreased unintentional abdominal organ puncture***
- Most truncal blocks are US based techniques

Should we stop doing blind transversus abdominis plane blocks?

G. McDermott^{*†}, E. Korba[†], U. Mata, M. Jaigirdar, N. Narayanan, J. Boylan and N. Conlon

- 36 adult patients
- Correct position (24%), other tissues or peritoneum (76%)
- Consultants in correct plane (46%), trainees (5%)
- Trainees in peritoneum (33%)

US & Neuraxial Blocks

- US has a role in improving efficiency of lumbar neuraxial anesthesia and in predicting depth-to-target
- US aides in identification of interspace level more accurately than palpation, but not as good as radiologic imaging

Preprocedure mapping of the spine

- Locate and mark midline (transverse spinous process view)
- Locate and mark interspinous spaces (transverse interspinous view)

Measure the distance to the ligamentum flavum

- Paramedian sagittal oblique view
- Guide selection of appropriate length spinal needle

Step 1:
Find midline

The diagram shows a lateral view of the lumbar vertebrae. Two vertical green lines are drawn through the center of each vertebral body to indicate the midline. A dashed blue crosshair is overlaid on a 3D model of a human torso in the bottom right corner, marking the midline on the back.

VISIBLE BODY®

Step 1:
Find midline



The diagram shows a lateral view of the lumbar vertebrae. Two vertical green lines are drawn through the center of each vertebral body to indicate the midline. A dashed blue crosshair is overlaid on a 3D model of a human torso in the bottom right corner, marking the midline on the back.

VISIBLE BODY®

Transducer

Patient

Annotate

Settings

DRO



GARNER ANESTHESIA SERVICES



GARNER ANESTHESIA SERVICES

SP

Lamina

Lamina

2 4 6

C60 92% MI 1.1 TIS 0.2

SP

Lamina

Lamina

2 4 6

C60 92% MI 1.1 TIS 0.2

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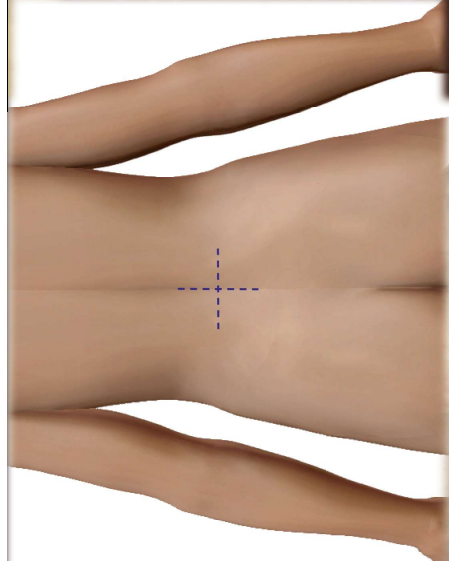
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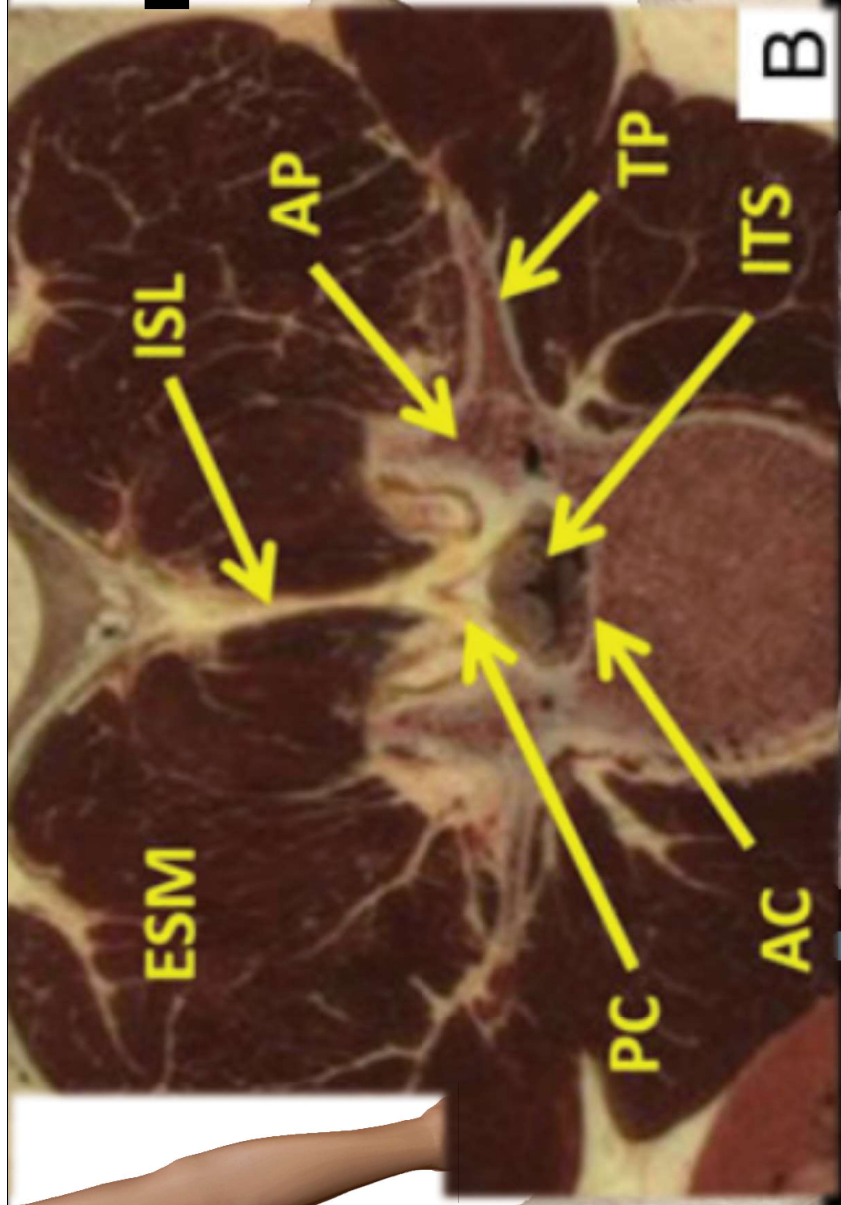
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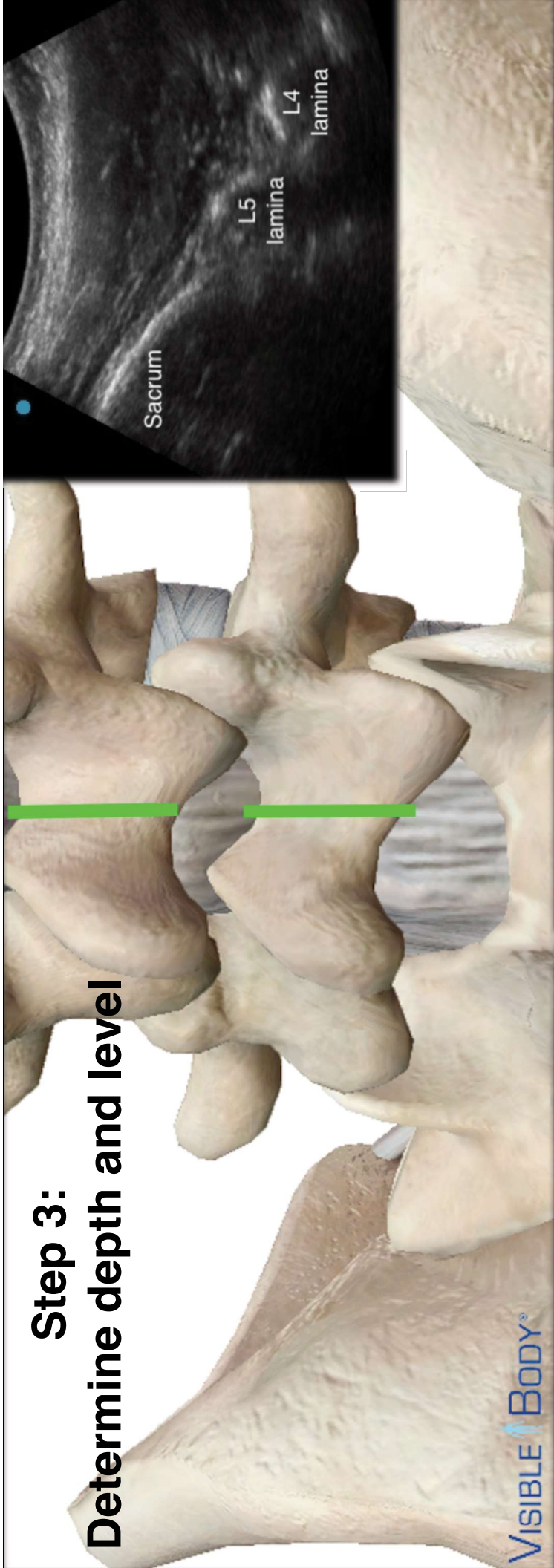


Step 2: Find interspace



Step 3:

Determine depth and level



US & Patient Safety

- Does not reduce postoperative neurologic symptoms (PONS)
- Reduce the incidence and intensity of hemidiaphragmatic paresis (HDP)
- ***Significant reduction of local anesthetic systemic toxicity (LAST)***
 - 2.6 per 10,000 blocks

The Second ASRA Practice Advisory on Neurologic Complications Associated With Regional Anesthesia and Pain Medicine

Executive Summary 2015

Joseph M. Neal, MD, Michael J. Barrington, MBBS, FANZCA, PhD,† Richard Brull, MD,‡
Admir Hadzic, MD,§ James R. Hebl, MD,|| Terese T. Horlocker, MD,|| Marc A. Huntoon, MD,**
Sandra L. Kopp, MD,|| James P. Rathmell, MD,†† and James C. Watson, MD||*

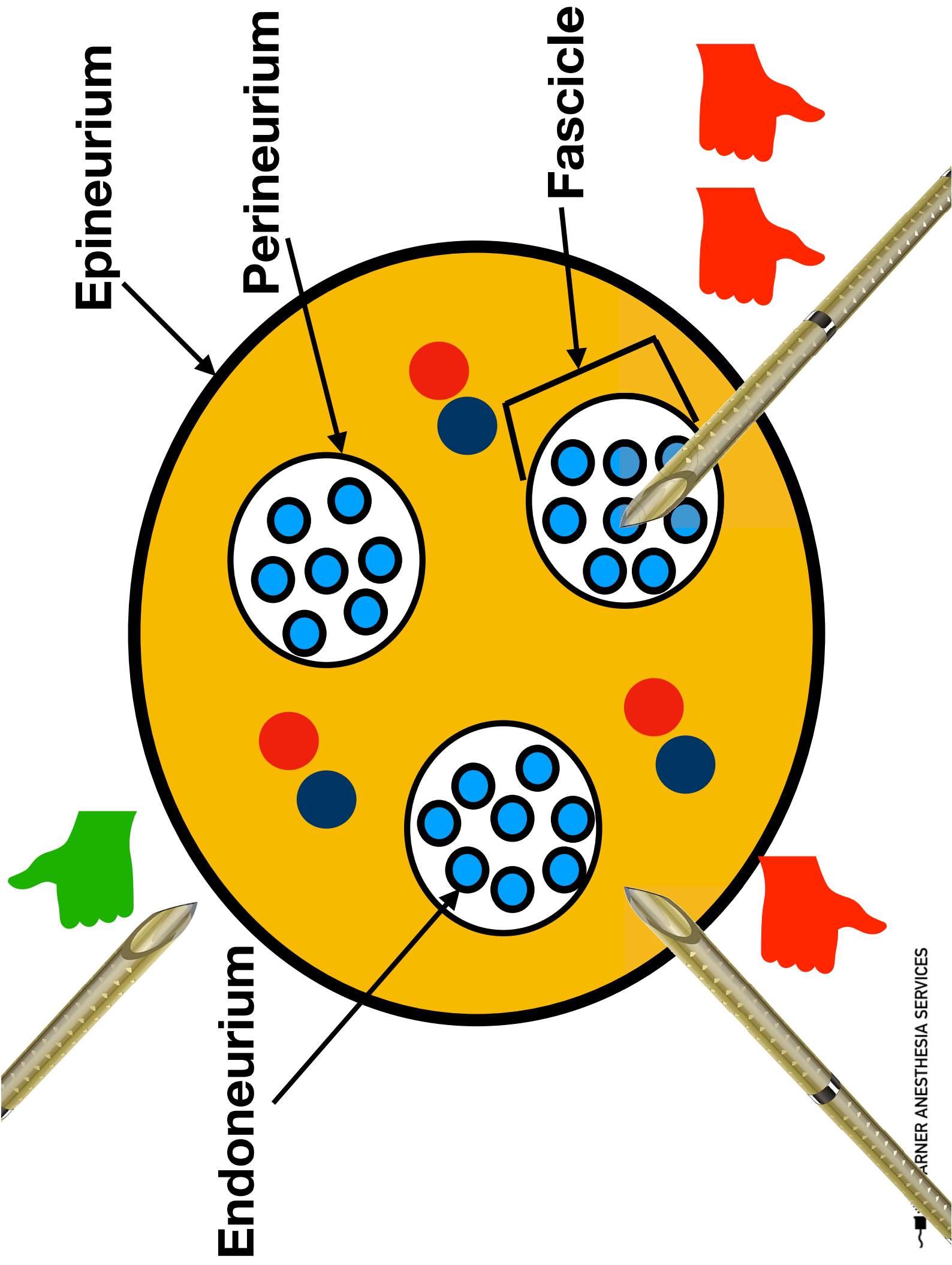
- New information on incidence of nerve injury in common elective orthopedic surgeries
- Updated information on pathophysiology of neuraxial and peripheral nerve injury (PNI)
- Advisability of performing procedures in anesthetized or deeply sedated patients

Epineurium

Perineurium

Fascicle

Endoneurium



Incidence of sub-perineural injection using a targeted intraccluster supraclavicular ultrasound-guided approach in cadavers

Susanne Retter¹, Jennifer Szerb^{1,*}, Kwesi Kwofie¹, Patricia Colp², Robert Sandeski³ and Vishal Uppal¹

- Single needle pass targeting the middle or lower trunk 'cluster' with ink
 - Extra-epineural (32%)
 - Sub-epineural (44%)
 - **Sub-perineural (24%)**

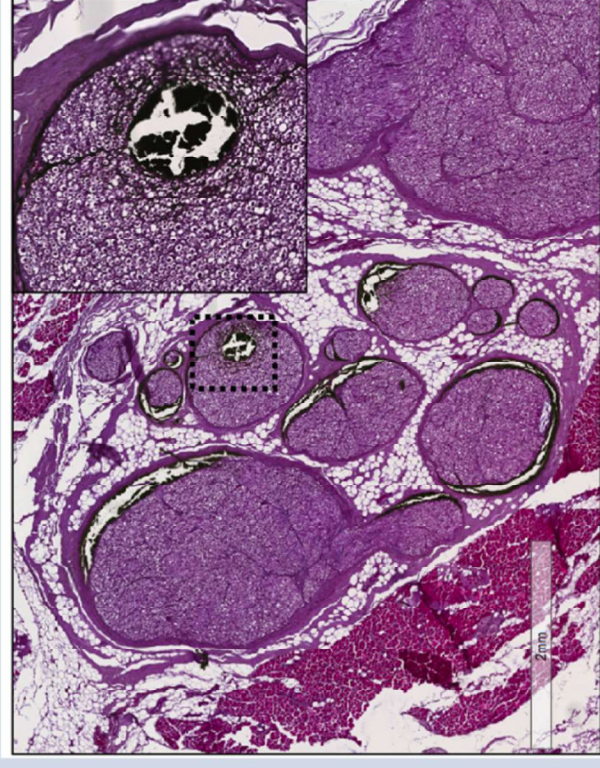


Fig 3. Haematoxylin and eosin stained slide demonstrating ink deep to the perineurium of multiple fascicles. Inset: a magnified fascicle with a distorted fascicle and intrafascicular ink.

Nerve Injury

- **Incidence of PNI has remained stable**
- Long-term injury after PNB is 2-4 per 10,000 blocks
 - May be secondary to needle trauma, pressure injury from LA or hematoma formation, ischemia, or via direct effects from LA and/or adjuncts
- Accumulating evidence suggesting rising incidence of catastrophic neuraxial complications
 - More robust registries and improved reporting?
 - Limits of neuraxial blocks being pushed to sicker patients?

Neuraxial Injury

- **Rare but often permanent injuries**
- Incidence varies widely and difficult to cite an overall risk
 - Preexisting neurologic disease may increase incidence (0.3-1.1%)
 - General population (0.001-0.07%)

Peripheral Nerve Injury

- ***Transient PONS are very common in first days to month after PNB***
 - 0-2.2% at 3 months
 - 0-0.8% at 6 months
 - 0-0.2% at 1 year
- ***PNIs are more likely unrelated to PNB***
 - 9x more likely to be secondary to non-nerve block cause

Barrington M, et al. Reg Anesth Pain Med 2009;34:534-541

Anesthetic Factors

- ***More likely related to patient and surgical factors than PNB***
- PNI with LA is greatest with intrafascicular injection (axonal exposure to high LA concentrations and mechanical damage)
- Intrafascicular injections are associated with higher opening pressures and risk of PNI
- LA toxicity is time and concentration dependent
- ***Epidural and GA, but not PNB, have been associated with PNI***

Patient Factors

- *Preoperative neurologic deficit or neural compromise theoretically places patient at increased risk*
- “Double crush”
- Ulnar nerve at elbow and common peroneal nerve are at increased risk

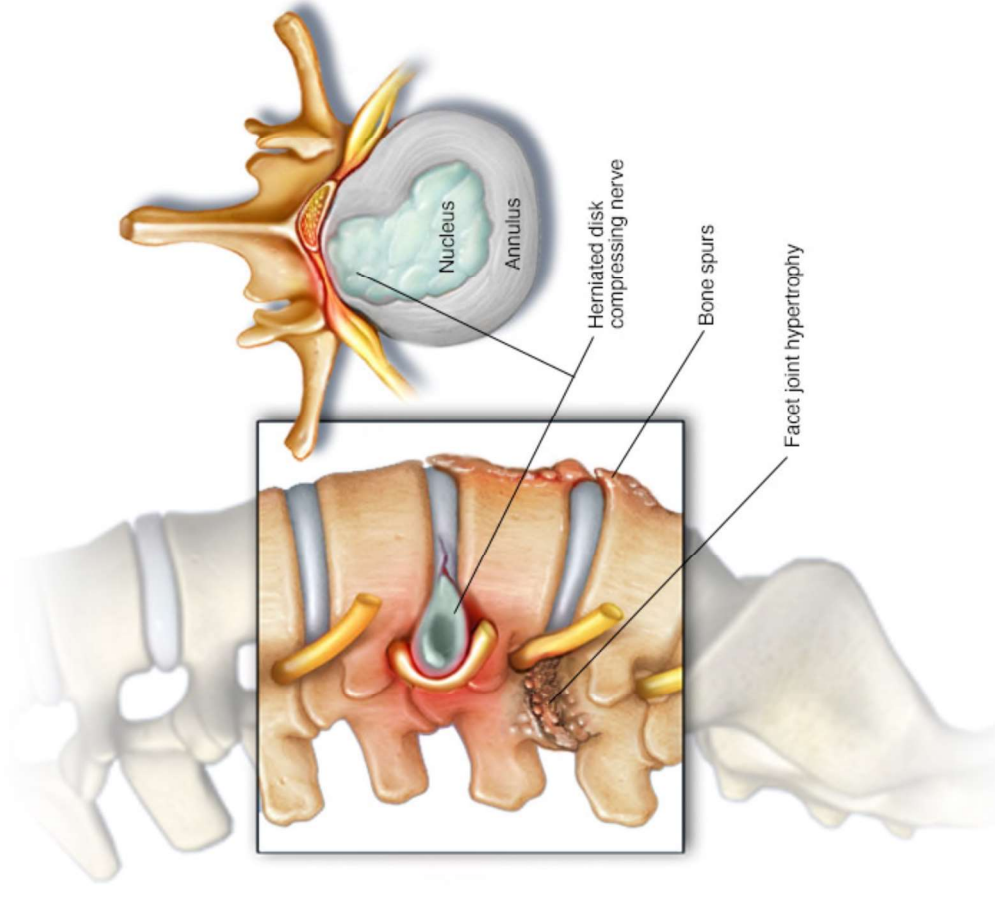
Pre-existing Disease

Data regarding association between pre-existing and neurologic disease and post-regional anesthesia dysfunction often conflicting

- Definitive recommendations can rarely be made from the scientific literature
- Review the specific disease and available literature to make an informed decision
- Perform a thorough preoperative assessment and discuss the risk/benefit of regional anesthesia with the patient

Spinal Stenosis

- Association between spinal stenosis and injury after neuraxial block
- Significant spinal stenosis (19% prevalence in sixties)
- Often unrecognized
- Consider risk vs benefit
- Consider reducing total mass of LA
- Increased vigilance

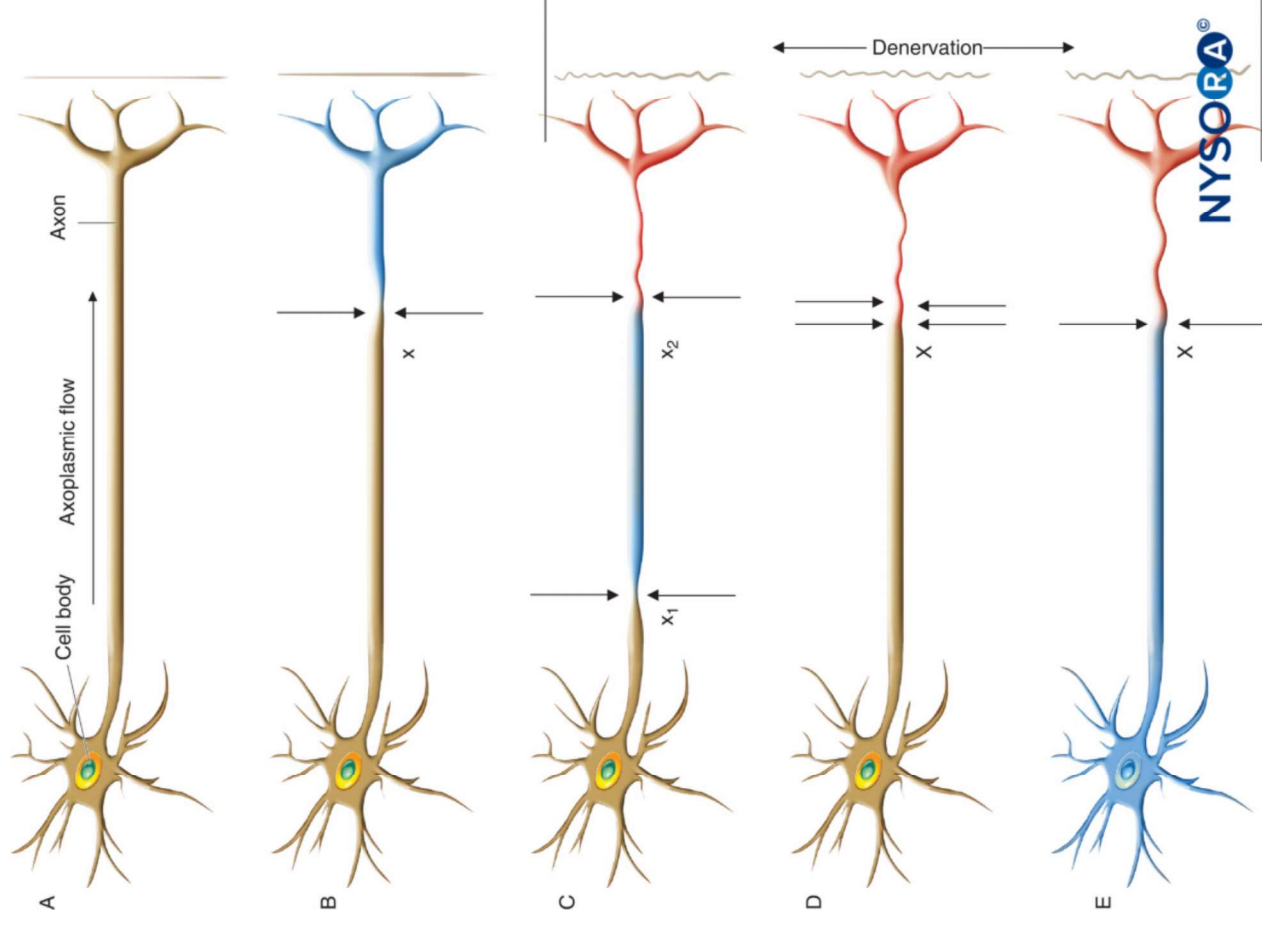


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Pre-existing Disease

Double crush theory

- “Diseased” axon may be impaired and not tolerate a minor neural insult
- Risk factors: Diabetic neuropathy, PVD, smoking, vasculitis, HTN
- Consider decreasing the concentration or total dose of LA, ***eliminate epinephrine additives***



Surgical Factors

- *Tourniquet duration and inflation pressure*
- Surgical procedures have unique risk profiles
- Inflammatory mechanisms for PNI are recognized and exhibit features that are physically and temporally remote from PNB

Nerve Injury

- Discrimination between surgical, anesthetic, and patient factors is often difficult
- Arthroscopic shoulder surgery (0.1-10%)
 - Surgical traction, portal placement close to nerve pathways
- Total shoulder replacement
 - Diffuse brachial plexus injuries (transient in up to 17%)
 - Reverse TSA - permanent arm lengthening



Ortho Surgery

- Elbow surgery high risk d/t minimal soft tissue protection and nerve-rich area
- THA (1%)
 - Compression from retractors, traction from dislocation, excessive leg lengthening
- TKA (0.3-9.5%)
 - CPN, SaN and cutaneous nerves of thigh
- Foot and ankle surgery
 - Cutaneous nerves, traction neuropraxia, portal placement

Recommendations

- Awareness of the causation, location, and frequency of nerve injuries might help in diagnosis - often difficult to pinpoint the factors
- ***Differential diagnosis should include prolonged tourniquet (> 120 min)***
- Consider delaying blocks until postop if nerve function is assessed

Key Points

- ***Avoid prolonged hypotension (> 20-30% below MAP, especially for > 20 min)***
 - Lower limit of autoregulation for cerebral and spinal cord blood flow is likely higher than previously believed (MAP 60-65 vs 50)
- Keep LA below max recommended doses
- Incidence of TNS after 40-50 mg 2-CP is low
- Separate antiseptic from block trays, allow solution to dry before needle placement

Anesthetized Patients

- No data to support the concept that USG of needle placement reduces risk of neuraxial injury
- *Adults: should be performed rarely*
- *Children: ensures cooperative and immobile child*

Nerve Localization

- No human data to support the superiority of one nerve localization technique over another with regard to reducing PNI
- **Presence of motor response at current of < 0.5 mA indicates intimate needle-nerve relationship (high specificity)**
 - Absence of motor response up to 1.8 mA does not exclude needle-nerve contact (low sensitivity)
- Injection pressure monitoring can detect needle-nerve contact
 - Assessing injection pressure by “hand feel” is inaccurate
- **Ultrasound can detect intraneural injection**
 - *Cannot detect between interfascicular and intrafascicular injection*

Intraneural Injection

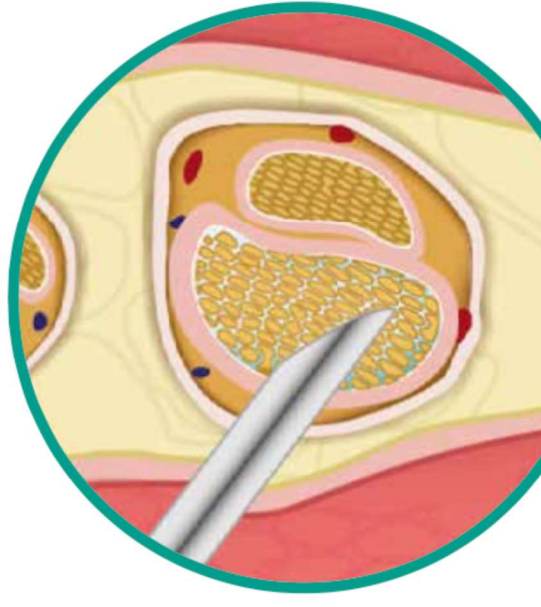
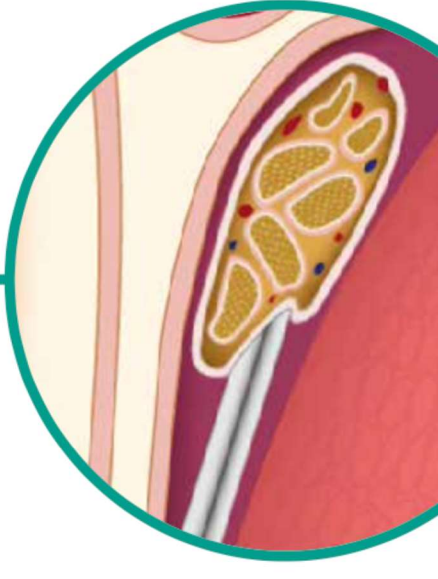
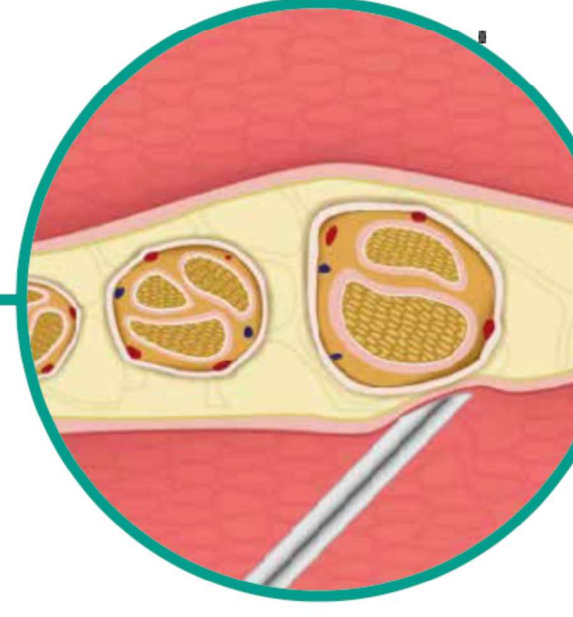


Pressure Monitoring

- Syringe-feel method of assessing injection force is inconsistent
- ***Needle-nerve contact with opening injection pressures ≥ 15 psi***
- *When needle 1 mm away from nerve
OIP < 15 psi*

Gadsden J, et al. Anesthesiology 2014;120:1246-53

- Disposable manometer devices readily available



The Maximum Effective Needle-to-Nerve Distance for Ultrasound-Guided Interscalene Block

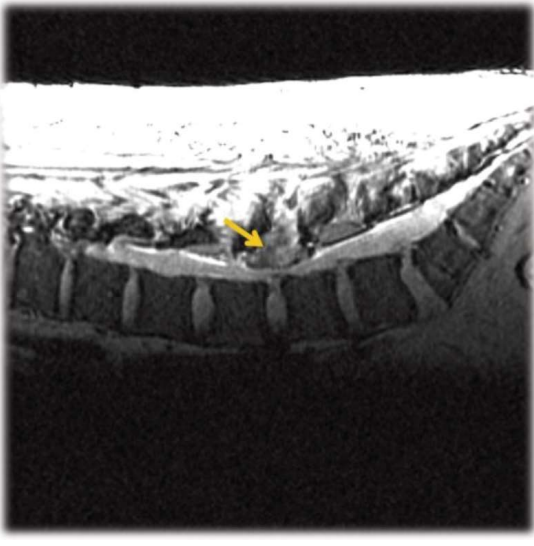
An Exploratory Study

Eric Albrecht, MD, DESA, Kyle R. Kirkham, MD, FRCPC,* Patrick Taffè, PhD,†
Ryan V.W. Endersby, MD, FRCPC,* Vincent W.S. Chan, MD, FRCPC,* Cyrus Tse, BSc,*
and Richard Brull, MD, FRCPC**



- 20 patients undergoing ambulatory shoulder surgery
- ISB with 20 mL bupiv 0.5% with epi, first injection was lateral to sheath at C5 and C6
 - Subsequent injections adjusted by 2 mm
- MED50 8.5 mm, MED80 5.2 mm, MED95 1.6 mm
- ***Needle-nerve contact is not a requirement for an effective ISB***

Diagnosis of Nerve Injury



Neuraxial

- ***Emergent neuroimaging***
- MRI is preferred, CT or CT myelography are acceptable initially to exclude compressive lesion
- Compressive lesion demands emergency neurosurgical consultation

Peripheral nerve injury

- Neurologic consultation for complete or incomplete injuries with severe limitations, or progressive neurologic dysfunction
- EMG may help confirm neuropraxia with conduction block or define preexisting disease when performed acutely
- Axonal loss and extent of injury will be better clarified by EMG 3 weeks after injury

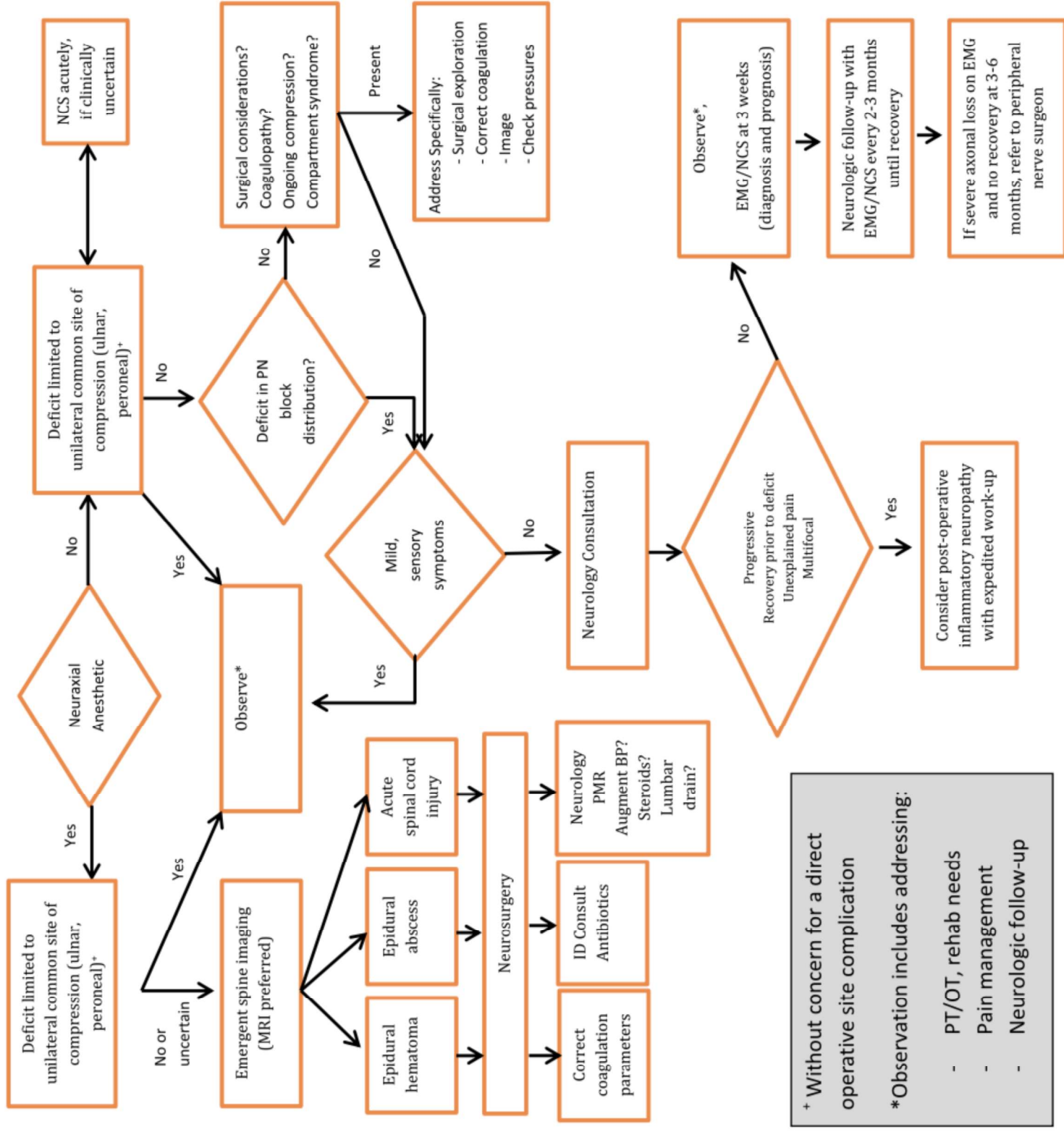
“Red Flag” Symptoms

Cauda Equina Syndrome

- Severe low back pain
- Motor weakness, sensory loss, or pain in one or both legs
- Saddle anesthesia
- Bladder and bowel dysfunction/sensory abnormalities
- Recent onset of sexual dysfunction
- Loss of reflexes in the legs

Treatment of Nerve Injury

- ***Neurologic outcomes improve with early decompression (<8-12 h) in epidural hematoma and (<36 h) for spinal epidural abscess and when preoperative neurologic deficits are milder in severity***
- Treat neuropathic pain pharmacologically
- Nerve lesions that fail to improve 3-5 months after initial evaluation should prompt surgical consultation
- Ensure normal BP or high-normal BP in spinal cord ischemia
- Corticosteroids may have benefits after direct spinal cord trauma, not recommended for ischemic spinal cord injury



+ Without concern for a direct operative site complication

*Observation includes addressing:

- PT/OT, rehab needs
- Pain management
- Neurologic follow-up

Incidence and etiology of postoperative neurological symptoms after peripheral nerve block: a retrospective cohort study

Karen K Lam,¹ Neilesh Soneji,¹ Hans Katzberg,² Li Xu,¹ Ki Jinn Chin,¹ Arun Prasad,¹
Vincent Chan,¹ Ahtsham Niazi,¹ Anahi Perlas¹

26,251 PNBs

- Incidence transient PONS (< 10 d) was 14.4%
- 20 cases of prolonged PONS (≥ 10 d)
- **3 were deemed block related (2 fully resolved)**

Risk Reduction

- Focused history for presence of current or previous paresthesias, dysesthesias, or pain in the limb
- Informed consent
- Caution with sedatives
- ***Triple monitoring: USG, PNS, injection pressure monitoring***
 - ***Use USG - don't get THAT close to nerves!***
- Thorough documentation
- Written instructions with precautions
- Follow-up with patient

Regional Anesthesia in the Patient Receiving Antithrombotic or Thrombolytic Therapy

*American Society of Regional Anesthesia and Pain Medicine
Evidence-Based Guidelines (Fourth Edition)*

Terese T. Horlocker, MD, Erik Vandermeulen, MD,† Sandra L. Kopp, MD,* Wiebke Gogarten, MD,‡
Lisa R. Leffert, MD,§ and Honorio T. Benzon, MD||*

- Unified set of recommendations from ASRA, NPMS, and SOAP regarding timing of epidural catheter placement/removal and initiation of postpartum thromboprophylaxis
- Update on frequency and severity of bleeding complications associated with PNBs
- Summary of interventional spine and pain guidelines

Recommendations are pharmacologically based

- Time interval between discontinuation of drug during therapeutic anticoagulation and subsequent neuraxial block is 5 half-lives (dependent on renal function), allows for resolution of 97% of effect
- Time interval for prophylaxis, 2 half-lives
- Based on 8 h minus time it takes for peak effect
- Approximately 8 h for platelet plug to stabilize

Anticoagulants



VZW Wi-Fi



Home



Regional



VZW Wi-Fi



Drugs



VZW Wi-Fi



Block



VZW Wi-Fi



Restart



VZW Wi-Fi



Block



VZW Wi-Fi



Intervention



VZW Wi-Fi



Restart

9:45 AM

9:46 AM

Regional

Block

Intervention

Restart

Regional Guidelines for Antithrombotic or Thrombolytic Therapy

Begin

View Full Guideline



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Based on the ASRA Practice Advisory on Regional Anesthesia 2018

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clonidine

Please select desired intervention:

HOLD MEDICATION
before procedure

RESTART MEDICATION
after procedure

HOLD MEDICATION
before catheter removal

RESTART MEDICATION
after catheter removal

clonidine

Please select block type:

Neuraxial Block

Deep Plexus/Deep Peripheral Block

Superficial Peripheral Block

Anticoagulated Parturient Neuraxial Block

clonidine

Please select desired intervention:

HOLD MEDICATION
before procedure

RESTART MEDICATION
after procedure

HOLD MEDICATION
before catheter removal

RESTART MEDICATION
after catheter removal

 GARNER ANESTHESIA SERVICES

Heparin

- Unfractionated heparin (UFH)
 - Binds to antithrombin, accelerating its ability to inactivate thrombin (IIa), Xa, IXa
 - *Hold 4-6 h or assessment of coagulation status*
- ***Low-molecular-weight heparin (LMWH)***
 - Xa > IIa, more predictable pharmacokinetic properties than UFH
 - Hold 12 h (prophylaxis) - 24 h (therapeutic) prior to neuraxial block
- Heparin-induced thrombocytopenia (HIT) may occur during administration, recommend platelet count prior to neuraxial block or catheter removal in patients receiving heparin for > 4 d

Anti-Factor Xa Agents

- Fondaparinux (Arixtra)
 - Injectable, long half-life
- *Rivaroxaban (Xarelto), Apixaban (Eliquis), “xaban”*
 - Oral, rapid onset, short half-life, no routine lab monitoring, safer than warfarin
- **Hold 72 h prior to neuraxial block**

Direct Thrombin Inhibitors

- Desirudin, Bivalirudin, Argatroban
 - Parenteral, recommend against neuraxial techniques
- ***Dabigatran (Pradaxa)***
 - Oral, long half-life, careful consideration of neuraxial techniques
 - **Hold 5 d (3-5 d depending on renal function) prior to neuraxial block**

Vit K Antagonists

- Interfere with synthesis of vitamin K-dependent clotting factors II, VII, IX, X
- Increased response to warfarin: increased age, female, low weight, Asian, comorbidities (renal), drug interactions
- ***Stop therapy (5 d) and normalize INR (1.2)***
 - Remove catheters when INR < 1.5
 - Bridge with LMWH

BRIEF TECHNICAL REPORT

Clotting-Factor Concentrations 5 Days After Discontinuation of Warfarin

Honorio T. Benzon, MD, Yogen Asher, MD,* Mark C. Kendall, MD,† Loyda Vida, D Min,‡
Robert J. McCarthy, PharmD,§ and David Green, MD, PhD‡*

- Evaluated INR levels of clotting factors (CFs) II, VII, IX, X 5 days after d/c of warfarin
- Adequate activities of vitamin K-dependent CFs with INR of 1.2 or less 5 days after d/c of warfarin
 - **INRs of 1.3-1.4 had factors II, X activities < 40%**
 - Despite normal INR, CF activities may not be > 40% in end-stage renal failure

Antiplatelet

- ***NSAIDs do not appear to add significant risk***
- Thienopyridines - ticlopidine (Ticlid), clopidogrel (Plavix), prasugrel (Effient)
 - Irreversibly inhibit ADP-induced platelet aggregation
 - ***Clopidogrel: hold 5-7 prior to neuraxial block***
- Ticagrelor (Brilinta)
 - Reversibly inhibit ADP-induced platelet activation
- Cangrelor (Kengreal)
 - Direct and reversible IV P2Y12 inhibitor
- Abciximab (Reopro), eptifibatide (Integrilin), tirofiban (Aggrastat)
 - Platelet GPIIb/IIIa receptor antagonists
- Cilostazol (Pletal)
 - Selective inhibition of PDE IIIA
- Dipyridamole

Herbals

TABLE 15. Three Herbal Medications With the Greatest Impact on Hemostasis*

Herb	Important Effects	Perioperative Concerns	Time to Normal Hemostasis After Discontinuation
Garlic	Inhibition of platelet aggregation (may be irreversible) Increased fibrinolysis Equivocal antihypertensive activity	Potential to increase bleeding, especially when combined with other medications that inhibit platelet aggregation	7 d
Ginkgo	Inhibition of platelet-activating factor	Potential to increase bleeding, especially when combined with other medications that inhibit platelet aggregation	36 h
Ginseng	Lowers blood glucose Increased prothrombin and activated partial PTs in animals Other diverse effects	Hypoglycemia Potential to increase risk of bleeding Potential to decrease anticoagulant effect of warfarin	24 h

*At this time, it is not deemed necessary to discontinue herbal medications and allow resolution of their effects on hemostasis prior to surgery or anesthesia.



Spinal Hematoma

- ***Incidence < 1:150k epidural and < 1:200k in patients not receiving thromboprophylaxis***
- Frequency is likely higher than calculated
- ***Higher frequency in patients with hemostatic abnormality***
- Risk varies with age, spinal cord/column abnormalities, underlying coagulopathy, difficulty during needle placement, indwelling catheter during sustained anticoagulation

Hypercoagulable state may be protective

- Younger pt has more compliant epidural space than older pt
- Follow ASRA guidelines
- In high-risk parturient receiving VTE prophylaxis and requiring urgent interventions, the risk of GA may be greater than neuraxial, and exceptions to ASRA guidelines may be appropriate

Pain Guidelines

Elective procedures

- Stratification based on risk of bleeding and seriousness of hemorrhagic sequelae
- High risk spine procedures require a more conservative approach
 - Antiplatelet therapy is discontinued for medium-high risk procedures (spinal cord stimulator, intrathecal pump, kyphoplasty)

Evolving area of regional anesthesia

- For perineuraxial, deep plexus, or deep PNB, follow neuraxial guidelines
- For other plexus or peripheral techniques (catheters), management based on site compressibility, vascularity, and consequences of bleeding

Research report

Retrospective analysis of peripheral nerve blocks in patients on anticoagulants and antiplatelet agents

Prachi M Patel,¹ Mary C Leemputte,¹ Robert J McCarthy ,² Honorio T Benzon ¹

284 pts received 357 low or intermediate-risk PNBs

- 38% had their antiplatelet (AP) and/or anticoagulant (AC) medication discontinued, all ACs, except warfarin were discontinued
- ***Bleed complication rate requiring surgery with patients on AP and/or AC was 2.5% vs 2.4% with discontinuing***

Practice Advisory for the Prevention, Diagnosis, and Management of Infectious Complications Associated with Neuraxial Techniques

*An Updated Report by the American Society of Anesthesiologists Task Force on Infectious Complications Associated with Neuraxial Techniques and the American Society of Regional Anesthesia and Pain Medicine**

Eleven topics addressed with regard to the prevention of infectious complications related to neuraxial technique

- Literature often insufficient

Prevention

- Conduct a history and physical examination relevant to the procedure and review relevant laboratory studies
- Consider alternatives to neuraxial techniques for patients at high risk
- Consider preprocedure antibiotic therapy in known or suspected bacteremic patient
- Select neuraxial technique on a case-by-case basis
- Avoid lumbar puncture with known epidural abscess

Prevention

- Use aseptic techniques (remove jewelry, hand washing, caps, masks, sterile gloves, sterile draping)
- Use individual packets of antiseptics
 - Allow adequate drying time
- Use sterile occlusive dressings
- Limit disconnection and reconnection
- ***Consider removing unwitnessed accidentally disconnected catheters***
- Catheters should not remain in situ longer than clinically necessary



Diagnosis

Perform daily evaluation of patients with indwelling catheters (e.g., fever, backache, headache, erythema, and tenderness at insertion site)

- Promptly attend to signs or symptoms
- If infection is suspected
 - Remove catheter and consider culturing
 - Order appropriate blood tests
 - Obtain appropriate cultures
 - ***If abscess is suspected or neurological dysfunction is present, perform imaging studies and consult with appropriate specialties***

Management

- Administer appropriate antibiotic therapy at the earliest sign or symptom of a serious neuraxial infection
- Consider consultation with a physician with expertise in infectious disease
- If abscess is present, obtain surgical consultation

The European Society of Regional Anaesthesia and Pain Therapy and the American Society of Regional Anesthesia and Pain Medicine Joint Committee Practice Advisory on Controversial Topics in Pediatric Regional Anesthesia

Giorgio Ivani, MD, Santhanam Suresh, MD,† Claude Ecoffey, MD,‡ Adrian Bosenberg, MB, ChB, FFA(SA),§ Per-Anne Lonngvist, MD,|| Elliot Krane, MD, FAAP,** Francis Veyckemans, MD,†† David M. Polaner, MD, FAAP,‡‡ Marc Van de Velde, MD,§§ and Joseph M. Neal, MD||||*

Four topics of PRA controversy

1. The performance of blocks under deep sedation or GA
2. The value of a test dose
3. Air vs saline for LOR for epidural space detection
4. RA and risk of obscuring compartment syndromes

Deep Sedation/GA

Standard of care

- Overall risk of complications is 0.66%, while risk of paralysis is estimated at 0
- Serious complications may still occur

Test Dose

- Difficulty interpreting a negative test dose, use should remain discretionary
- Inject slowly with intermittent aspiration
- Any modification of T wave or of HR within 30-90 sec should be interpreted as IV injection
- Imaging modalities may help avoid or visualize accidental needle placement in PNBs

Air vs Saline

- Either technique is acceptable
- Combination of air and saline may represent a better alternative
- The volume of air in the syringe should be limited to < 1 mL and should not be repeated
- Avoid air in right-to-left cardiac shunt

Compartment Syndrome

No current evidence that RA increases risk for acute compartment syndrome (ACS) or delays its diagnosis

- Preoperative discussion with family and surgical team about this rare but serious complication

Does epidural analgesia delay the diagnosis of lower limb ACS?

Clinical signs of impending ACS in the lower limbs

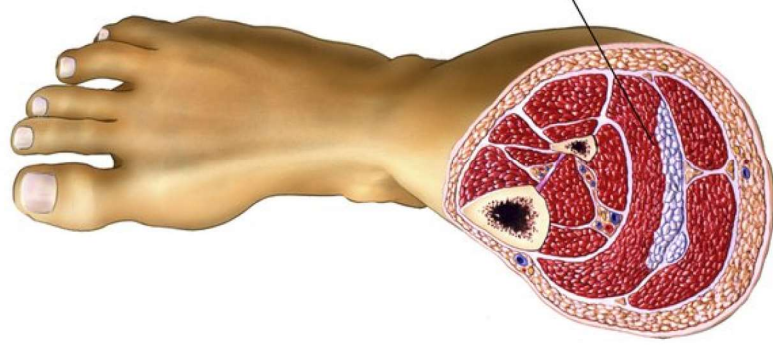
1. Increasing pain with increasing need for analgesics
2. Pain remote to site of surgery
3. Paresthesia that is not attributable to analgesia technique
4. Signs of reduced perfusion of the painful site
5. Local swelling
6. Pain on passive movement of limb

Johnson & Chalkiadis, Paediatr Anaesth, 2009;19:83–91

The Controversy of Regional Anesthesia, Continuous Peripheral Nerve Blocks, Analgesia, and Acute Compartment Syndrome

Olga C. Nin, MD, Matthew R. Patrick, MD,† and André P. Boezaart, MD, PhD*†*

- Syndrome characterized by increase in pressure in a confined space that compromises blood flow, leading to necrosis of tissue
- Incidence of 3.1 per 100,000, 10x higher in males
 - **1/3 of all cases caused by closed tibial shaft fracture**
- RA has many benefits yet some argue that it may mask ischemic pain from ACS



Compartment Syndrome

Pain typically “out of proportion” or unexpected to the clinical scenario

- Ischemic pain pathway is complex and different from nociceptive and neuropathic pain
 - Theory that ACS ischemic pain is sympathetically mediated
- “Silent” ACS
- ***Evidence that PNBs do not block this pain, while neuraxial techniques may***

Compartment Syndrome

- Opioids may mask ischemic pain
- **cPNBs with low concentration of LA**
- *Improved pain control, increased function, faster recovery, limits opioids, increased tissue blood flow*
- ***Communicate with surgeon prior to initiating nerve blockade***

■ ORIGINAL CLINICAL RESEARCH REPORT

Regional Anesthesia Associated With Decreased Inpatient and Outpatient Opioid Demand in Tibial Plateau Fracture Surgery

Daniel J. Cunningham, MD, MHSc,* Micaela LaRose, BA,† Gloria Zhang, BS,† Preet Patel, BS,† Ariana Paniagua, BA,† Jeffrey Gadsden, MD‡, and Mark J. Gage, MD*

- Retrospective, observational study of adult patients undergoing tibial plateau fracture surgery
- 264 patients (60 received regional anesthesia)
- ***RA reduced inpatient opioid consumption up to 48 h postop and reduced outpatient opioid demand up to 90 d postop***
- No associated risk of ACS

Compartment Syndrome

“Best practice rules”

1. Caution with certain fractures, surgical procedures, and high-energy injuries (tibial shaft/plateau, calcaneal/Lisfranc, and mid-shaft forearm fractures)
Dwyer T, et al. Reg Anesth Pain Med 2021;46:1091–1099
2. ***Use low concentration (0.1-0.25%), continuous infusions (limit to 0.1%)***
3. Restrict volume and concentration in high-risk surgeries
4. Use additives with caution
5. Appropriate follow-up by acute pain service
6. If ACS is suspected, urgently assess compartment pressure measurements

The American Society of Regional Anesthesia and Pain Medicine Checklist for Managing Local Anesthetic Systemic Toxicity 2017 Version

Joseph M. Neal, MD, Crystal M. Woodward, MD,* and T. Kyle Harrison, MD†*

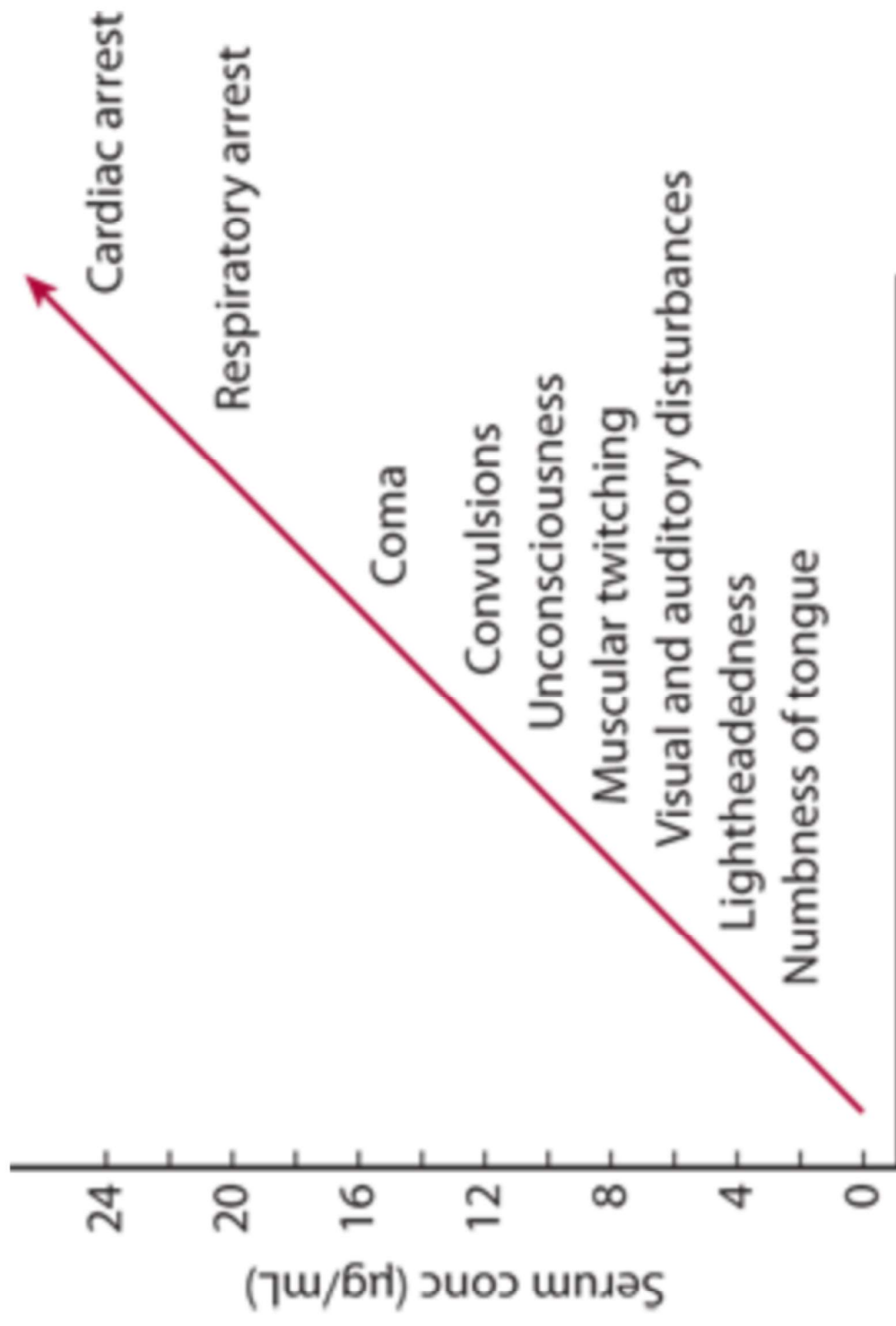
Three content updates

1. Lipid emulsion is now recommended at the first sign of a serious LAST event
2. Specific timeframes recommended for post-event monitoring
3. Upper limit of lipid emulsion dosing increased to 12 mL/kg

LAST

- LAs interfere with the function of all organs in which conduction or transmission of nerve impulses occurs
- In lab experiments, most LAs will not produce CV toxicity until the blood concentration exceeds 3x that necessary to produce seizures.
 - Produce dose-dependent myocardial depression
 - ***Bupivacaine: accumulates in mitochondria and cardiac tissue at a ratio of 6:1 or > relative to plasma***
- Occurs from direct injection into vascular space or absorption from surrounding tissues

LAST



Lipid emulsion MOA theories

1. Lipid sink
2. Provide the injured myocardium with fatty acid for fuel

100	Intralipid® 20%		100 ml
	Fat emulsion for intravenous use		
75	100 ml contains: Purified soybean oil 20 g Excipients: Purified egg phospholipids 1.2 g, Glycerol anhydrous 2.2 g, may contain Sodium hydroxide., Water for injection to 100 ml. Energy content: 0.84 MJ (200 kcal)/100 ml.		
50	The contents of this bag are for a single infusion only. Any remaining emulsion must be discarded. Electrolyte solutions should not be added to this bag. Read the package leaflet before use. Store at or below 25°C. Do not freeze. Fresenius Kabi Limited Cestrian Court Eastgate Way Manor Park Runcorn Cheshire WA7 1NT UK POM PL 8828/0110 MA 134-00101 Batch no: _____ Expiry date: _____ FRESENIUS KABI  05 PP		
25	 5 018750 815862 334 494 V002/UK		

LAST Key Points

- ***Treatment of LAST differs from cardiac arrest scenarios***
 - Standard doses of epinephrine and vasoconstrictors and drugs that impair cardiac contractility (β -blockers, CCBs, LA antiarrhythmics) are detrimental
- Fixed 100 mL bolus of lipid emulsion followed by infusion of 200-250 mL over 15-20 min (>70 kg)
 - Precise volume and flow rate are not critical
- LAST Rescue Kit (1 total liter of lipid emulsion)

Local Anesthetic Systemic Toxicity Checklist



- Call for help
 - Get LAST rescue kit
 - Consider cardiopulmonary bypass team
- +** Consider administering LIPID EMULSION early

Seizure?

- Ensure adequate airway
- Benzodiazepine preferred
- If only propofol available, use low dose, e.g., 20 mg increments



- EPINEPHRINE**
- Smaller than normal dose preferred
 - Start with ≤ 1 mcg/kg

- AVOID**
- Local anesthetics
 - Beta-blockers
 - Calcium channel blockers
 - Vasopressin

Arrhythmia or Hypotension?

BEWARE
LAST Resuscitation is DIFFERENT from Standard ACLS

- AVOID**
- Local anesthetics
 - Beta-blockers
 - Calcium channel blockers
 - Vasopressin

Stable?

- Continue lipid emulsion ≥ 15 min once hemodynamically stable
- Maximum lipid dose: 12 mL/kg

- Once Stable, OBSERVE**
- 2 hrs after seizure
 - 4-6 hrs after cardiovascular instability
 - As appropriate after cardiac arrest

over 70 kg

under 70 kg

- Bolus ~100 mL over 2-3 min
 - Infuse ~250 mL over 15-20 min
- IF PATIENT REMAINS UNSTABLE:**
- Repeat bolus
 - Double infusion

- Bolus ~1.5 mL/kg over 2-3 min
 - Infuse ~0.25 mL/kg/min (consider using a pump if < 40 kg)
- IF PATIENT REMAINS UNSTABLE:**
- Repeat bolus
 - Double infusion

LIPID EMULSION 20%

The order of administration (bolus or infusion) and method of infusion (manually, iv roller clamp, or pump) are not critical

LAST

- Incidence of 1:1000 PNBs (likely under-reported)
- Still occurs with the use of USG (16% of cases)
- Occurs in all forms of injections throughout the body
- ***Can be immediate-onset or delayed-onset (~40% in last decade)***
 - Accidental vessel puncture, intravascular injection, or rapid vascular absorption
- ***Seizure most common initial sign overall (~50% of cases)***

LAST Key Points

Risk reduction

- Ultrasound-guidance
- Consider using epinephrine as a vascular marker
- Frequent aspiration and fractionated dosing
- **Use lowest possible, still effective dose**
- *Caution in extremes of age, pregnancy and cardiac, renal, hepatic dz*
- Beware of delayed uptake
- **Beware of additive nature of LAST**

Closed Claims - PNB

Reviewed all available (113) closed malpractice claims related to regional anesthesia in surgical patients between 2006-2016

- Analyzed 62 claims and most were classified as permanent minor injuries
- Interscalene = greatest number
- Femoral & sciatic = most common resulting in payment

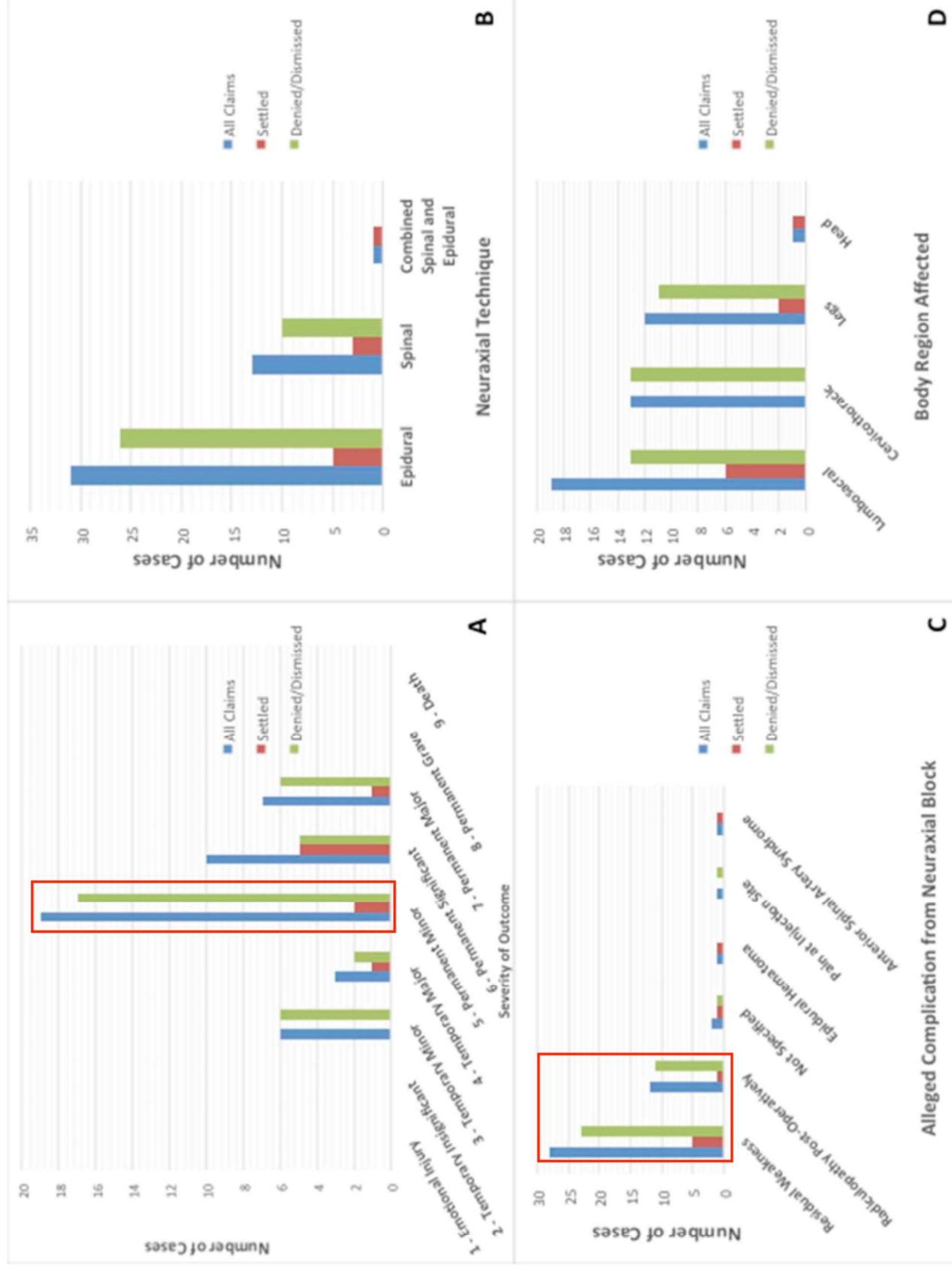
Closed Claims - PNB

Block-Type	Settlement Amount (USD)	Narrative
Femoral Nerve Block	\$500,000	The case involved a 30 year-old patient undergoing a total knee arthroplasty (TKA). The anesthesiologist reported that the patient had “exquisite tenderness with just ultrasound probe placement,” during the block but never had any paresthesia or shooting pain in the femoral nerve distribution. The patient describes having “10 out of 10 pain”, although this was denied by the assisting nurse who stated that they would have stopped if the patient was in that much pain. This preoperative block was noted to be unsuccessful and the team performed a second femoral nerve block post-operatively with no comment on complications. After the blocks wore off the patient reported decreased quadriceps strength and EMG showed near complete loss of function of the femoral nerve. Magnetic resonance imaging showed swelling of the femoral nerve from the inguinal ligament to the area of Hunter’s canal. The patient’s nerve and muscles ultimately recovered over a 2-year period, with the orthopedic surgeon noting a complete recovery from the nerve injury. The patient claimed she still could not stand, squat, or run and that her knee buckled at times. The patient has been walking with a limp since the procedure.
Popliteal Nerve Block	\$600,000	The case involved a patient who underwent a popliteal nerve block which was complicated by common peroneal neuritis diagnosed several days after injection. The performance of the block was not documented by the anesthesiologist and the patient developed complex regional pain syndrome which was then treated with opioids.
Interscalene Block	Denied/ Dismissed	The case involved a patient with a history of a coronary artery bypass graft undergoing a subacromial decompression and rotator cuff repair. He underwent a documented uncomplicated interscalene nerve block prior to the procedure. Post-operative course was uneventful. A month later the patient presented to the Emergency Department with shortness of breath. Imaging revealed an elevated right hemidiaphragm with associated pulmonary edema and right lung base infiltrates. He was seen by a pulmonologist and it was noted that the diaphragm elevation may be from the nerve block. Later it was noted that the diaphragm injury may have been due to his cardiac surgery and the case was ultimately dismissed.

Closed Claims - PNB

Contributing Factor	Settlement Amount (USD)	Narrative
Technical Knowledge/ Performance	\$375,000	The case involved a patient who underwent a popliteal fossa nerve block for repair of Haglund's deformity of the left heel. After confirmation of needle positioning with ultrasound and nerve stimulation, 50 mL of ropivacaine 0.5% with clonidine was injected around the sciatic nerve at the level of the popliteal fossa. Nursing notes state that the patient was complaining of pain on injection but, "not out of the ordinary," for this procedure. An additional 10 mL of ropivacaine 0.5% with clonidine was injected into the saphenous nerve. It was noted that the proceduralist had to make several passes to reach the proper location. Post-operatively, the patient developed numbness and tingling of toes and plantar surface of foot with EMG showing denervation of associated muscles. Experts noted that the amount of volume administered (50 mL) was not consistent with the standard of care (usual 30 mL) and likely contributed to the injury.
Technical Knowledge/ Performance	\$45,000	The case involved the performance of a femoral nerve block for a TKA while the patient was under general anesthesia. The patient had a post-operative course significant for weakness and ultimately diagnosed with femoral nerve neuropathy. Although the patient was consented and the procedure was documented appropriately, there was noted to be a lack of saved imaging or patient feedback during the performance of the procedure (given the patient was under general anesthesia). The claim was ultimately settled as they could not rule out an inadvertent intraneural injection.
Pre-existing Injury/ Radiculopathy	\$193,000	The case involved a patient with 4 out of 10 ankle pain and tingling after a massage 6 months prior who was ultimately diagnosed with tibial nerve neuroproxia. She underwent an anterior tarsal tunnel release after a popliteal nerve block and had worsening of her pain and tingling post-operatively. This was partly attributed to the nerve block that the plaintiff expert explained should have been avoided given pre-existing nerve injury.
Delayed Specialist Consultation	\$75,000	The case resulted from a femoral nerve block for a patient with known multiple sclerosis (MS) who underwent a TKA with resulting femoral neuropathy. The anesthesiologist evaluated the patient prior to discharge and thought weakness was secondary to a multiple sclerosis flare. The patient was discharged without escalation of care for concern of long-term neuropathy.
Documentation Error/Missing	\$30,000	The case had an expert anesthesia witness and medical consult both describing no evidence of negligence towards a patient with persistent quadriceps weakness following a femoral nerve block. Unfortunately, there was no documentation of the procedure and the case was ultimately settled for \$30,000.
Bleeding/ Coagulopathy	Denied/Dismissed	The claim was filed due to a "large unappealing bruise" covering much of the patient's neck after an interscalene block with no long-term complications.
Bleeding/ Coagulopathy	Denied/Dismissed	The case involved a retrobulbar block for cataract surgery that resulted in retinal artery damage – the patient made a full recovery and the case was ultimately dismissed.

Closed Claims - Neuraxial



Closed Claims

Opportunities for improvement with focus on safety and evidence-based care

- **Patients with existing injury or radiculopathy**
 - Consider avoiding RA, perform an alternative technique, or greater emphasis during informed consent on risk of nerve injury
- **Honest communication and discussion with patient if an adverse outcome occurs**
- **Provide thorough discharge instructions and follow-up care**

Ex-NFL player Sharif Floyd sues Dr. James Andrews and others for \$180 million

ESPN

Nov 5, 2018



Not only was the surgery unsuccessful but Floyd experienced a post-operation treatment that he says was unnecessary and that caused him irreparable injury. One of Andrews's colleagues, Dr. Gregory Hickman, performed a “post-operative adductor-canal nerve block” on Floyd—a decision that Floyd insists was done without his consent. This post-op procedure entailed the administration of substances to numb Floyd’s pain. However, Floyd notes that the “post-operative adductor-canal nerve block carried the risk of career-ending complications” and was unwarranted in the circumstances. As Floyd notes, not only did he not offer consent to the nerve block—to that point, as an

Key Points

- **Regional anesthesia has been historically safe**
 - Neuraxial injury is rare but often catastrophic
 - Peripheral nerve injury is often multifactorial and not block related
- **Most preexisting neurologic disease is not an absolute contraindication to regional anesthesia, but decision should be made on an individual, case-by-case basis**
- **Perform and document a thorough preoperative evaluation**
- **Ultrasound guidance has several benefits over other nerve localization techniques**

Clinical Pearls

- Perform a pre-procedural checklist
- Awake vs sedated vs asleep
- ***Consider risk vs benefit and obtain informed consent***
- Be vigilant and act in a timely manner
- ***Have lipid emulsion nearby***

Thank You

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