Beyond the OR: Advancing Perioperative Pain Management and Safety Across the Lifespan

GSA 2026 Winter Forum

Download the Syllabus

Peripheral nerve injury- Risks and Management

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- No Conflict of Interest

Learning Objectives

- **Describe the incidence, mechanisms, and risk factors** associated with peripheral nerve injury following regional anesthetic blocks.
- **Identify patient-specific, procedural, and block-related predictors** that increase vulnerability to nerve injury.
- **Apply evidence-based strategies to reduce the risk of nerve injury**, including ultrasound guidance optimization, and safe needle practices.
- **Develop a structured approach for evaluation and early management** of patients presenting with potential nerve injury after regional anesthesia.
- **Outline appropriate pathways for referral, follow-up, and interprofessional communication**, including indications for neurology consultation, EMG, imaging, and peripheral nerve surgery referral.

Postoperative Neurological Injury (PNI) or Post-block Neurologic Dysfunction

Defined by 2 criteria:

- patient reported, or
- evaluator identified sensory, or motor dysfunction present at minimum of 5 days after surgery with an anatomic basis to support the block contributing to neurologic dysfunction

Incidence

- PNI is difficult to determine due to the heterogeneity of studies and varying definitions of what constitutes a PNI
- The incidence of long-lasting PNI ranges from 2 to 4 per 10,000 patients

- Multiple studies have led to the American Society of Regional Anesthesia and Pain Medicine to cite the incidence between 1 and 2.2% at 3 months post injury, which falls to 0–0.2% at 1 year

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

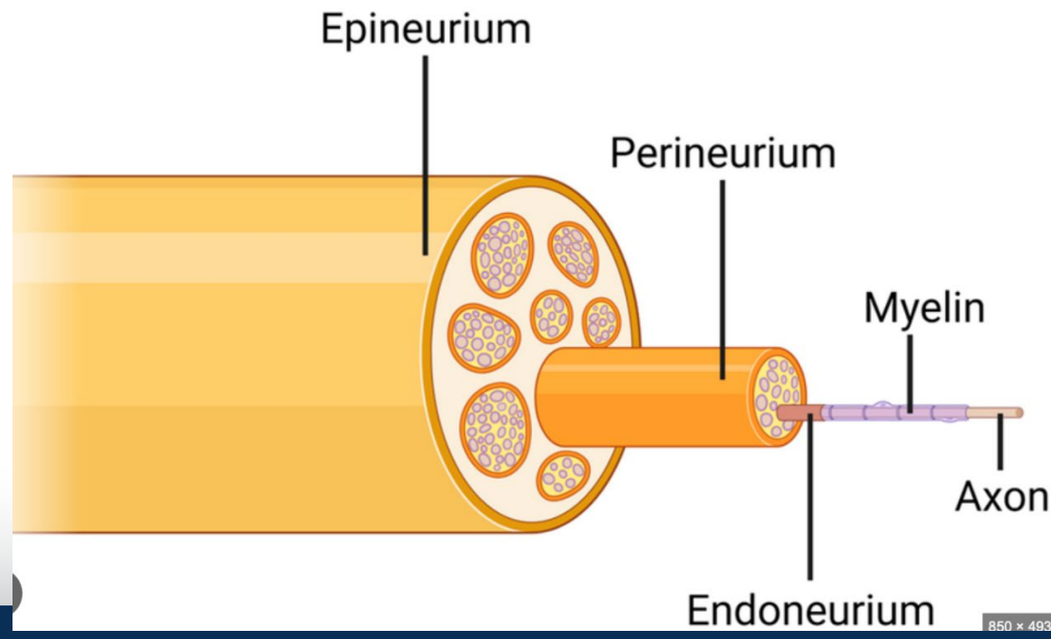
Anatomy

Peripheral nervous system comprises three types of cells: neuronal, glial, and stromal.

- Neuronal cells, or peripheral nerves- convey signals between the spinal cord and the body
- Glial cells such as Schwann cells myelinate nerves
- Stromal cells such as endoneurial fibroblasts provide structural support

Stromal cells composed of three layers:

- **Endoneurium-** encases individual axons of a nerve
- **Perineurium**- circumferentially bundles axons together into fascicles
- **Epineurium-** is dispersed between fascicles and surrounds the nerve trunk



Seddon and Sunderland Classification System for Nerve Injuries

- **Grade I (**Neurapraxia)- focal segmental demyelination without any damage to the axons or connective tissue.
- **Grade II-** the axon is damaged, but the connective tissue is intact
- **Grade III-** endoneurium is also damaged
- **Grade IV-** endoneurium and perineurium are damaged in addition to the axon.
- **Grade V-** (Neurotmesis) complete transection of the nerve and connective tissue

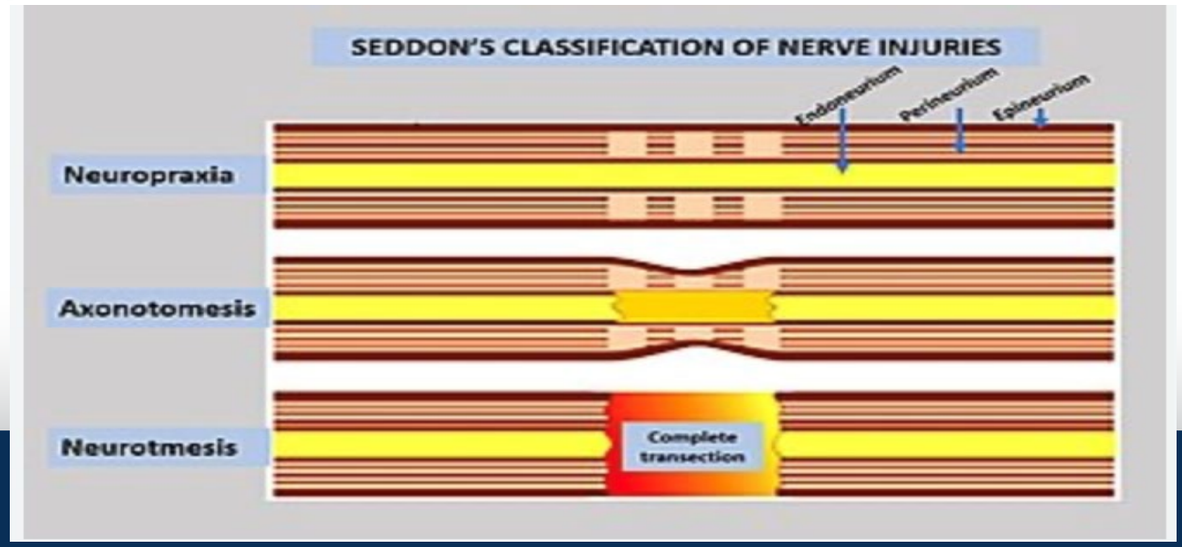


Table 1. Classification of Peripheral Nerve Injury

Sunderland[14]	Seddon[13]	Structural Damage	Fibrillation	Motor Unit Potential	Prognosis
First degree	Neurapraxia[a]	Segmental demyelination Axon preserved	–	Normal	Symptoms usually last for a few weeks, predominately affecting myelinated motor nerves Remyelination usually occurs within a few weeks No Wallerian degeneration
Second degree	Axonotmesis	Axon discontinuity Endoneurium preserved	+	+	Axonal regeneration from the site of injury to its distal target (eg, muscle) at 3–4 mm/d Regeneration is slow but usually with complete recovery
Third degree	Axonotmesis	Axon and endoneurium discontinuity Perineurium and fascicular arrangement preserved	+	+	Axonal regeneration is very slow (1–2 mm/d) Often resulted in partial recovery implying that axonotmesis may result in long-term disabilities and prolong recovery
Fourth degree	Axonotmesis	Axons, endoneurial tubes, perineurium, and fasciculi discontinuity Epineurium preserved	+	–	Axonal regeneration is very slow (1–2 mm/d) May require surgical intervention
Fifth degree	Neurotmesis	Loss of continuity of entire nerve trunk	+	–	No axonal regeneration Permanent injury is expected unless there is surgical intervention

Mechanisms of Injury

The American Society of Regional Anesthesia (ASRA) describes four mechanisms of PNI associated with regional anesthesia administration

- Mechanical
- Ischemic
- Injection
- Neurotoxic

"Humpty Dumpty had a great fall. But many of his coworkers suspect he did it intentionally just to get time off and collect disability benefits."

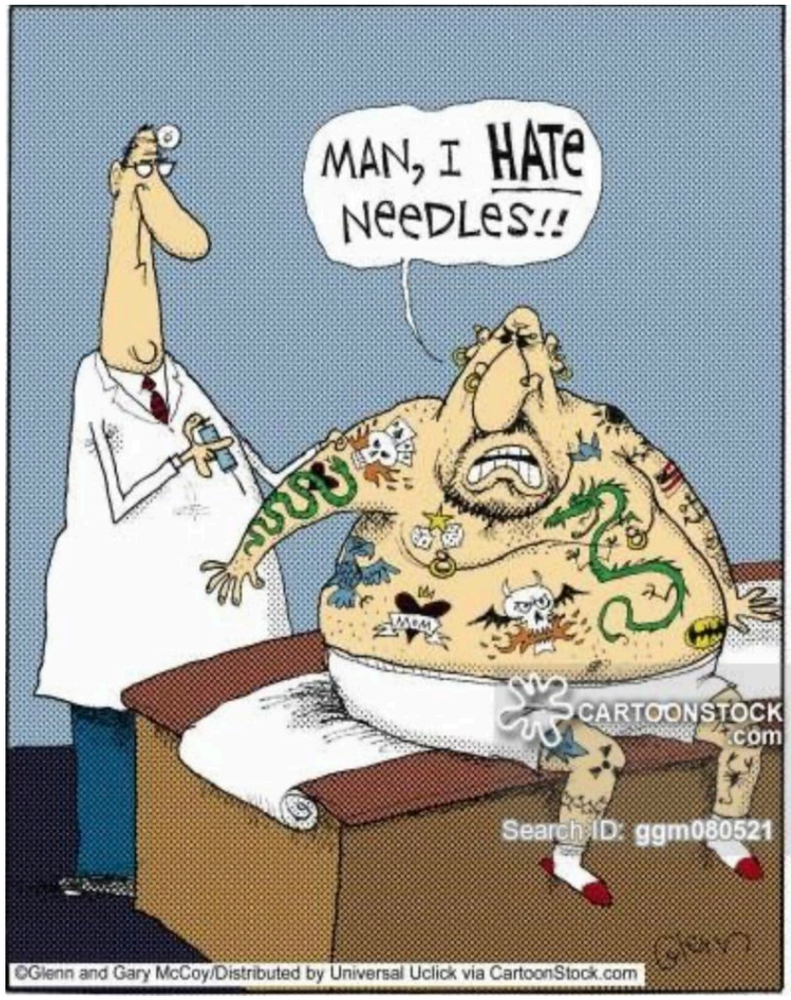
Mechanical Injury

Sondekoppam et al. found that, in animal studies, needle design was a risk factor for PNI following a regional anesthesia block:

- Long-bevel needles were more likely to penetrate fascicular bundles than short-bevel needles
- Transverse insertion of the bevel is associated with higher amounts of nerve damage than long axis insertion
- 17- and 18-G needles caused significantly more fascicular damage than 22-G needles

- Injury more likely to result from nerve contact with sharp beveled needles than with a blunt-beveled needle
- Mechanism of injury- shift in membrane channel expression, sensitivity to algogenic substances, neuropeptide production and activation of intracellular signal transduction, both at the injury site and in the cell soma in the dorsal root ganglion, leading to increased excitability at both sites

- Mechanical injury can also be caused by mechanical compression from the administration of a tourniquet



Ischemic Injury

- Hogan discusses ischemic PNI- severity is proportional to the duration of interruption of blood flow
- Tourniquet- induced neuropathy is only partly caused by ischemia; direct compression of the nerve by the tourniquet also causes nerve damage
- Ischemia can cause metabolic stress and paresthesias- in the acute phase due to depolarization of sensory neurons; followed by nerve conduction block causing loss of sensation
- Nerve function is not permanently lost at this stage
- Lunborg et al. found that nerve function can return within 6 h if ischemic time is less than 2 h

- Irreversible damage, including substantial distortion of myelin lamellae and axonal shrinkage, may ensue as early as 2 to 4 hours after tourniquet inflation
- Predominantly affects large diameter neurons
- Main findings of tourniquet-induced neuropathy are motor loss and diminished touch, vibration, and position sense, with preserved senses of heat, cold, and pain and the absence of spontaneous paresthesias

Injection Injury

- Injection of a needle around or through the nerve may be associated with injuries because of pressure effects
- Injection inside the perineurium with a high injection pressure may overcome the compliance of the intraperineural space and cause rupture of the perineurium

- High intrafascicular pressure may result in neural ischemia and inflammation if it exceeds capillary perfusion pressure, exacerbating other types of injuries
- Systematic review studying injection pressure for intraneural injections in 2019 validates this finding, reporting that high injection pressures at the needle tip were associated with an increased risk of nerve damage

Neurotoxic Injury

- PNI by the anesthetic agent is a rare phenomenon with estimated incidence ranging from 4 in 1,000 patients to 3 in one hundred
- Nouette-Gaulain et al. reports that the effect local anesthetics have on neurons includes affecting calcium homeostasis, reducing mitochondrial metabolism and thereby increasing oxidative stress and directly increasing the rate of cell death
- The net result of these processes results in a dose-dependent neuronal death, with low doses of anesthetic inducing apoptosis and a high dose inducing necrosis

- Local anesthetics produce a variety of cytotoxic effects in cell cultures, including inhibition of cell growth, motility, and survival, and may also produce morphologic changes
- The extent of these effects is proportionate to the duration that the cells are exposed to and the concentration
- Cytotoxic changes are greater as concentrations increase.

- LAs are applied in formidable concentrations during nerve block.
- Injection of 1.5% Lidocaine exposes the neural tissue to a 64mM concentration, whereas medications given by means other than regional anesthesia arrive at their target in micromolar or nanomolar concentrations

Risk Factors

- Patient risk factors predisposing to nerve injury are those which decrease the neural integrity, including systemic metabolic/toxic disease, vascular and neurogenic ischemia.
- Neuropathy can be classified as focal (along nerve course) such as nerve entrapment, demyelinating lesions, hereditary neuropathy or diffuse as caused by systemic neuropathy such as ischemic, toxic, metabolic or hereditary etiologies.

- Acquired peripheral neuropathies, such as diabetic neuropathy, alcoholic or chemotherapy induced neuropathy, predispose to peripheral nerve injury
- Judicial dosing of local anesthetic and potentially removing epinephrine to decrease ischemic injury to micro-vascularly injured neural tissue may decrease the risk of regional anesthesia

- **Postsurgical inflammatory neuropathy** is a diagnosis where an immune-mediated response to surgical stress response creates aberrant nerve conduction
- This pathology may present as focal or diffuse deficits but without anatomic distribution affected by regional anesthesia or surgical procedure.
- Inflammatory neuropathies such as Guillain-Barre syndrome and postsurgical inflammatory neuropathy have inadequate data to make strong recommendations and use of regional anesthesia should be individualized to patients

- For patients with central nervous system disorders, such as multiple sclerosis, post-polio syndrome and amyotrophic lateral sclerosis, patients are likely to exhibit neurologic deficits of various severities.
- Patients with these illnesses may have stable neurologic deficits and if so may be a candidate for regional anesthesia given the increased likelihood of worsening of neurologic symptoms regardless of anesthetic technique used
- A large retrospective study demonstrated no increased exacerbation of multiple sclerosis among obstetric patients
- However, anesthesiologists generally err on the side of caution and avoid nerve blocks which would add another risk factor for nerve deficits postoperatively.

- A recent case report utilized regional anesthesia to avoid airway manipulation in an ALS patient to avoid postoperative ventilation
- Individualized approach for patient and procedure, along with the patient's priorities and informed consent is likely the best approach for the anesthesiologist to adopt, rather than avoiding nerve blocks in a specific population.

Double Crush Hypothesis

- Upton and McComas in 1973, states that “neural function is impaired because single axons, having been compressed in one region, become susceptible to damage at another site
- Proximal neural injuries lead to higher likelihood of distal nerve injury
- Originally described as two sites of physical nerve entrapment with **cervical stenosis** and **carpal tunnel entrapment**, with the carpal tunnel syndrome not resolving despite carpal tunnel decompression
- Any disruption of axonal signaling may predispose to further injury along the neural tissue

- Ascribed to upstream poor axoplasmic flow
- Spinal canal stenosis increases with aging which can lead to poor axoplasmic flow from proximal injuries and predispose to distal peripheral injuries
- A Japanese study found that 64% of patients in their 50s and 93.1% of patients in their 80s may have moderate to severe central stenosis
- Spinal canal stenosis or lumbar disk disease may result in new or worsening of neurologic symptoms with regional anesthesia

- Patients with double crush injuries in the non-perioperative setting were found to have poorer patient-reported outcomes, less nerve recovery, and lower satisfaction after carpal tunnel release
- In the perioperative setting, especially after cardiac surgery, double crush injury is often invoked in relation to the onset of perioperative PNI

- Types of underlying neuropathy that are able to reliably predict double crush injury have yet to be determined.
- The fact that risk factors of perioperative PNI (eg, hypertension, diabetes, and tobacco use are similar to risk factors for chronic microvasculopathy and neuropathy supports the hypothesis that underlying nerve function is a major determinant of perioperative PNI

Anesthesia Closed Claims Project

- Spine, non-spine orthopedics, cardiac, and neurosurgery procedures account for 39% of PNI claims
- Most (84%) PNI claims involve an upper extremity with 36% brachial plexus, 30% ulnar nerve, 10% median nerve, and 8% radial nerve
- Closed claims data emphasize that the etiology of PNI is often not known and support the multifactorial pathogenesis and the unpredictable nature of PNI

Table 3. Patient and Case Characteristics, Severity of Injury, and Liability in Peripheral Nerve Injury Versus Other Malpractice Claims[a]

	No. (%) of Peripheral Nerve Injury Claims (n = 420)	No. (%) of Other Claims (n = 3034)	*P*
Male (n = 3438)	248 (59)	1475 (49)	<.01
Adult	416 (99)	2778 (92)	<.01
ASA physical status I–II (n = 3140)	246 (67)	1393 (50)	<.01
Emergency (n = 3293)	38 (9)	482 (17)	<.01
Age (y) (n = 3417): mean [SD]	47 [14]	46 [20]	.55
Surgical procedures			.269
Spine	60 (14)	391 (13)	
Orthopedic (nonspine)	59 (14)	522 (17)	
Cardiac	38 (9)	211 (7)	
Neurosurgery	7 (2)	59 (2)	
All other	256 (61)	1851 (61)	
Surgical position (n = 3206)			<.01
Supine	239 (59)	2120 (76)	
Lithotomy	63 (16)	158 (6)	
Prone	48 (12)	305 (11)	
Other	53 (13)	220 (8)	
Severity of injury			<.01
Temporary	162 (39)	1036 (34)	
Permanent nondisabling	156 (37)	306 (10)	
Permanent/disabling or death[a]	102 (24)	1692 (56)	
Liability			
Appropriate anesthesia care (n = 3029)	334 (91)	1540 (58)	<.01
Anesthesia payment made (n = 2532)	80 (30)	1104 (49)	<.01
Anesthesia payment amount: median (interquartile range)	$80,250 ($33,500–$285,650)	$262,500 ($81,500–$718,100)	<.01

Barriers to Early Recognition

- Patient and Caregiver Level of Education
- Professional and Trained Nurses at PACU
- Anesthetic Causes- Postoperative drowsiness, sedation, or analgesia can obscure or mask the symptoms of neurological complications
- Surgical Causes- Postoperative factors such as dressings, drains, castings, and activity restrictions can limit patient mobility and mask neurological deficits

- Multidisciplinary Team Communications- Effective neurological consultations often require detailed knowledge of the surgical procedure, regional anesthetic technique, and other intraoperative events, which can hinder accurate diagnosis
- Access to Imaging Tools- In the setting of neuraxial anesthesia, any concern of spinal cord dysfunction requires emergent neuroimaging. Diagnostic access to advanced diagnostic tools like MRI may be delayed

- Electro Physiologic Testing- Both electromyography (EMG) and nerve conduction studies (NCS) may help confirm neuropraxia with conduction block or define preexisting disease when performed acutely. The extent of a perioperative neurogenic injury will be better clarified by electro-diagnostic studies performed 3 weeks after injury

Peripheral Nerve Stimulation Vs Ultrasound Guidance

- Peripheral Nerve Stimulation (PNS) versus Ultrasound (US) in Regional Anesthesia (RS)- PNS is associated with higher risks of vascular complications such as vascular punctures and LA systemic toxicity and is time-consuming compared to the US.
- US offers comprehensive visualization of the nerve plexuses and vascular structure, decreasing complications, decreasing block setup, and enhancing patient comfort

- Recent studies comparing US-guided techniques with nerve stimulation techniques with and without stimulating catheters, indicate that US-guided peripheral nerve catheters are associated with faster placement, reduced patient discomfort, and lower failure rates than those placed with NS

Neurophysiological Studies (EMG and NCS)

- NCSs are electrophysiological tests whereby a peripheral motor, sensory, or mixed sensorimotor nerve is stimulated, and a recording is made of the motor or sensory response.
- EMG can help localize the site of a nerve injury as well as assess the severity of the injury and whether recovery is occurring

- EMG and NCS are complementary to one another and are almost always performed together, and in common practice are referred to collectively simply as EMG
- Electrophysiology testing yields its best results14–21 days after an injury.
- However, it should be considered immediately if there is a question of pre-existing injury

Prevention of Neurological Complications Following RA and Pain Interventions

- General
- Local Anesthetics
- Needles
- Technique
- Monitoring
- Education and Training

General

- Adopt evidence-based practices and updated guidelines
- Obtain adequate history and careful patient selection
- Pre-procedure assessment and physical examination
- Obtaining informed written consent before any procedure
- Document the type and the dose of the LA used
- Proper documentation of the procedure, medication, and technique
- Pre-procedure safety checklist
- Improving documentation including any potential side effects or complications

Local Anesthetics

- Fractionated injections
- Start by the smallest volume and lowest effective dose
- Avoid injection of a bolus without an aspiration test
- Choose your local anesthetic solution wisely
- Add epinephrine at a ratio of 1:200,000 to slow vascular uptake, unless it is contraindicated
- Consider neurologic signs or symptoms as a manifestation of anesthetic toxicity

Needles

- Use short bevel insulated needles
- Needles of appropriate length and diameter for each block technique
- Slow needle advancement
- Avoid needle or catheter placement without imaging devices

Technique

- Accurate localization of the nerve by using tools such as nerve stimulators and US
- Strict aseptic technique
- Avoidance of forceful, and fast injections
- Avoidance of injection against abnormal resistance
- Be careful when injecting around vessel-rich regions
- Abort injection if the patient reports pain
- Avoid performing blocks in anesthetized or deeply sedated patients
- Maintain verbal communication with the patient

Monitoring

- Emphasize the routine use of imaging techniques like US and fluoroscopy
- Blood pressure monitoring during neuraxial techniques
- Maintain verbal communication with the patient
- Describe the early symptoms of local anesthetic toxicity to patients
- Instruct patients to inform the physician if they experience any uneasiness
- Postoperative monitoring and continuous follow-up

Education and Training

- Education and simulation training for anesthesiologists
- Hand-on workshops on cadavers and live scenarios
- Full orientation by landmarks and surface anatomy
- Regular auditing and feedback

- ASA published comprehensive preventive strategies for perioperative PNI with focus on proper patient positioning, padding, and periodic assessment are important but remain insufficient to completely prevent perioperative PNI.
- Most recommended practices are based on consensus or low level of evidence (level 4–5 evidence)
- Many commonly used practices may be improperly executed and might result in failure or even paradoxical injury (such as padding the elbow too tightly)

- As local mechanical insult is not the only contributor to perioperative PNI, other types of insults (eg, sustained hypotension, inflammation) and preexisting neuronal function are often overlooked
- Therefore, a simple preventative measure that is effective in all patients is unlikely to be found.
- Prevention may require a different strategy, such as continual monitoring of nerve function in selected high-risk patients and procedures (level 5 evidence)

Intraoperative Neurologic Monitoring

- SSEP has long been used in neurology as a diagnostic test for peripheral neuropathy
- In the surgical setting, SSEP is used to assess the completeness of nerve repair, to guide peripheral nerve decompression, and to detect spinal cord injury and cerebral ischemic injury in neurosurgical procedures (level 3–4 evidence)
- Also used for early detection of peripheral nerve ischemia related to positioning in patients (level 3–4 evidence)

- One prospective study during cardiac surgery found a high proportion (23/30 patients) of abnormal SSEP and PNI (6 patients, level 3 evidence).
- Cardiac surgery patients with persistent (until the end of surgery) and severe (>3 SD) abnormal SSEP progressed to PNI, suggesting that there may be a “dosing effect” predisposing to PNI and that SSEP may be a reliable monitor to predict PNI.
- In contrast, another prospective study found that while 75% of 20 cardiac surgery patients had abnormal SSEP signals, none developed PNI (level 3 evidence)

- SSEP, MEP and EMG have been assessed for detection of surgery-related nerve injury during TSA, rotator cuff repair, humerus surgery and arthroscopy.
- These studies reported high incidences of signal changes (level 3 evidence), implying a high burden of nerve insults.
- Another study compared the susceptibility of median, ulnar, and radial nerves to ischemic insult and showed heightened ulnar vulnerability (level 4 evidence)

- Use of SSEP monitoring for intraoperative detection of PNI is appealing as most perioperative nerve insults are potentially reversible and treatable (level 5 evidence)
- However, the diagnostic accuracy of SSEP specific for PNI is yet to be determined, and it is also unclear if SSEP can decrease the risk of developing PNI.

Management Strategies of Neurological Complications Following Regional Anesthesia and Pain Interventions

- Requires multidisciplinary and multimodal approaches to ensure optimal outcomes
- Discontinue LA infusions
- Thorough assessment is vital and includes detailed history taking, physical examinations, and diagnostic imaging to assess the extent of neurological injury
- Early neurological consultation for an unbiased diagnosis
- Order diagnostic imaging and neurophysiological studies
- Initiating a physical therapy and rehabilitation program

- Initial medical treatment management includes rest, analgesics for pain, and adjuvants such as anxiolytics, muscle relaxants, and corticosteroids when indicated.
- Neuropathic pain is managed pharmacologically by antidepressants and anticonvulsants guided by the practice guidelines
- Corticosteroids are beneficial if significant inflammation is suspected or spinal cord injury resulting from direct trauma or interventional pain procedure.

- Collaborations with neurologists, neurosurgery, physical therapists, and rehabilitation specialists are essential to develop effective multidisciplinary team management
- In severe cases, neurosurgical interventions may be necessary for surgical decompression (e.g., epidural hematomas or abscesses) or when there is evidence of nerve injury

- Outcomes for compressive lesions (epidural hematoma or spinal epidural abscess) are dependent on the severity of neurologic impairment and the duration of symptoms at the time of neurosurgical decompression.
- Neurologic recovery is improved with early decompression (< 8–12 h from symptom onset in epidural hematoma and < 36 h from symptoms onset for spinal epidural abscess)

New Developments in Intraoperative Monitoring

- Routine clinical application of SSEP monitoring is currently limited due to large machine size, need for a designated technician and/or neurophysiologist, and a nonintuitive user interface.
- Recent report of using an automated SSEP technology for detection of PNI in 33 cardiac surgery and 21 total shoulder arthroplasty patients (level 3 evidence).
- This automated device consists of a small control box, a Bluetooth-enabled tablet, stimulation and acquisition cables, and non-needle stimulation and acquisition surface electrodes.

- Uses a novel proprietary algorithm for SSEP signal acquisition and optimization and a new automated electrocautery suppression technology for artifact rejection, which largely precludes the need of troubleshooting the technical issues during monitoring.
- An automated signal interrogation algorithm computes and updates the latency and amplitude content of each SSEP signal relative to baseline and signals an alert when relative amplitude decreases by 50% or latency increases by 10%.

Limitations

- Current diagnostic criteria for abnormal SSEPs is largely based on data derived from detection of spinal cord injury where direct surgical trauma to the nerve results in permanent damage
- Such all-or-none approach ignores the “dosing effect” where the duration and severity of insult are influenced by underlying neuronal reserves and may be ameliorated by early detection and prevention.
- There are no studies demonstrating prevention of perioperative PNI (not just nerve ischemia) by performing SSEP monitoring.
- The prevention of PNI by SSEP monitoring is therefore only supported by mechanistic level 5 evidence.

Conclusions

- PNI is defined as a severe nerve insult that resulted in the loss of anatomical nerve integrity, manifest by symptoms and signs, including, but not limited to, numbness, paresthesia, tingling, pain, or muscle weakness
- The overall incidence of perioperative PNI after general anesthesia is <1%
- Perioperative PNI is a multifactorial disease
- Stretching, compression, ischemia, and inflammation are the potential causes of perioperative PNI

- The most effective strategy for preventing neurological complications associated with regional anesthesia and pain interventions is strict adherence to evidence based clinical guidelines.
- Key preventive measures include appropriate patient selection, comprehensive preoperative assessments, proper utilization of the imaging tools, and continuous monitoring of the patients.

- Early recognition of neurological deficits is crucial for immediate interventions and improved patient outcomes
- Effective management of neurological deficits requires multidisciplinary teamwork, including anesthesiologists, neurologists, physical therapists, and rehabilitation programs to enhance patient safety and ensure optimal recovery.
- Recent development of automated SSEP monitoring technology in nerve function may help to detect nerve ischemia and prevent PNI

THANKS

AUGUSTA UNIVERSITY

Pain During Cesarean Delivery

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No Financial Disclosures

Objectives

1. Raise awareness of pain
2. Prevent the occurrence of pain during cesarean deliveries
3. Provide guidance for treating intra-op pain
4. Encourage tracking and researching cesarean pain

C-sections are the most common operation performed in the US

~1.2 Million annually

32% of all births


The
Retrievals
Season 2


The
Retrievals
Season 2

Clara Received

- Ketamine 150 mg
- Fentanyl 300 mg
- Midazolam 6 mg
- Nitrous oxide

For any other surgery, Clara would have been converted to General Anesthesia. So why wasn't she?

Review of Anesthesia-Related Maternal Mortality showed increased risk with GA compared to Regional

Table 3. Case Fatality Rates and Rate Ratios of Anesthesia-Related Deaths During Cesarean Delivery by Type of Anesthesia in the United States, 1979–2002

	Case Fatality Rates*		
Year of Death	General Anesthetic	Regional Anesthetic	Rate Ratios
1979–1984	20.0	8.6	2.3 (95% CI 1.9–2.9)
1985–1990	32.3	1.9	16.7 (95% CI 12.9–21.8)
1991–1996	16.8	2.5	6.7 (95% CI 3.0–14.9)
1997–2002	6.5	3.8	1.7 (95% CI 0.6–4.6)

CI, confidence interval.
* Deaths per million general or regional anesthetics.

HAWKINS ET AL ANESTHESIA-RELATED MORTALITY IN THE UNITED STATES 2011

Obstetric anesthesia practice has changed drastically over the past 40 years

Retrospective study in UK reported a decrease in the use of General Anesthesia for Cesarean Delivery from **76%** in 1982 to **7.7%** in 1998 to **4.9%** in 2008

Neuraxial Anesthesia is the "Gold Standard" for Cesarean Delivery

- Study of more than 14,000 general anesthetics for cesarean delivery, an overall risk of **difficult intubation of 1:49** and a risk of **failed intubation of 1:808** were observed
- Lower APGAR scores for neonates delivered under GA compared to spinal
- Higher blood loss
- Increased perioperative morbidity and mortality
- Better post-operative pain with neuraxial opioids

ANESTHESIOLOGY 2022; 136:697–708)

Society of Obstetric Anesthesia and Perinatology recommends a General Anesthesia rate of <5% for all c-sections (<1% if elective).

Effort should be made to avoid unnecessary general anesthetics.

95% of women experience their c-section awake

I feel pain, not pressure: a personal and methodological reflection on pain during cesarean delivery

Rachel Somerstein, PhD, MFA

Failure of communication: a patient's story

Susanna E.R. Stanford [a] · David G. Bogod [b]

Original Article

Pain during cesarean delivery: A patient-related prospective observational study assessing the incidence and risk factors for intraoperative pain and intravenous medication administration

Jose Sanchez, Rohan Prabhu, Jean Guglielminotti, Ruth Landau

ANESTHESIOLOGY®

Intraoperative Pain during Cesarean Delivery under Neuraxial Anesthesia: A Systematic Review and Meta-analysis

Elinor A. Charles, M.B.B.S., Hester Carter, Mb.Ch.B., Susanna Stanford, B.Sc., Lindsay Blake, Ed.D., Victoria Eley, Ph.D., Brendan Carvalho, M.B.Bc.H., Pervez Sultan, Mb.Ch.B., Justin Kua, M.B.B.S., James E. O'Carroll, M.B.B.S.

ANESTHESIOLOGY 2025; 143:156–67

- 34 articles
  (23 Randomized-Controlled Trials)
- **Patient reported** intraoperative pain
- 25 studies on scheduled elective cesarean

Incidence of Pain During Cesarean

- **Overall Incidence 17%**
- Spinal 14%
- CSE 18%
- Epidural top-offs 33%

Intraoperative Pain can have lasting Psychological effects

- PTSD
- Post-Partum Depression
- Avoidance of Medical System
- Avoiding having more children

Types of Pain Felt

TABLE 1
Nerves responsible for pain during and after cesarean delivery

Incisional pain	**Residual sensations**
Ilioinguinal nerve	Burning, shooting, hypersensitive pain around the scar (neuropathic pain). Pain located around the scar, groin and upper thigh
Iliohypogastric nerve	
Genitofemoral nerve	
Lateral femoral cutaneous nerve	
Uterine manipulation	**Acute symptoms**
Sympathetic nerves from the inferior hypogastric plexus (T10—L1)	Deep visceral pain, nausea, and vomiting
Parasympathetic fibers from the pelvic splanchnic nerves (S2—S4)	
Shoulder tip pain	**Referred pain**
Phrenic nerve (C3—C5)	Due to irritation of the diaphragm

Landau, R. AJOG. Jan 2026

Patient Predictors of Increased Pain during Cesarean

- History of pain during cesarean
- Fear of pain
- High BMI
- Repeat cesarean
- Prior spine surgery
- Chronic pain
- Opioid use disorder

Understanding a patient's risk for pain can help counsel them pre-operatively and develop a shared plan for treating pain if it occurs.

Other Risk Factors for Intraoperative Pain

- Urgent/emergent cesarean
- Intrapartum breakthrough pain
- Increased pain <2 hrs prior to cesarean
- Chorioamnionitis
- Duration of cesarean
- Exteriorization of the uterus

Predictors of Failed Labor Epidural to Surgical Anesthesia

- Epidural procedure without dural puncture
- More than 2 top-ups during labor
- Inadequate motor blockade
- Sensory level below T5

Strategies to Prevent Pain

1. Adequate counseling about risk of experiencing pain
2. Choice of anesthetic (Spinal > Epidural)
3. Active management of labor epidurals (check levels Q3-4 hrs)
4. Replace inadequate analgesic epidurals
5. Consider new neuraxial prior to c-section
6. Addition of neuraxial opiates

American Journal of Obstetrics & Gynecology
JANUARY 2026

Management of Pain

- Acknowledge patient's expression of pain
- Treat the pain
- Anxiolysis and sedation should not be used to treat pain
- STOP THE SURGERY
- If pain does not resolve, convert to General Anesthesia

Treatment Options for Intraoperative Pain

IV supplementation

- 1st line pain: Opiates
- 2nd line pain: Ketamine, Precedex

Anxiety: Midazolam

Nitrous Oxide: relatively ineffective for pain, causes sedation and hallucination

Dose epidural (2% Lidocaine with epi, 3% Chloroprocaine, Fentanyl, Clonidine)

Conversion to General Anesthesia

Next Steps

1

Develop protocols for treating intraoperative pain

2

Each institution should track incidence of pain and follow-up with patients

3

More research needed on pain during cesarean delivery

On the Horizon

SONAR 1	Estimate the incidence of pain during cesarean Describe how intraoperative pain is managed Evaluate Day-1 and 6-week reported pain outcomes Evaluate the physical and psychological impacts on patients
EAGLET-CD	RCT of early conversion to GA after 2 attempts of pain treatment

Conclusions

1. 1/6 patients may be experiencing intraoperative pain
2. Pain during cesarean can lead to PTSD
3. Identifying risk factors for pain can provide better informed consent and management options
4. Use strategies to prevent intraop pain
5. Develop protocols for pain treatment
6. Be willing to convert to GA
7. More research is needed to know the true incidence and effect of pain during cesarean

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"If you don't like something, change it. If you can't change it, change your attitude."

-

Maya Angelou

Dr. Vipin Bansal, MD
Children Healthcare of Atlanta
Emory University

Financial Disclosures

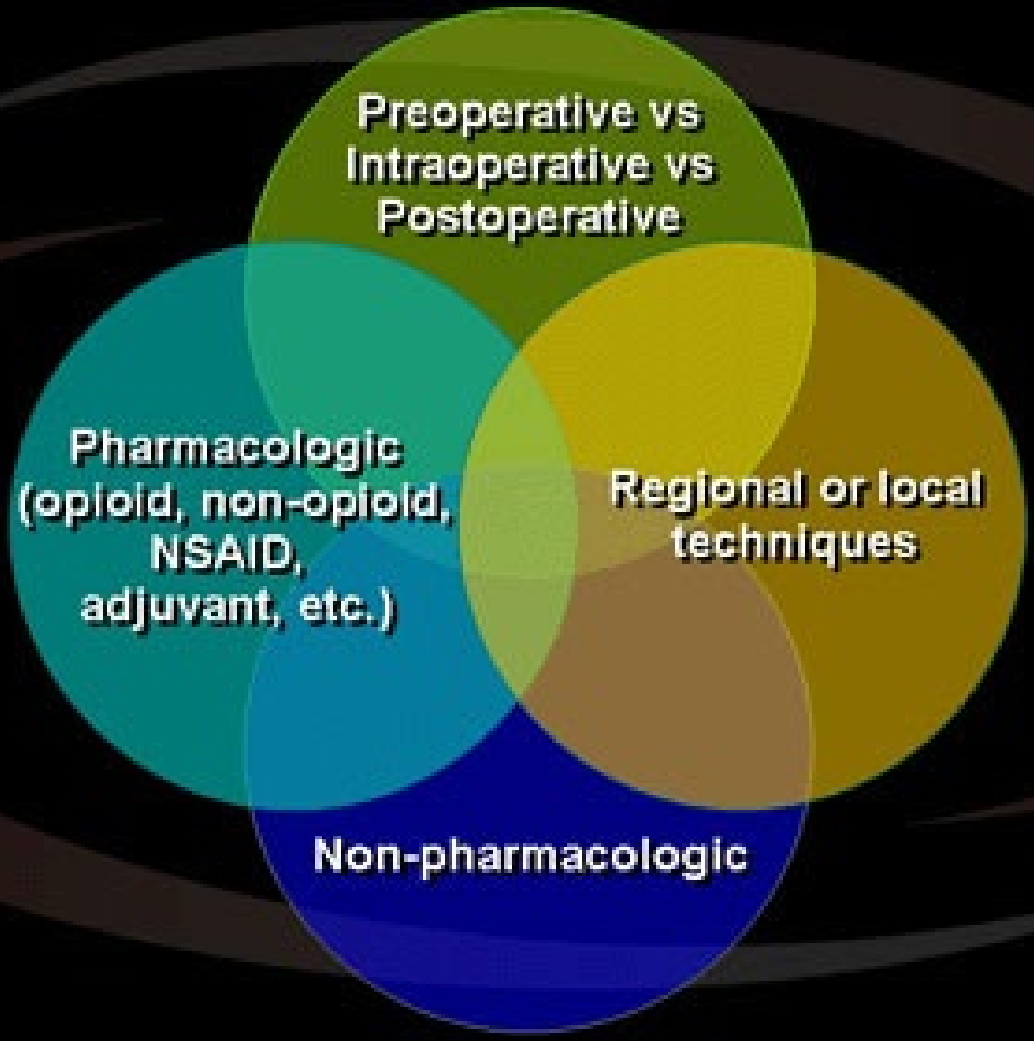
No financial disclosures

http://monkeyartawards.typepad.com/.a/6a00e5
5097ba2488340105361 9f88f970b-800wi

Outline

1) Multimodal
2) Neuraxial
3) Nerve Blocks
4) Plane Blocks
5) Neuromodulation
6) Future is here

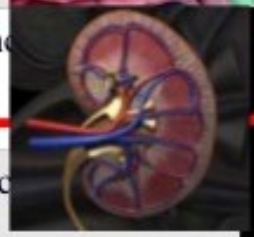
Considerations for Multimodal Therapy in the Perioperative Period



Side effects of our pain meds

Side effects of Opioid vs NSAID

	Opioids	NSAIDs
Side effects	Nausea /Vomiting	GI tract ulcer
	Constipation	Renal dysfunc
	Sedation (Titration)	Liver dysfunc
	Pruritis	Aspirine asthma
	...iratory ... rare)	

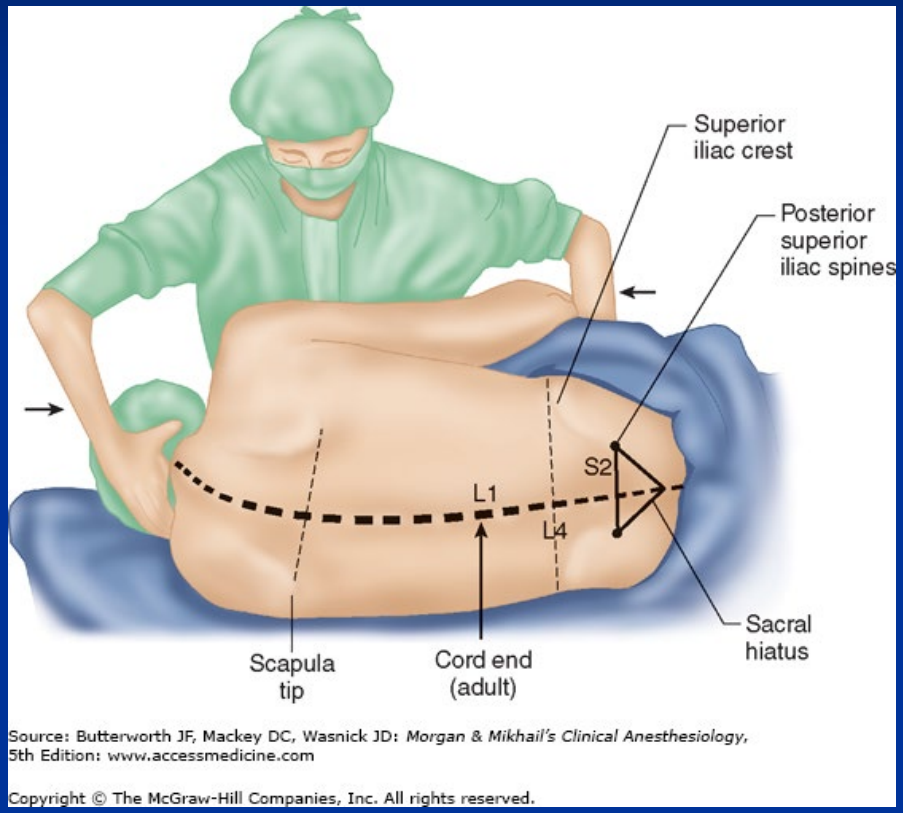


- we can see it immediately
  - ⇒ Rapid effect of opioid
- Easily treated
  - ⇒No organ damage.

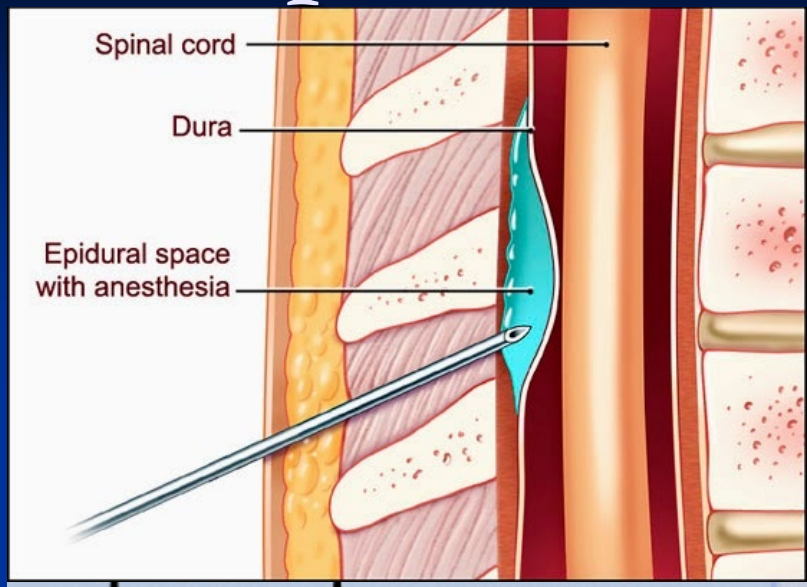
- Not immediately seen
  - ⇒Slow effect, usually masking
- Sometimes life threatening
  - ⇒ NSAID can damage GI & Kidney

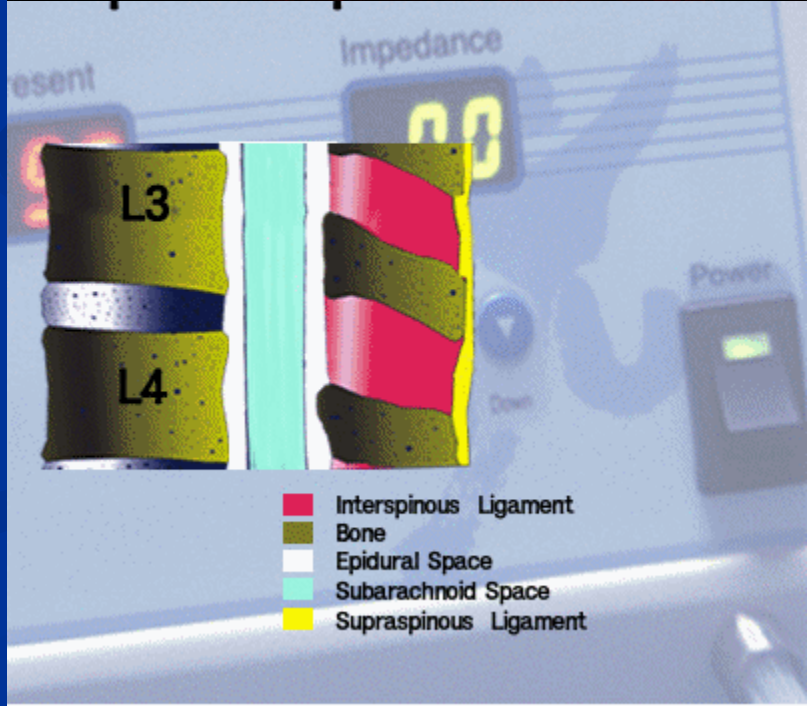
13

Neuraxial Anesthesia – epidural



Source: Butterworth JF, Mackey DC, Wasnick JD: *Morgan & Mikhail's Clinical Anesthesiology*, 5th Edition: www.accessmedicine.com





Neuraxial Anesthesia

- Central – caudal, spinal

Using ultrasound for caudal placement

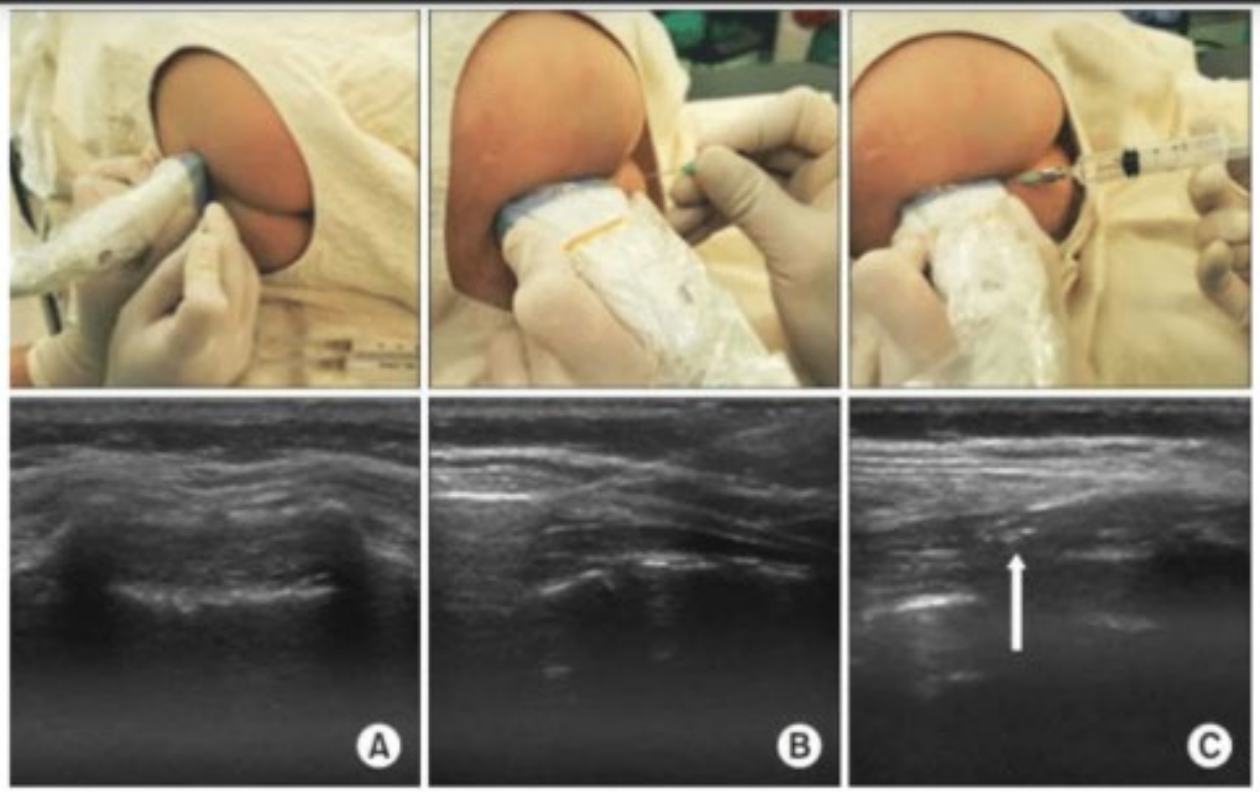
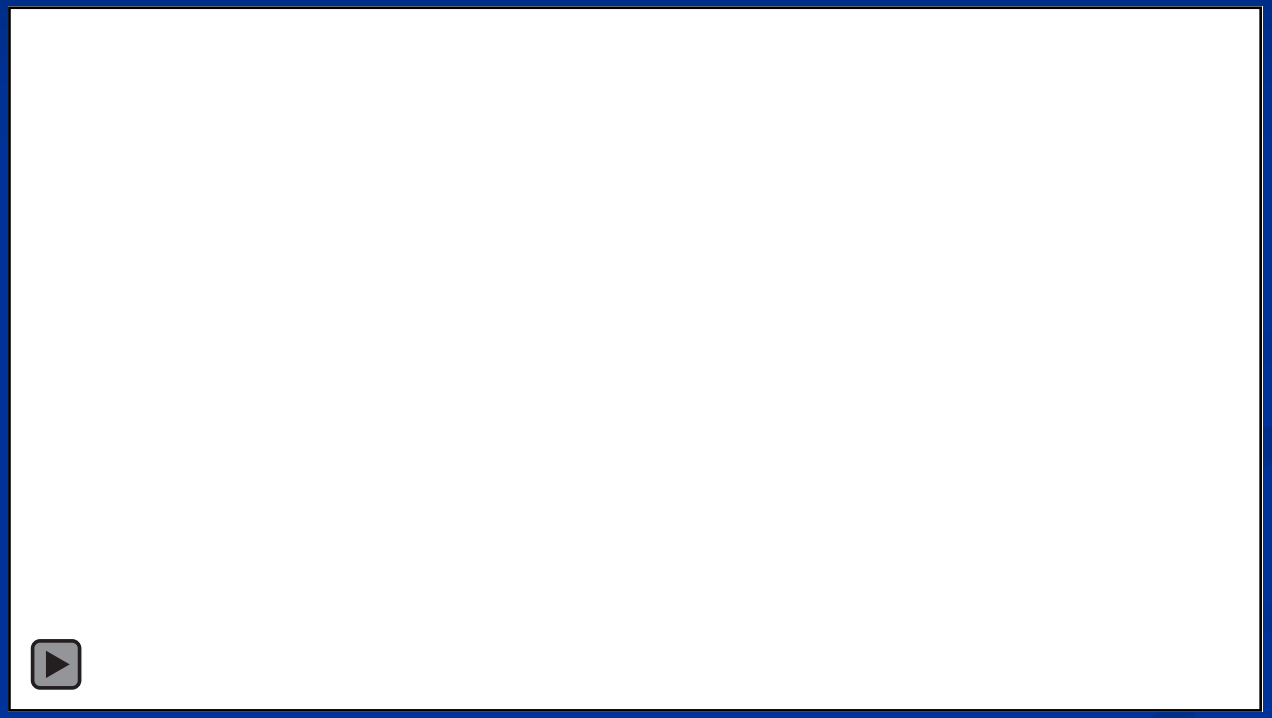
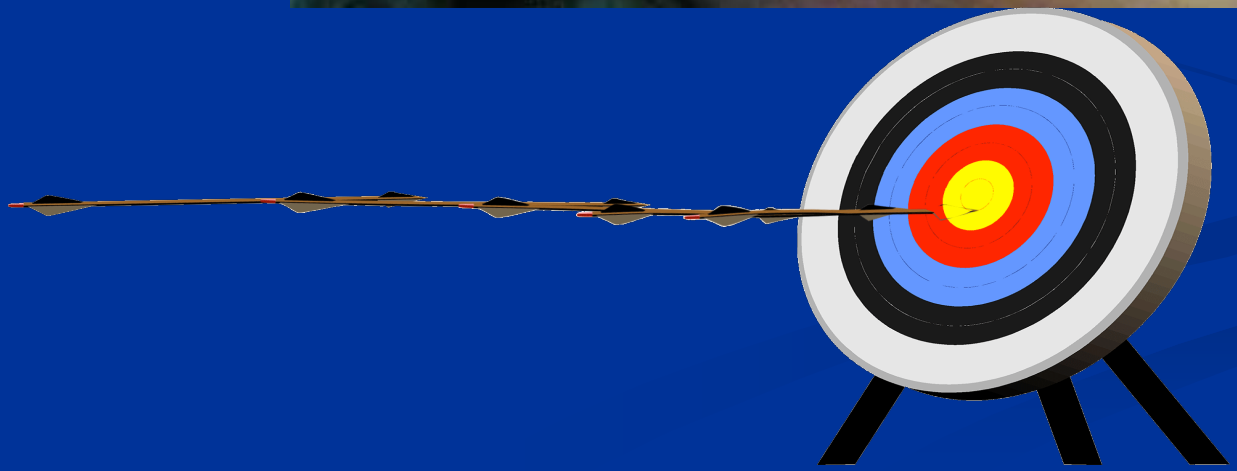


Figure 6. (A) Transverse scan (illustrating the 'frog's eyes' of the cornua), followed by (B) longitudinal scan with needle in caudal space, followed by (C) local anaesthetic in caudal space (arrow). Permission to use ultrasound image granted by Professor HK Kil, Yonsei University College of Medicine, Seoul, South Korea.

Real Time Caudal Injection

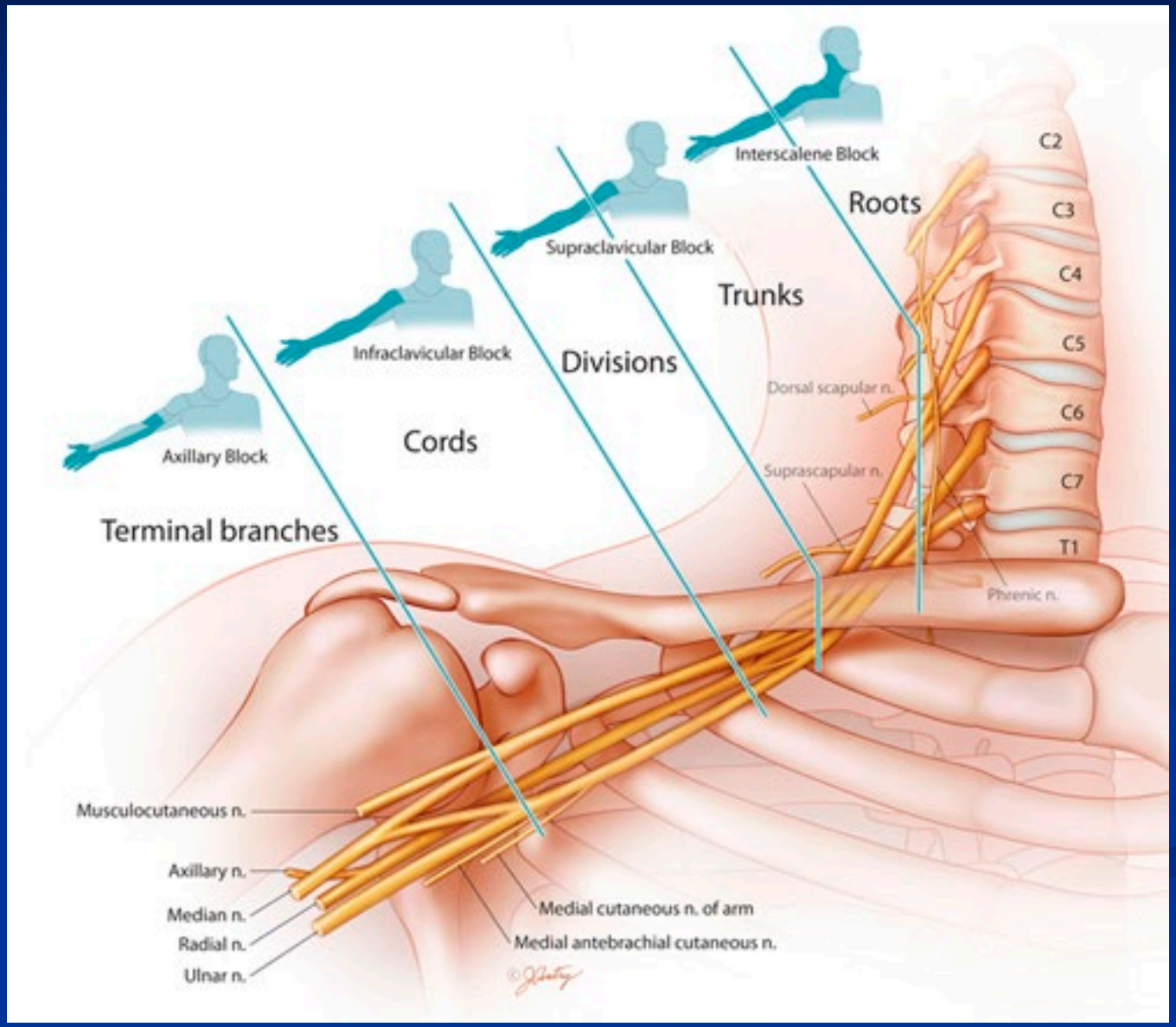


Regional Anesthesia

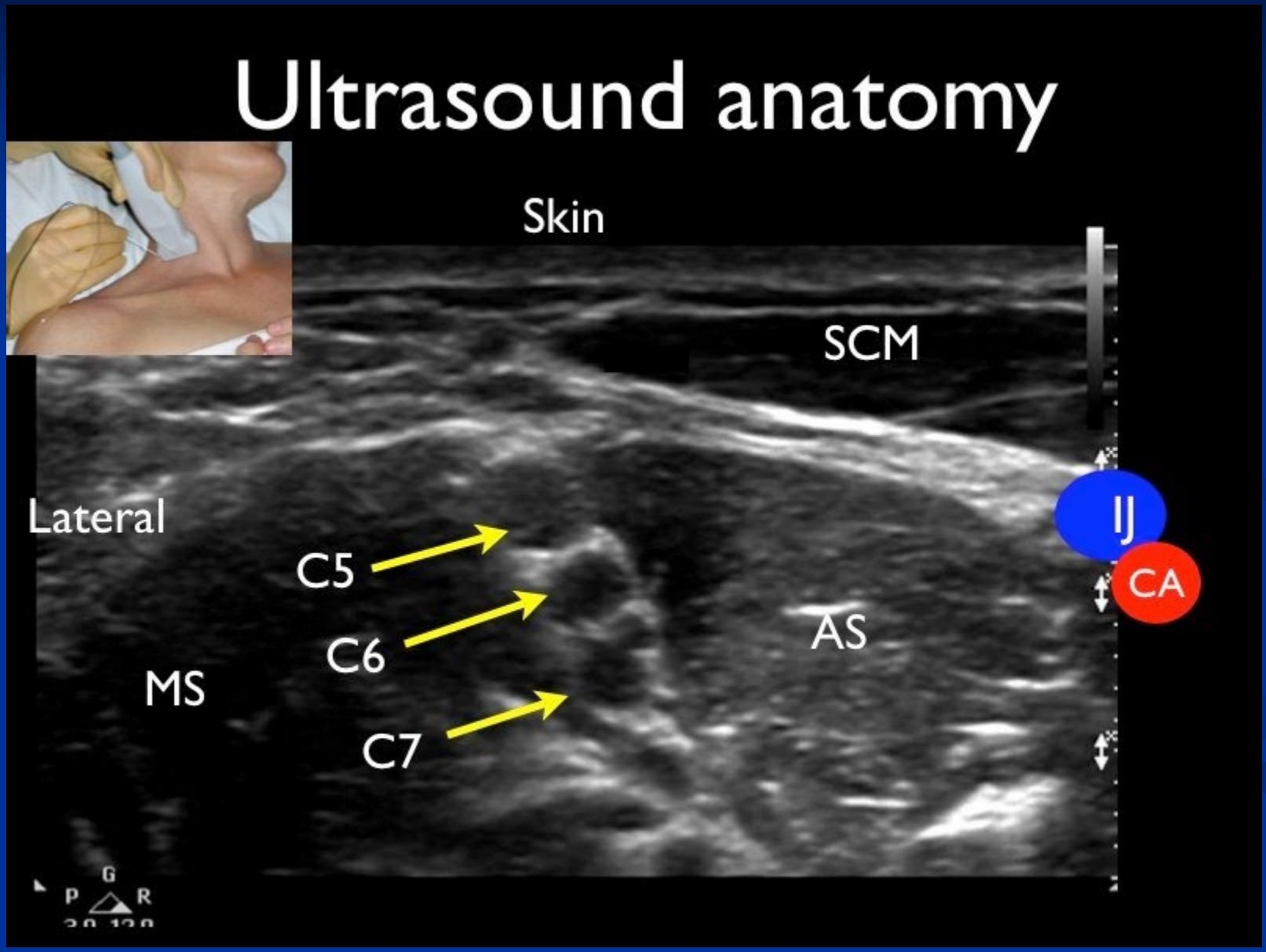


Upper Extremity Fracture

Upper Extremity

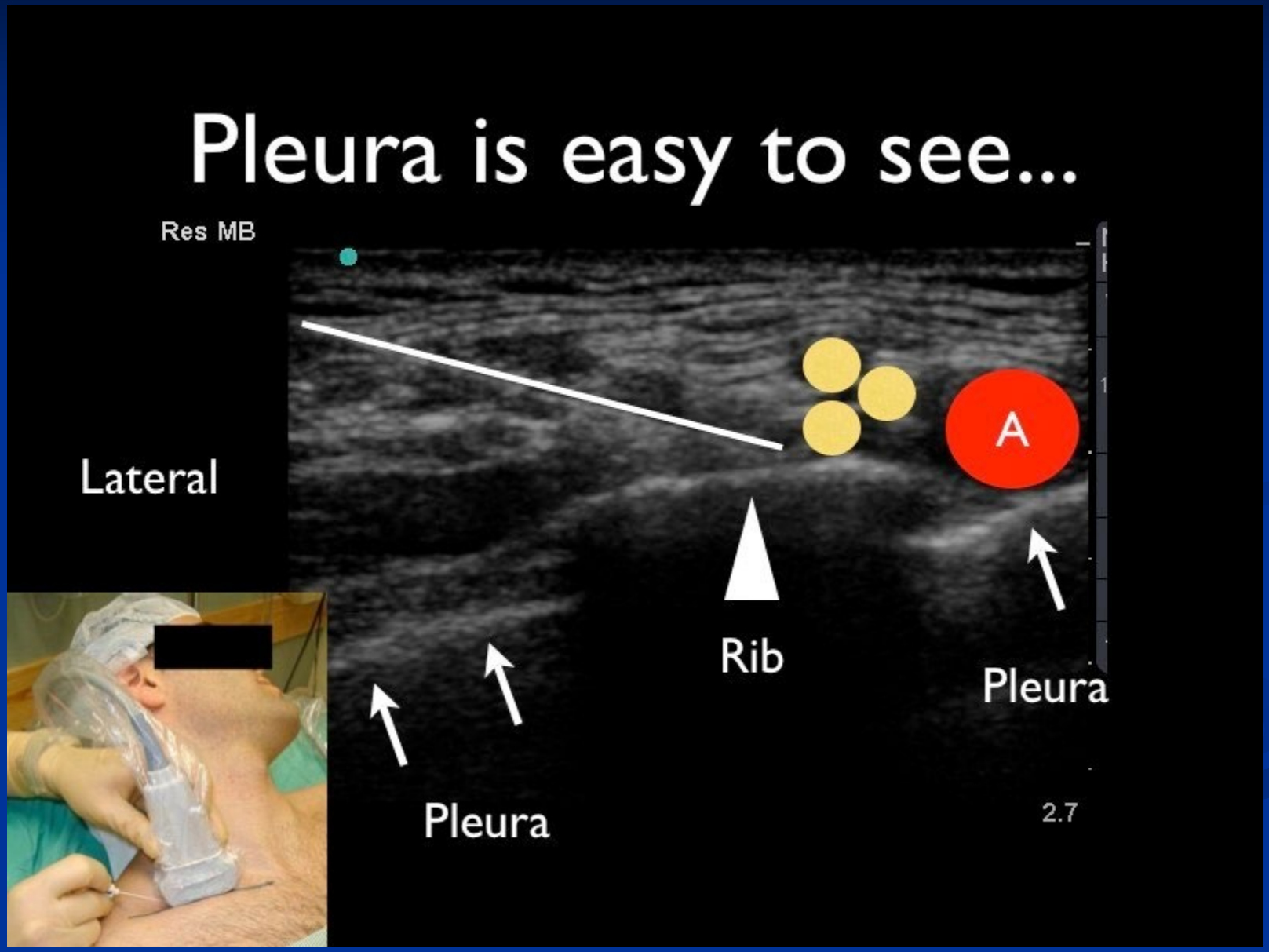


Interscalene Nerve Block

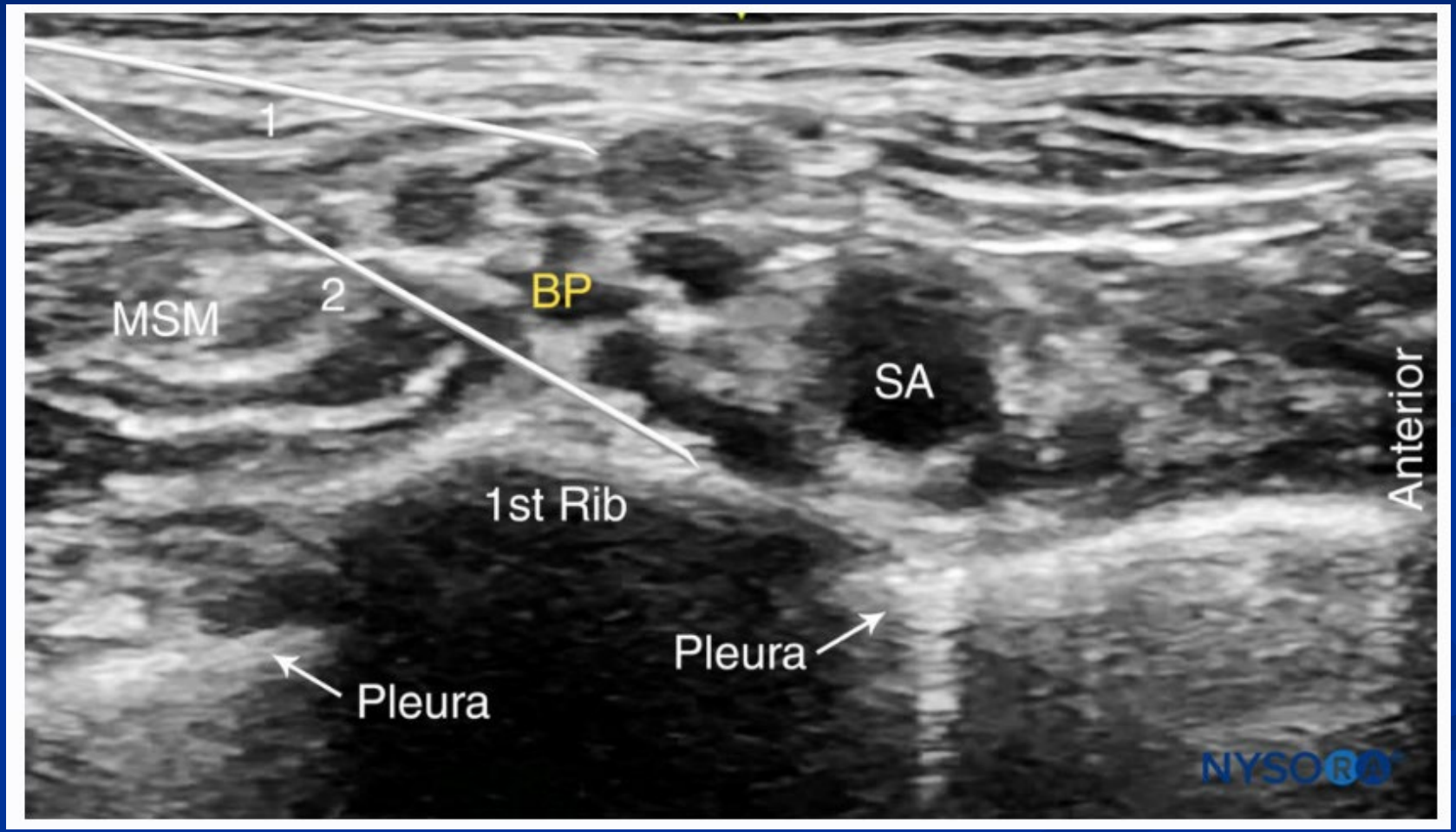


Interscalene catheter in 6 mo old for forearm amputation

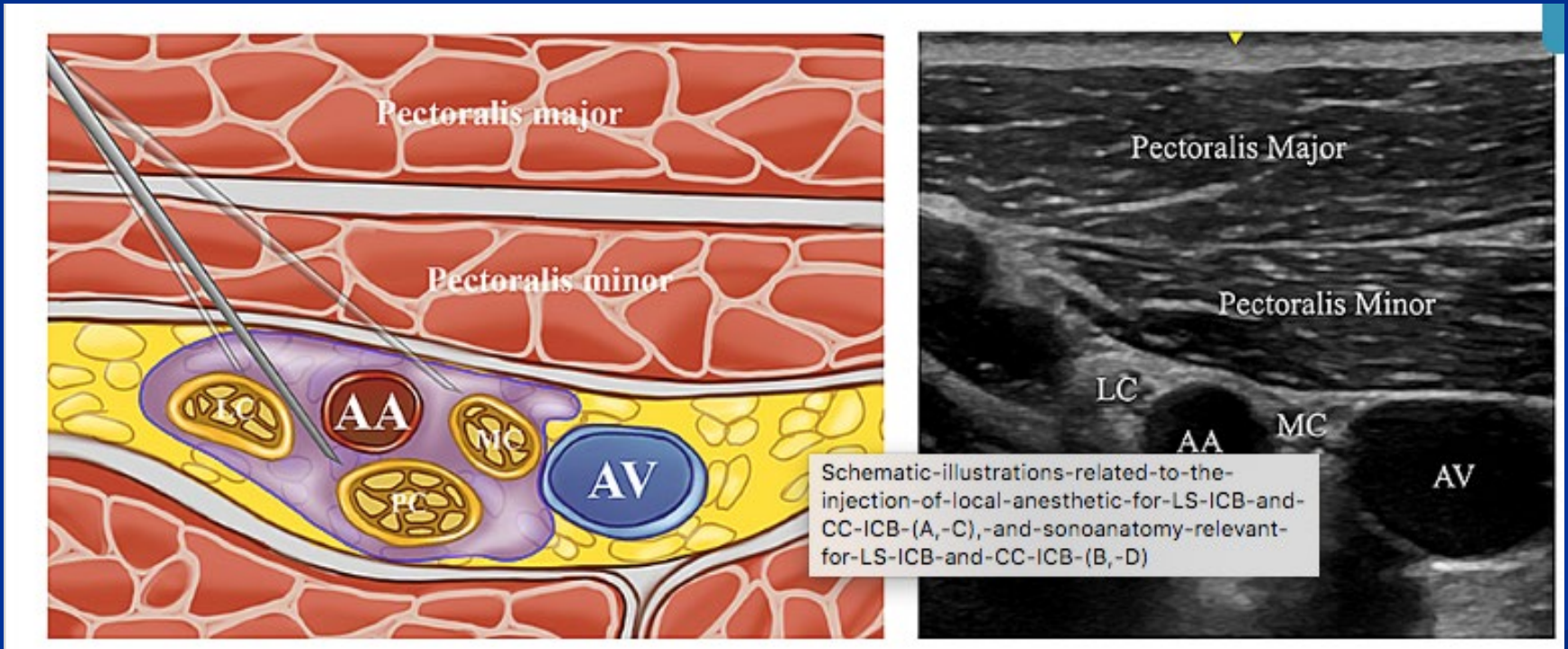
Supraclavicular Nerve Block



Supraclavicular Nerve Block



Infraclavicular N Block



Pediatric trick: Use probe with lowest footprint

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Locations Providers

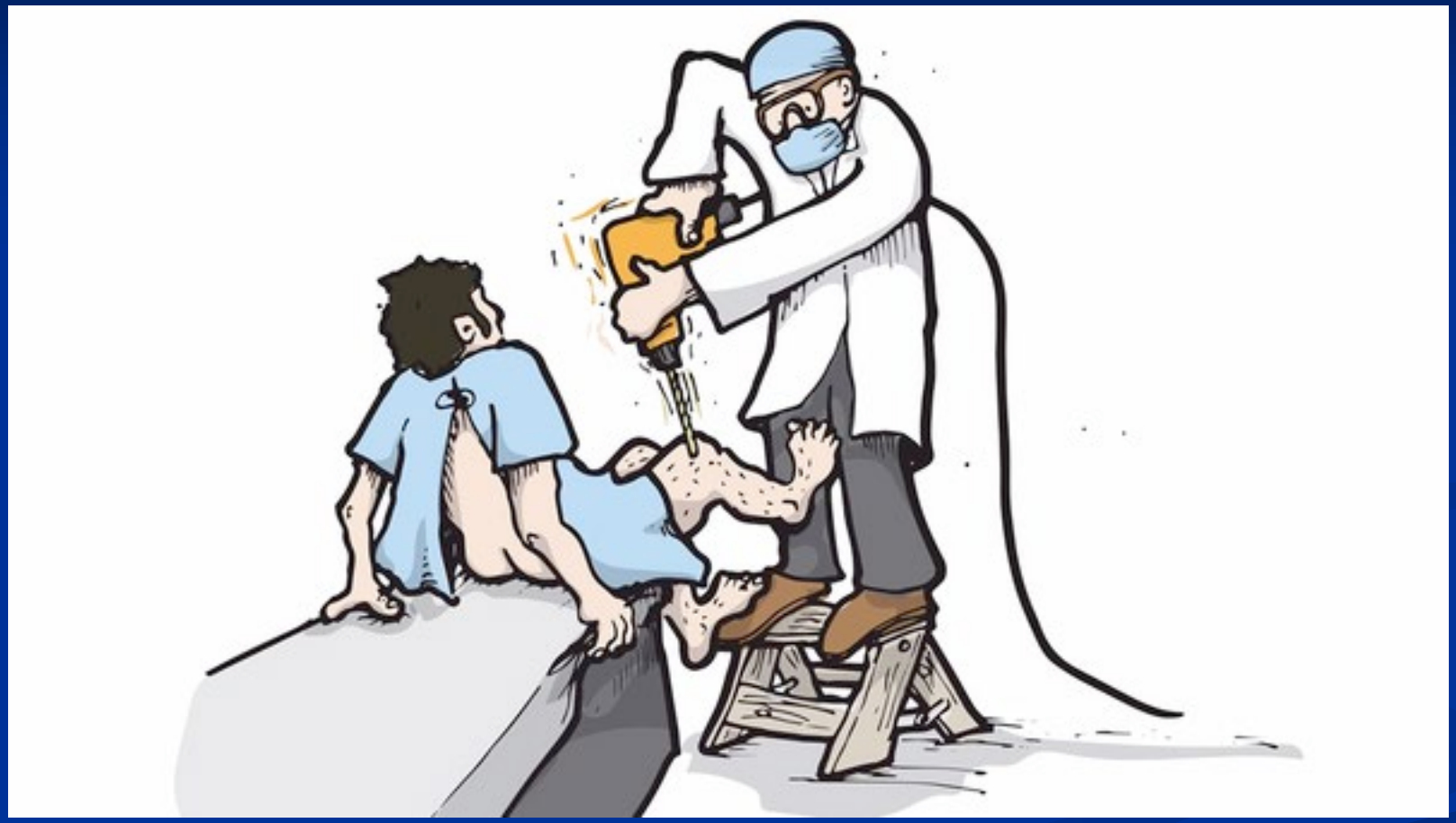
Search / Taylor William Grice, MD

Taylor William Grice, MD

Anesthesiology

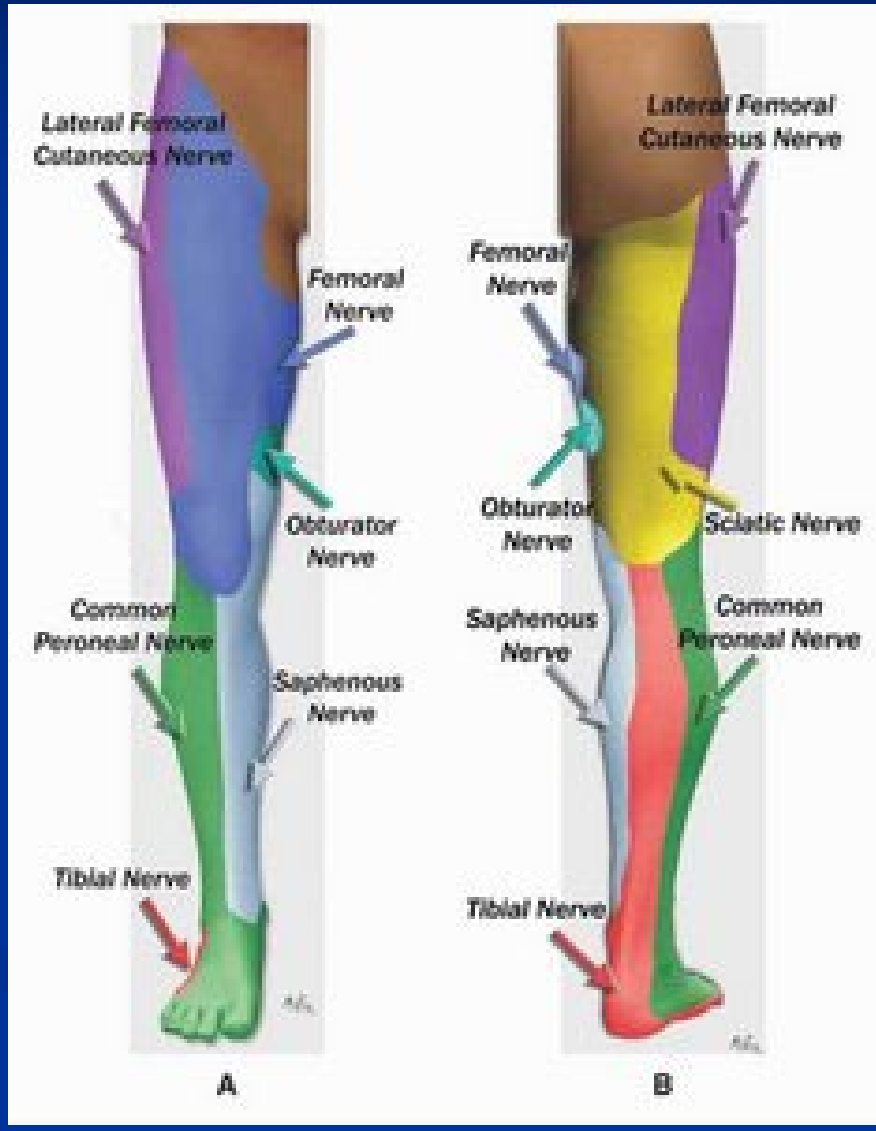
Accepting New Patients

Lower Extremity

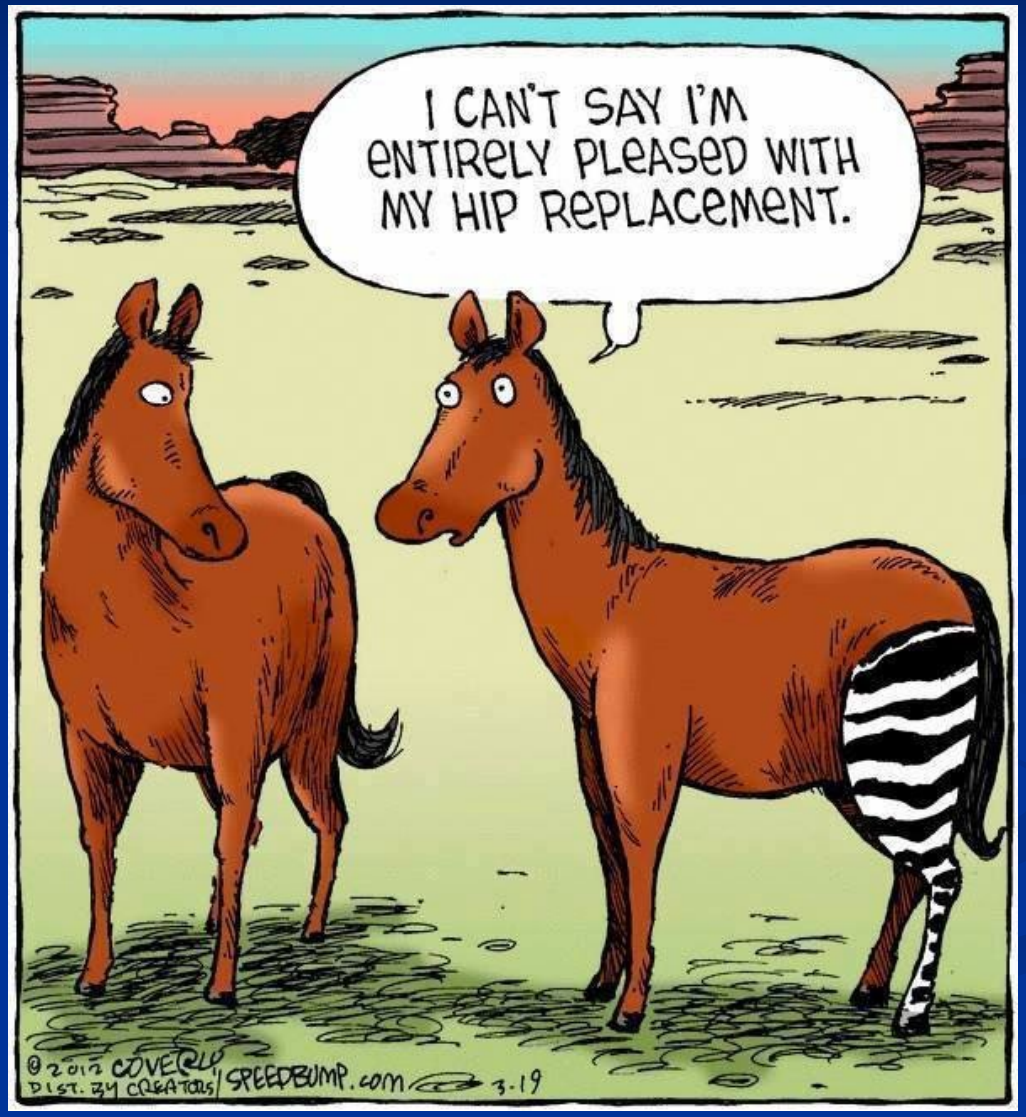


Lower Extremity Ultrasound Guided Regional Nerve Blocks

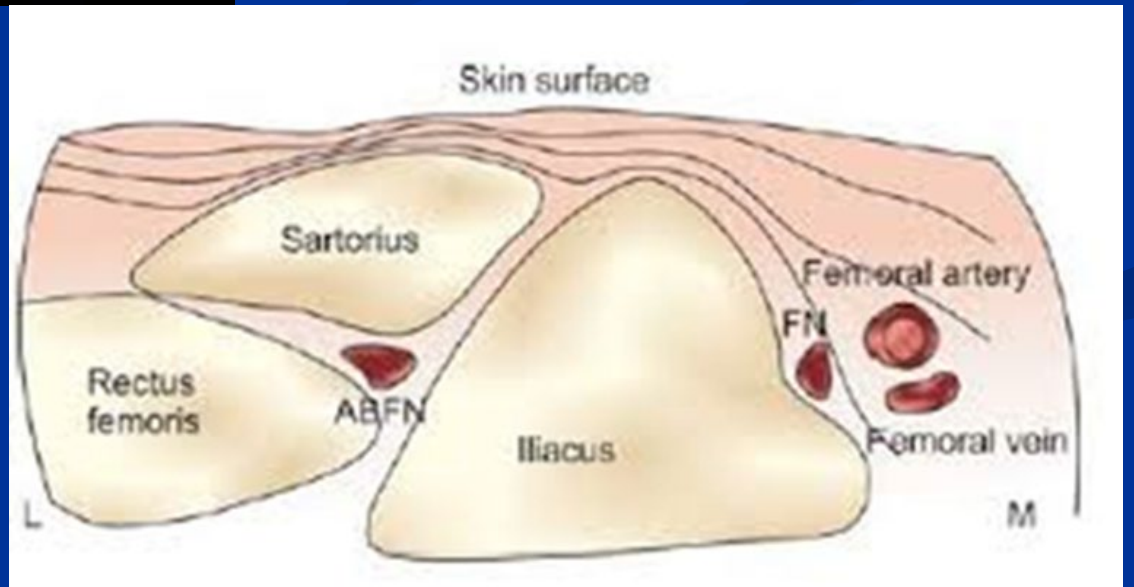
- Fascia Iliaca
- PENG
- Femoral
- Adductor Canal
- Sciatic (popliteal)
- Ankle



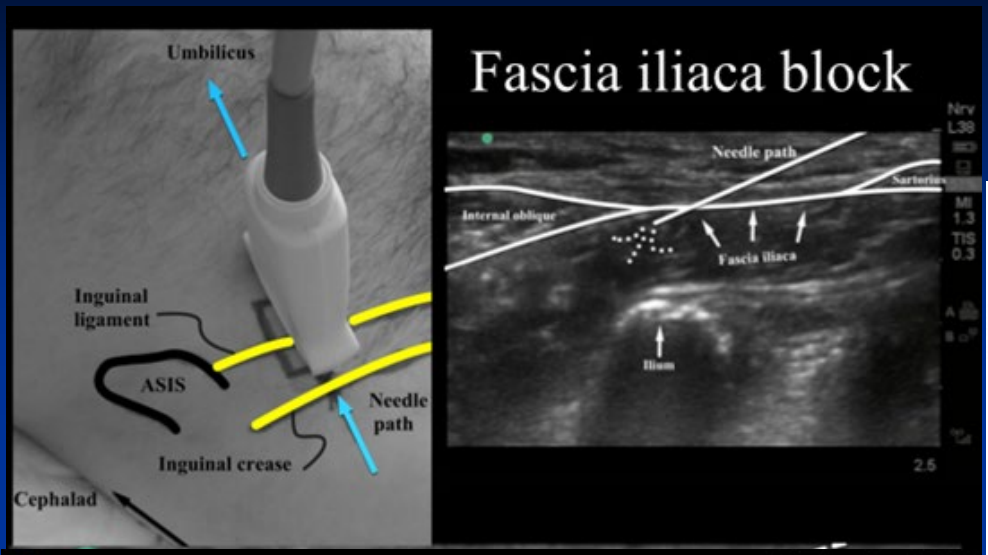
Hip Surgery

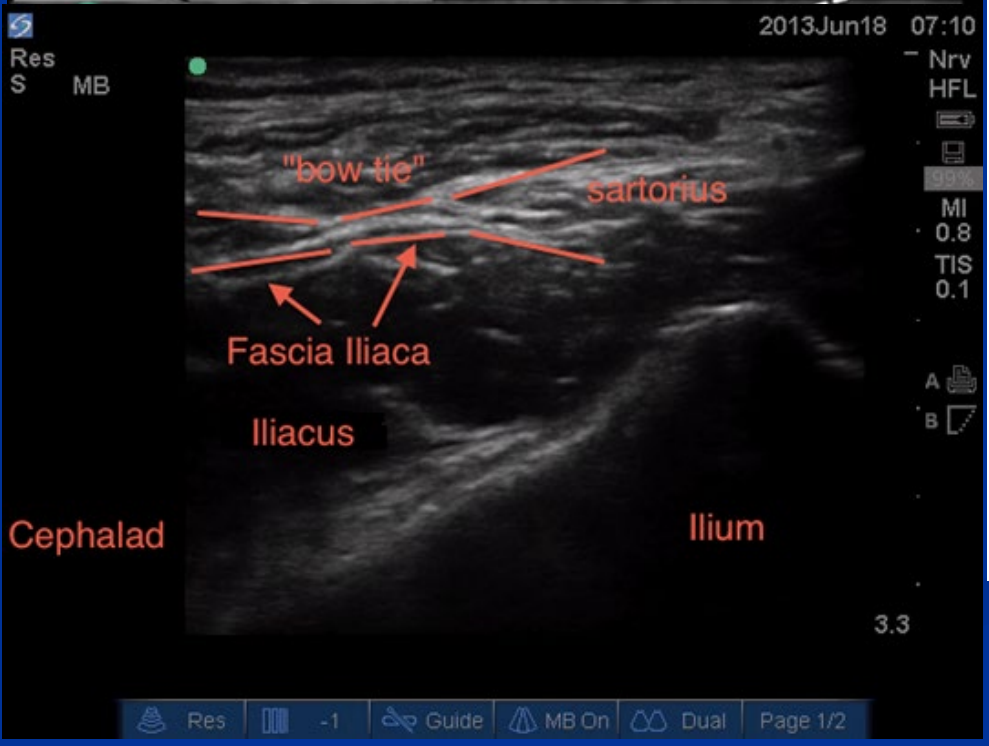

I CAN'T SAY I'M ENTIRELY PLEASED WITH MY HIP REPLACEMENT.
©2012 COVERLY DIST. BY CREATORS/SPEEDBUMP.COM 3-19

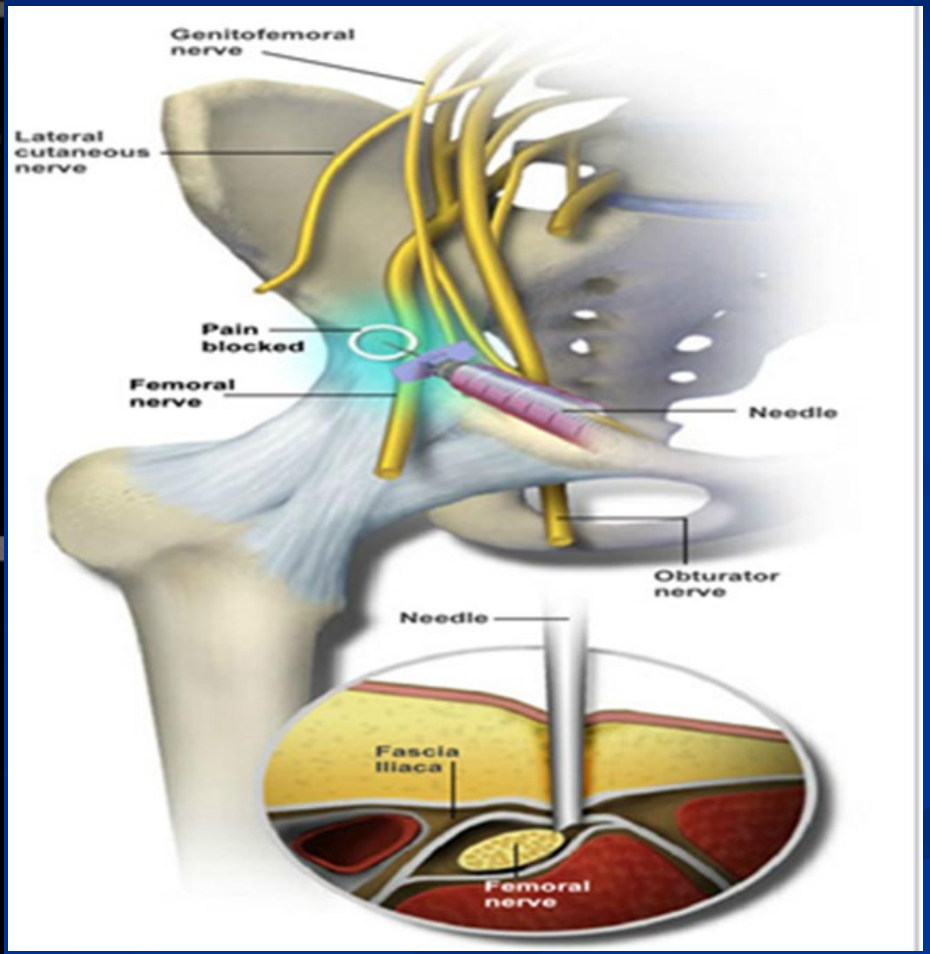
SupraInguinal Fascia Iliaca (SIFI)



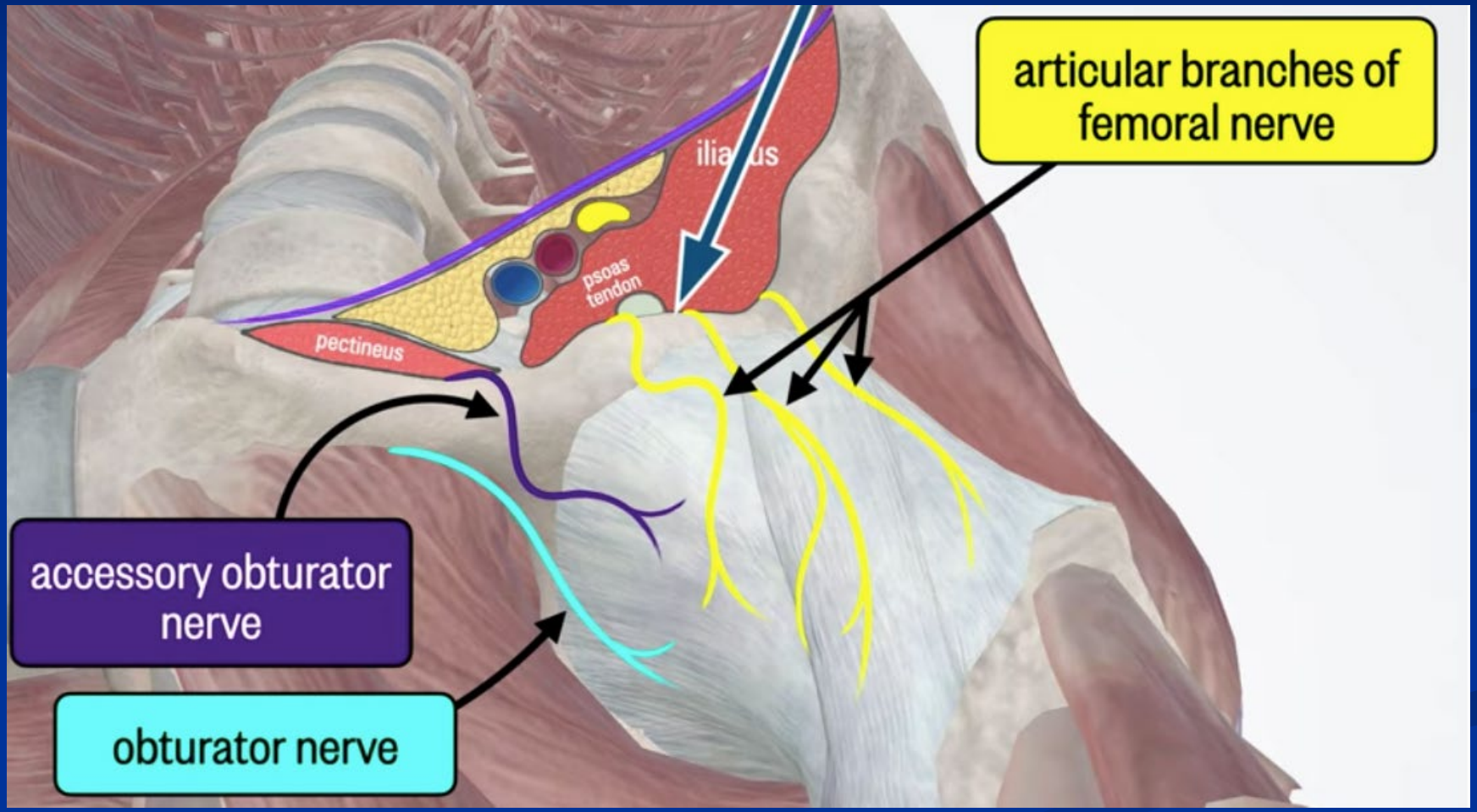
Fascia Iliaca Block



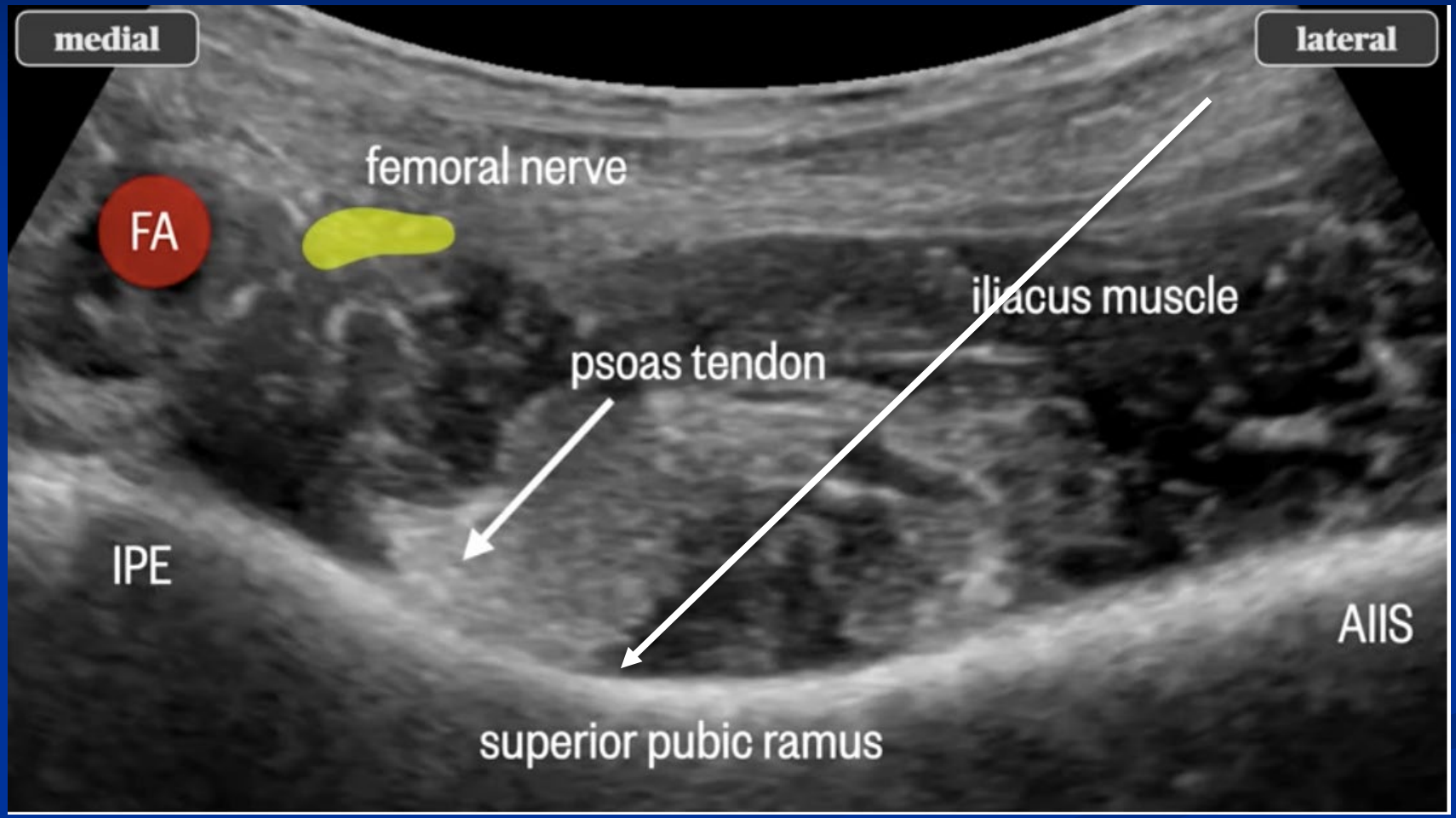




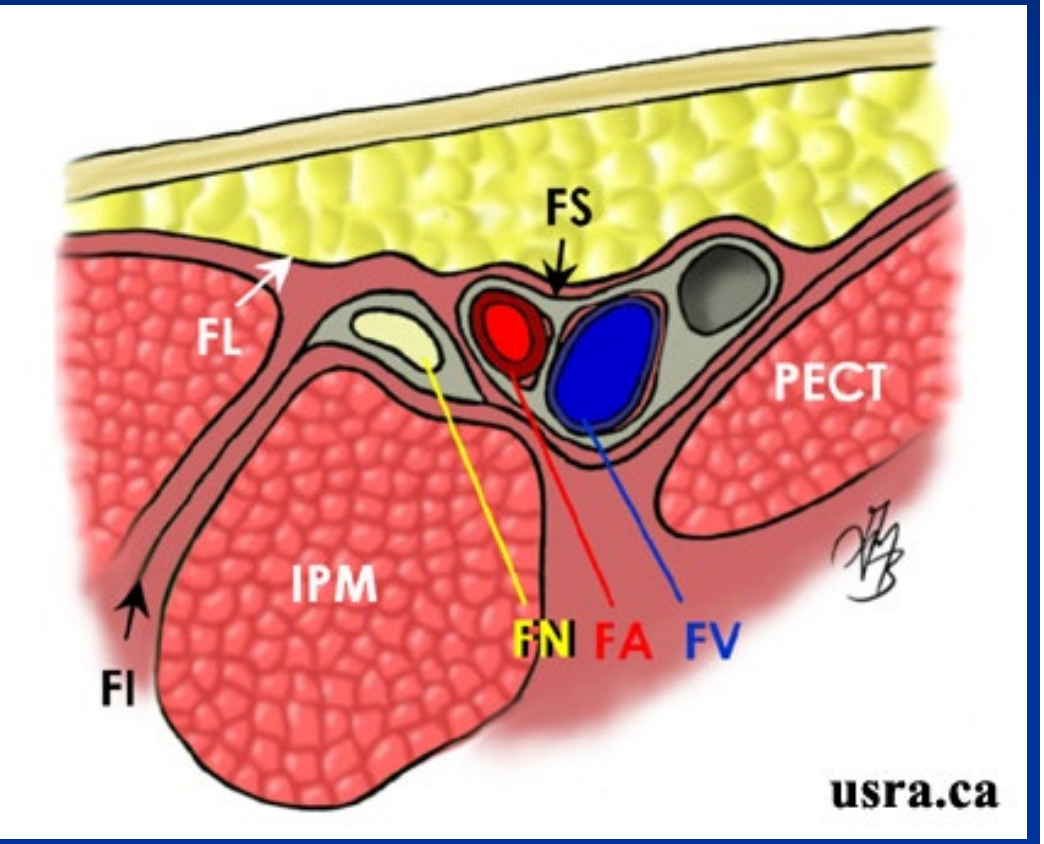
Pericapsular Nerve Group Block (PENG Block)

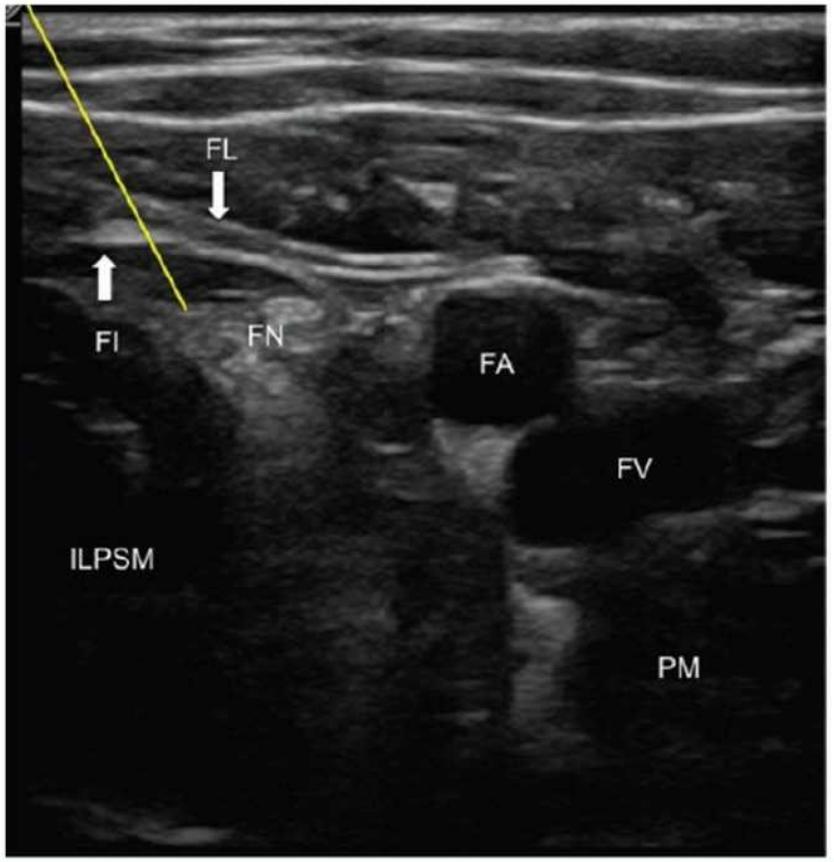


PENG Block


medial
lateral
femoral nerve
FA
iliacus muscle
psoas tendon
IPE
AIIS
superior pubic ramus

Femoral Nerve Block





Medscape

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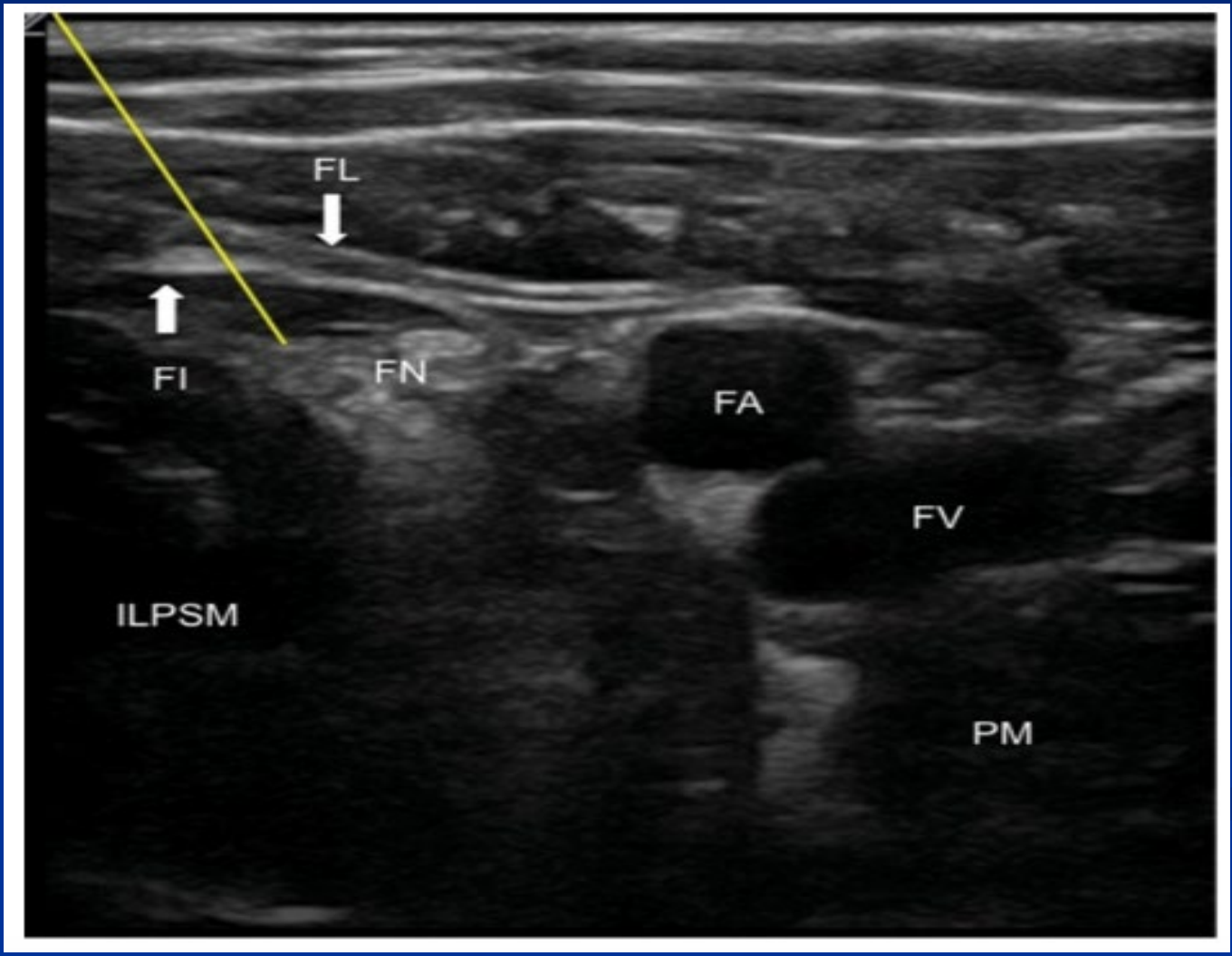
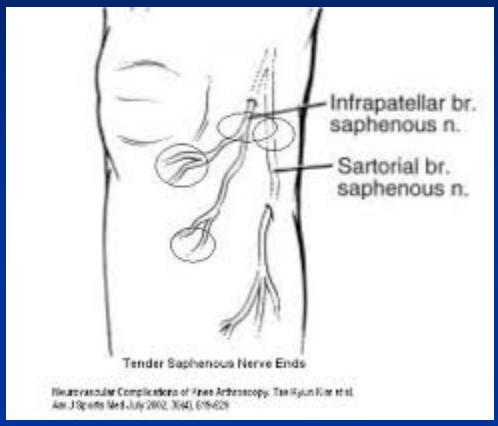
Femoral N Block



Adductor Canal



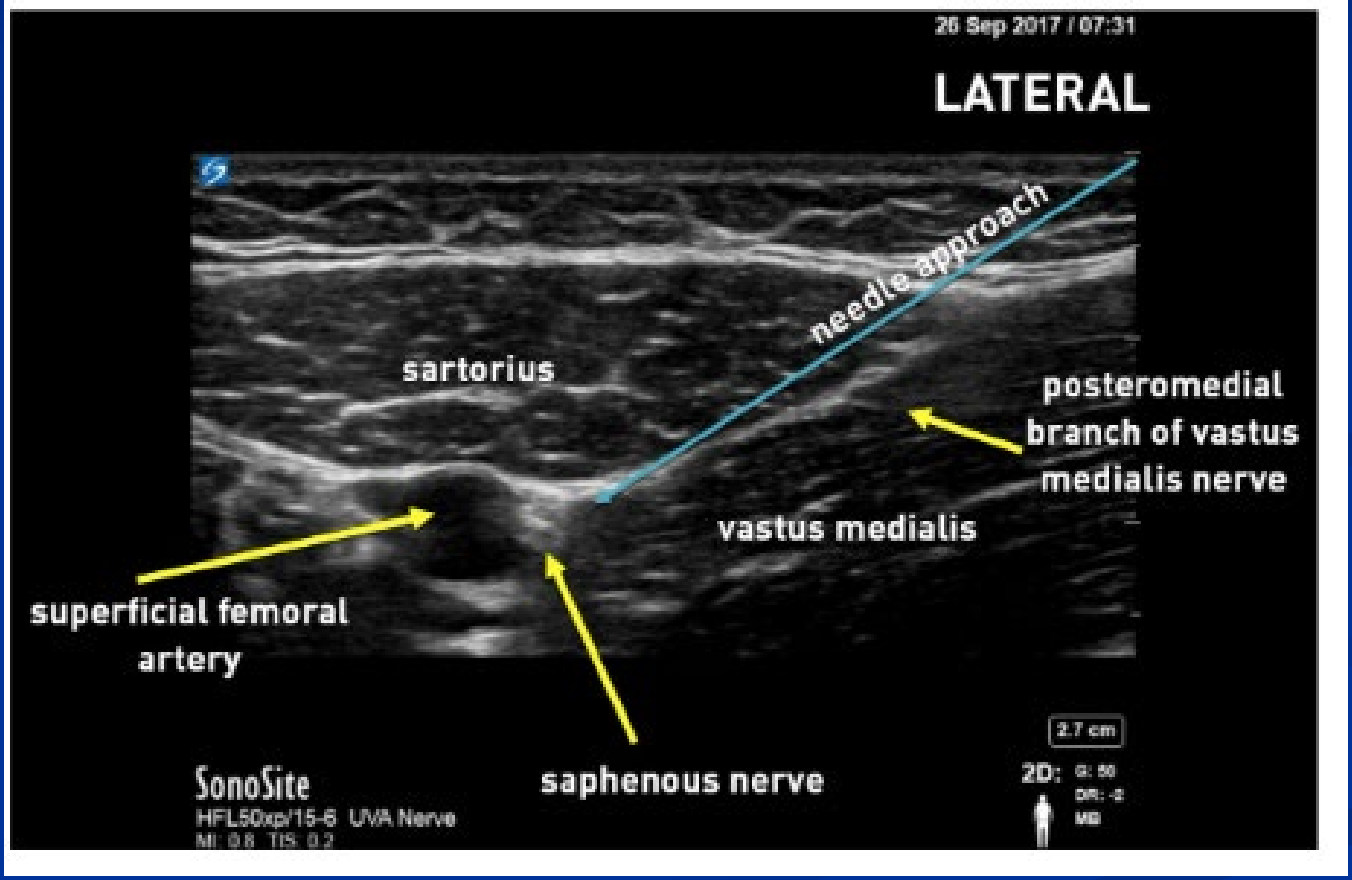
Symposium: Perioperative Pain Management In Orthopaedic Surgery
Clinical Orthopaedics and Related Research®
May 2014, Volume 472, Issue 5, pp 1377-1383

First online: 30 July 2013

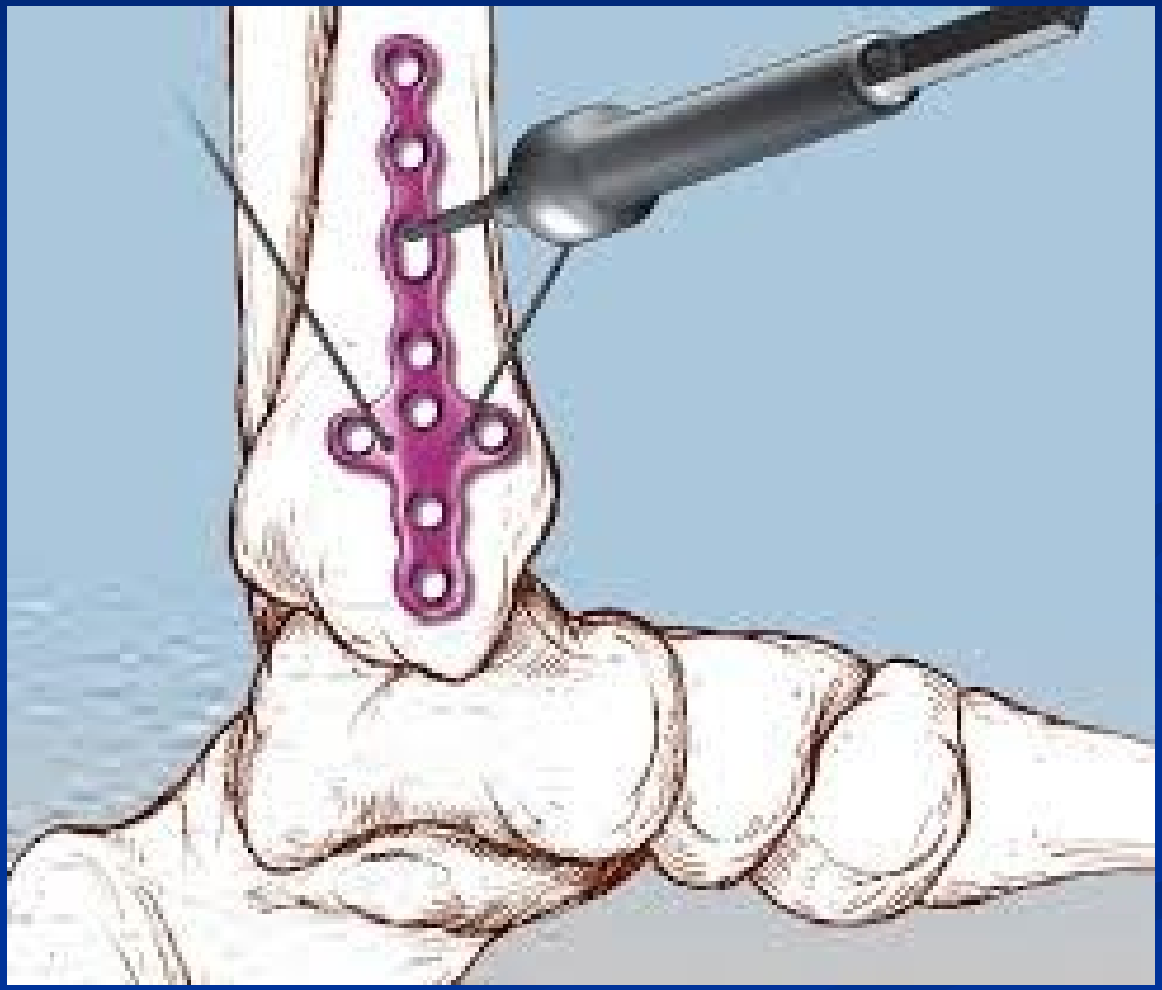
Continuous Adductor Canal Blocks Are Superior to Continuous Femoral Nerve Blocks in Promoting Early Ambulation After TKA

Seshadri C. Mudumbai, T. Edward Kim, Steven K. Howard, J. Justin Workman, Nicholas Giori, Steven Woolson, Toni Ganaway, Robert King, Edward R. Mariano

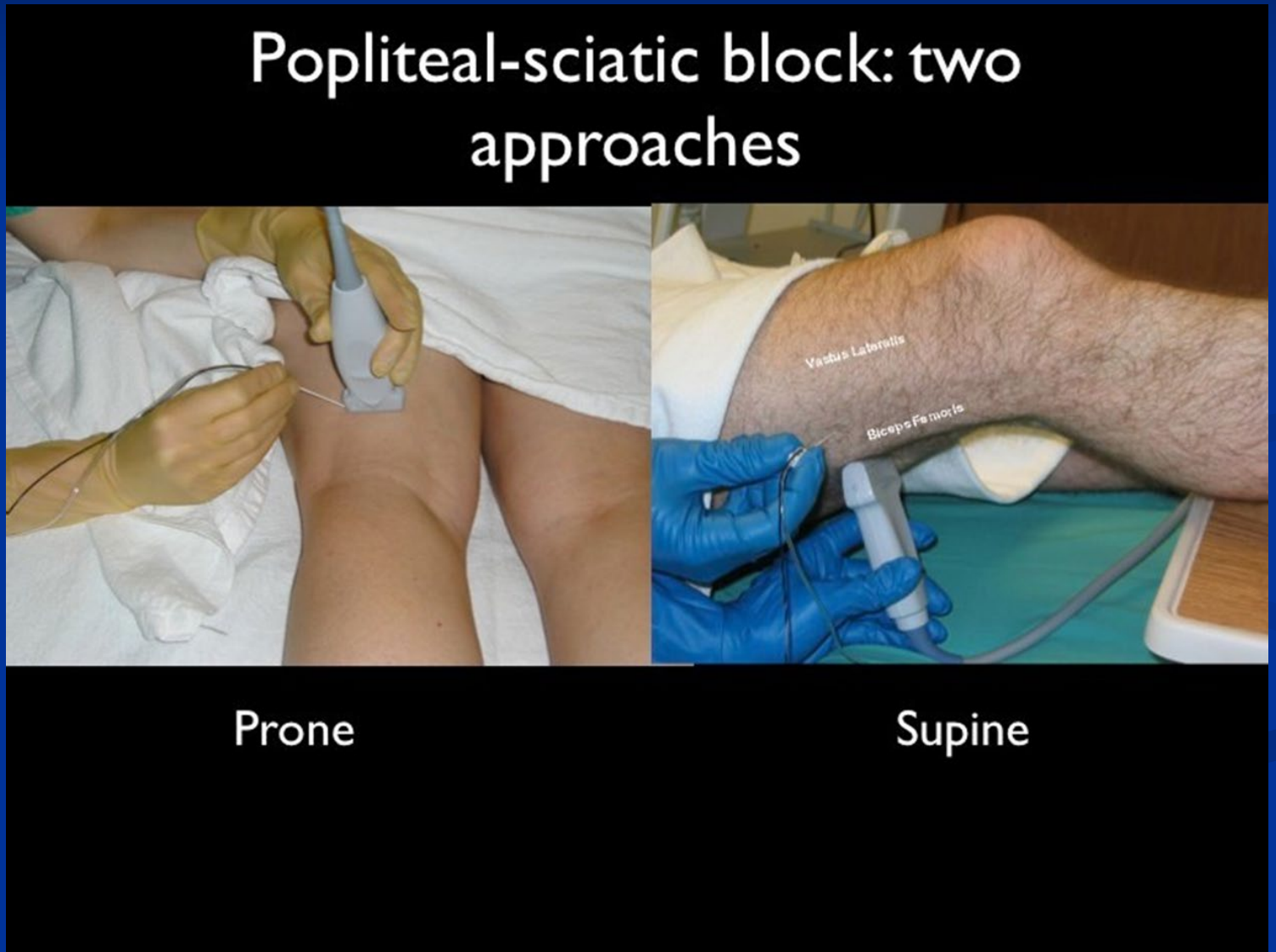
Adductor Canal Block



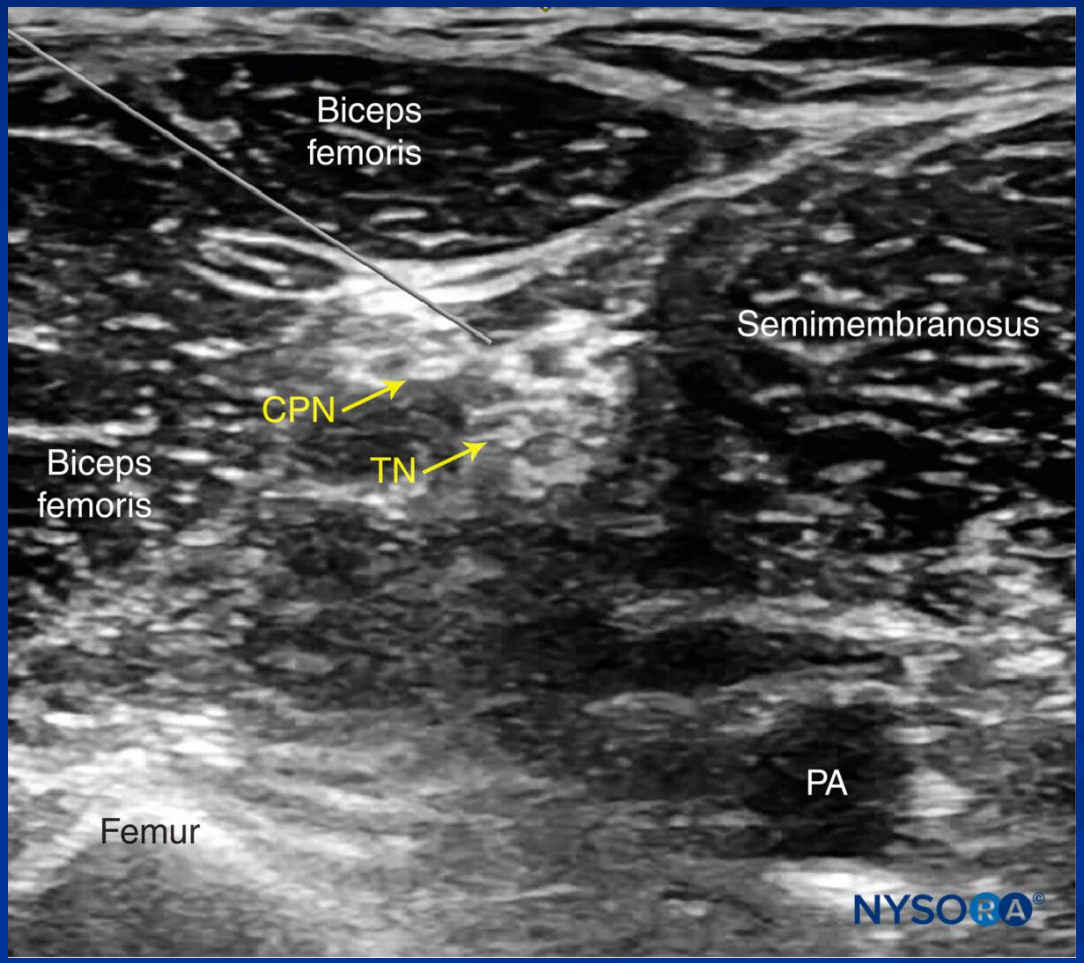
Lower Extremity Fracture



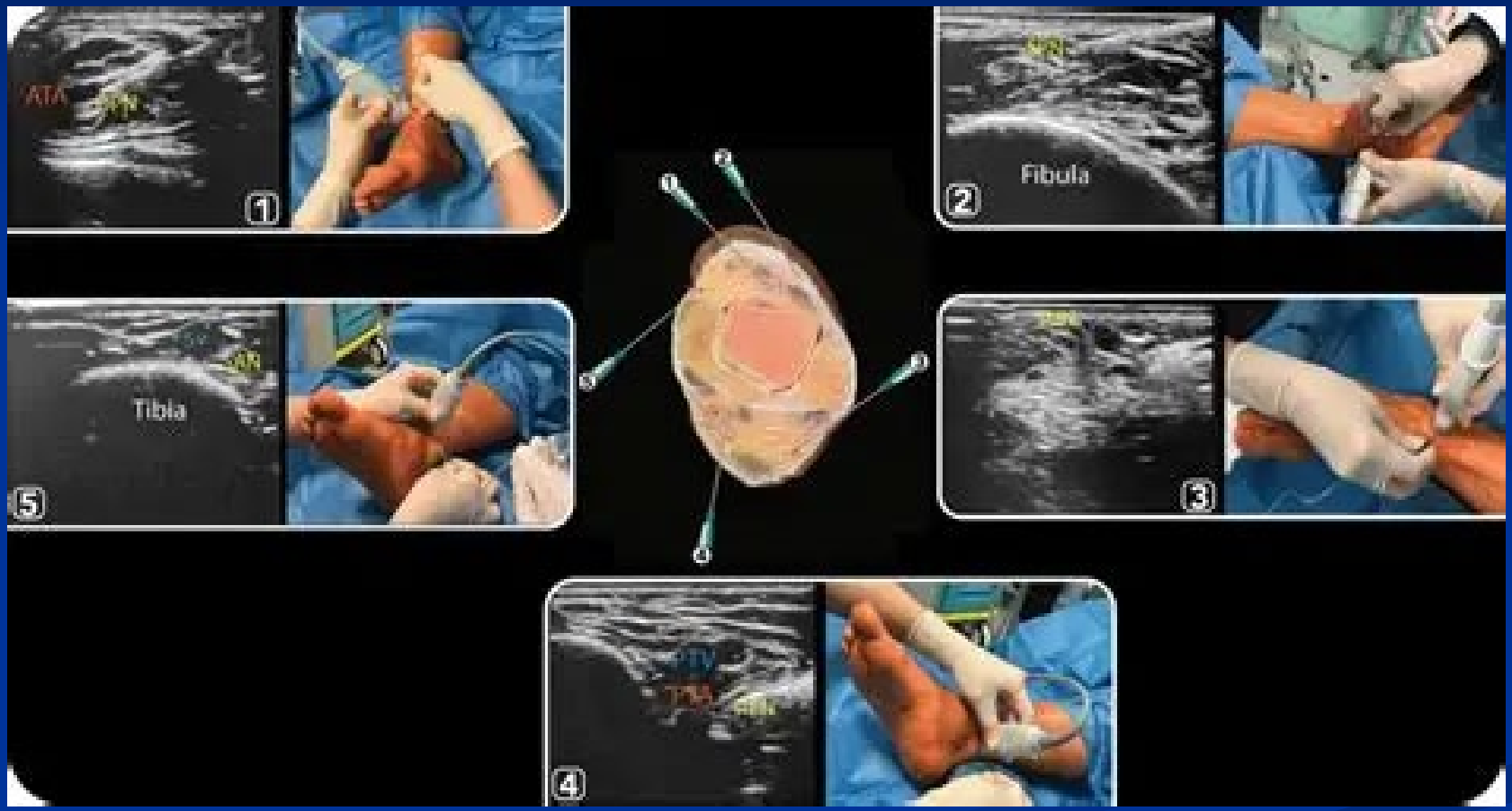
Popliteal Sciatic Nerve Block



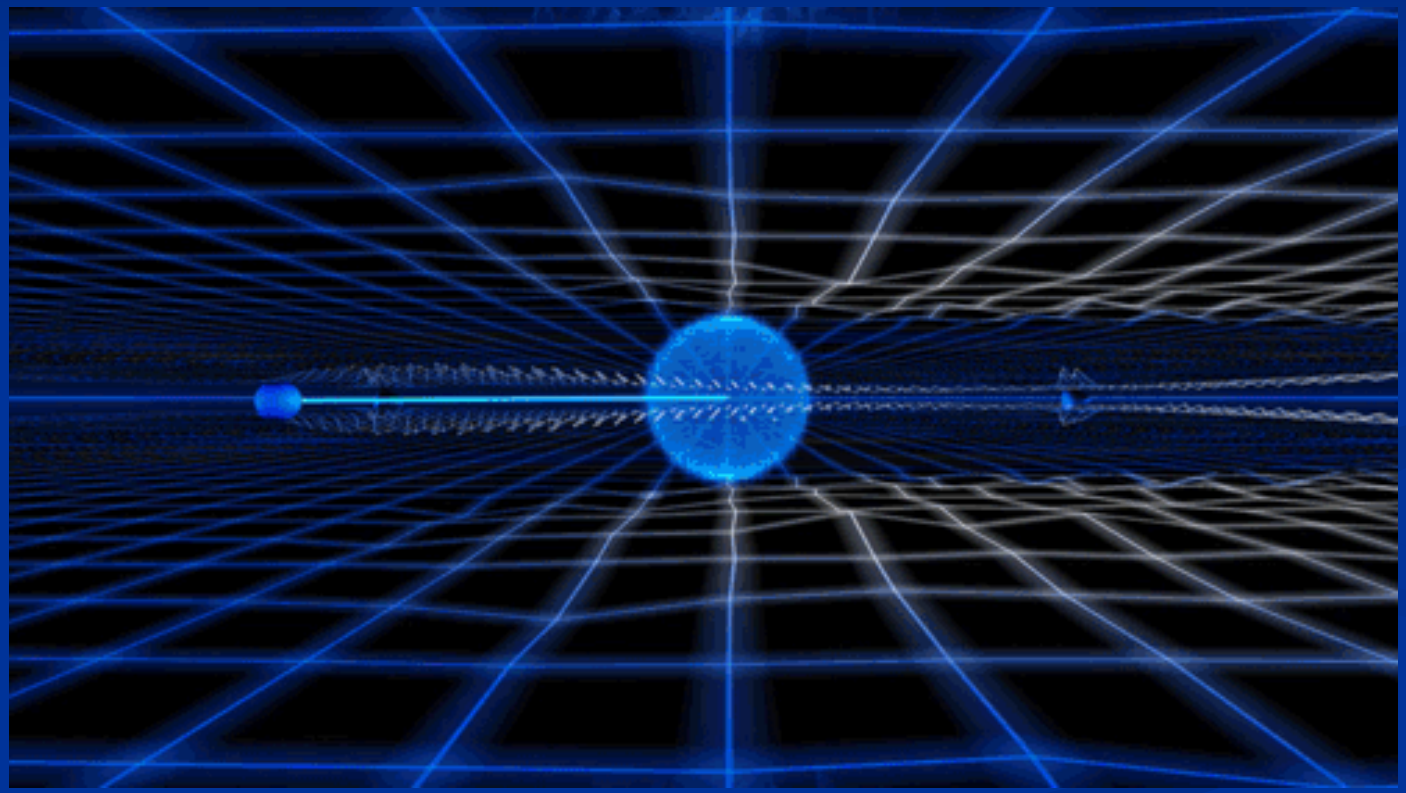
Popliteal Nerve Block



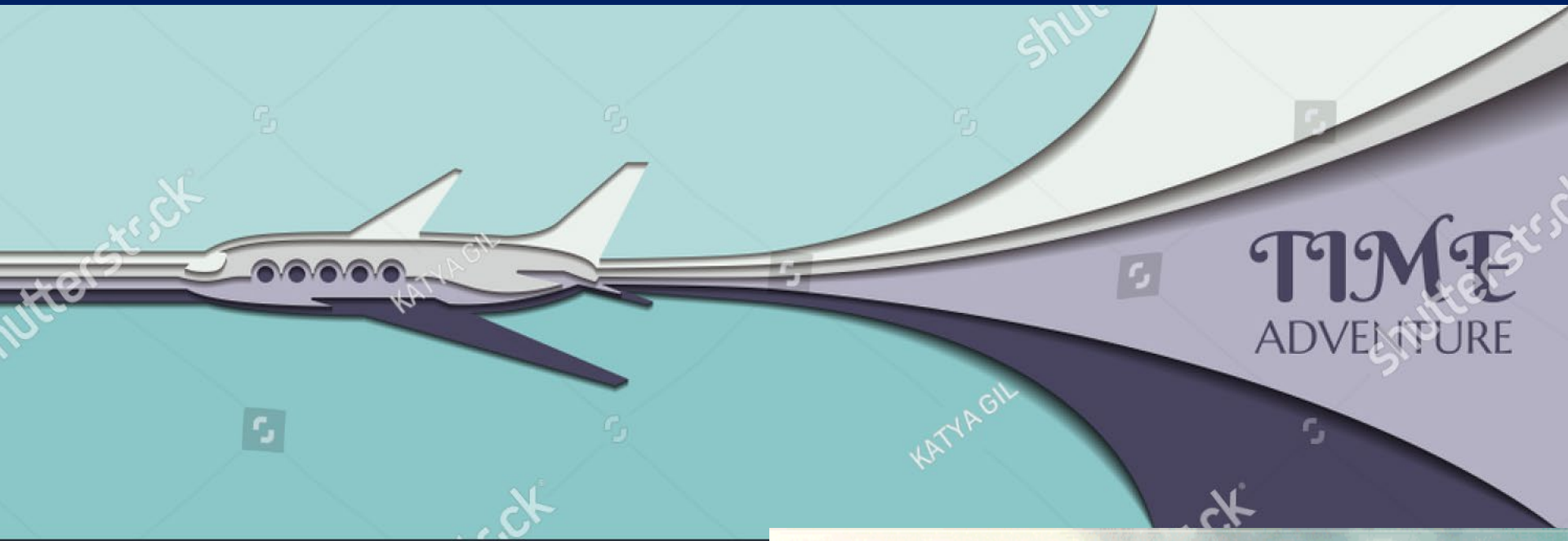
Ankle Block



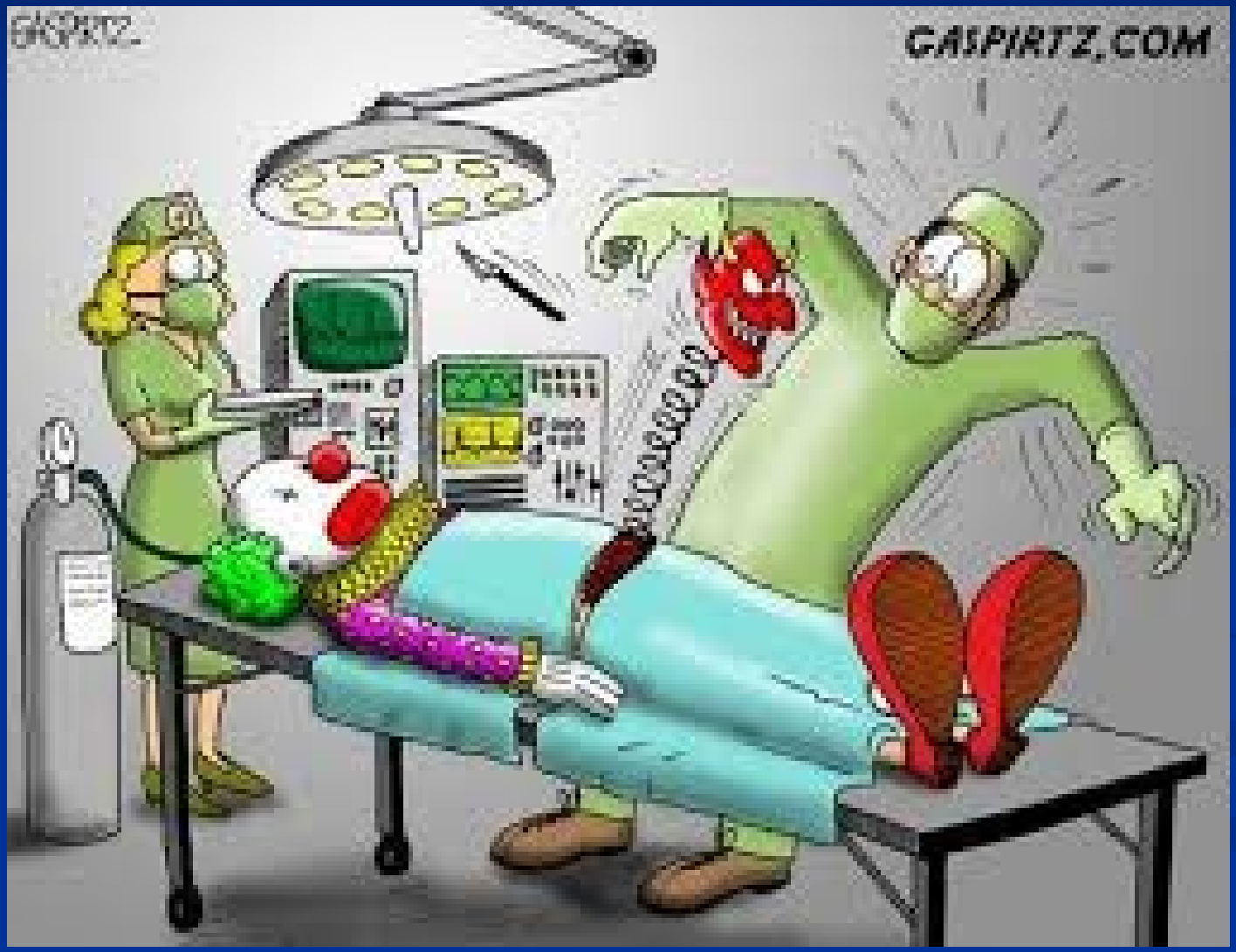
The new quantum level of regional anesthesia



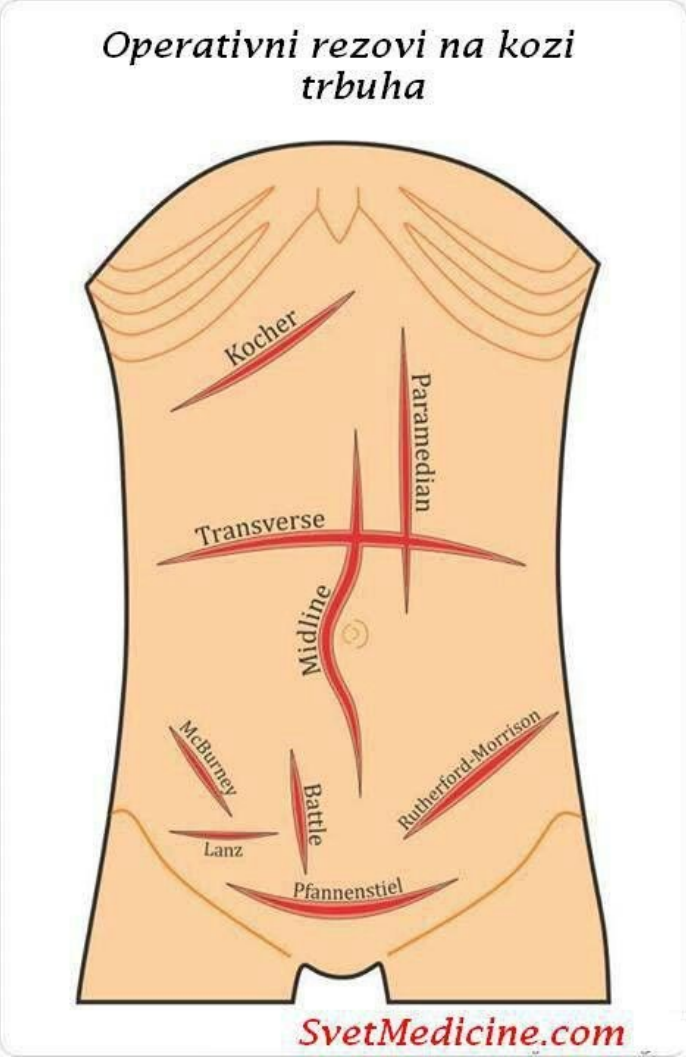
Plane Blocks, Not Nerve Block

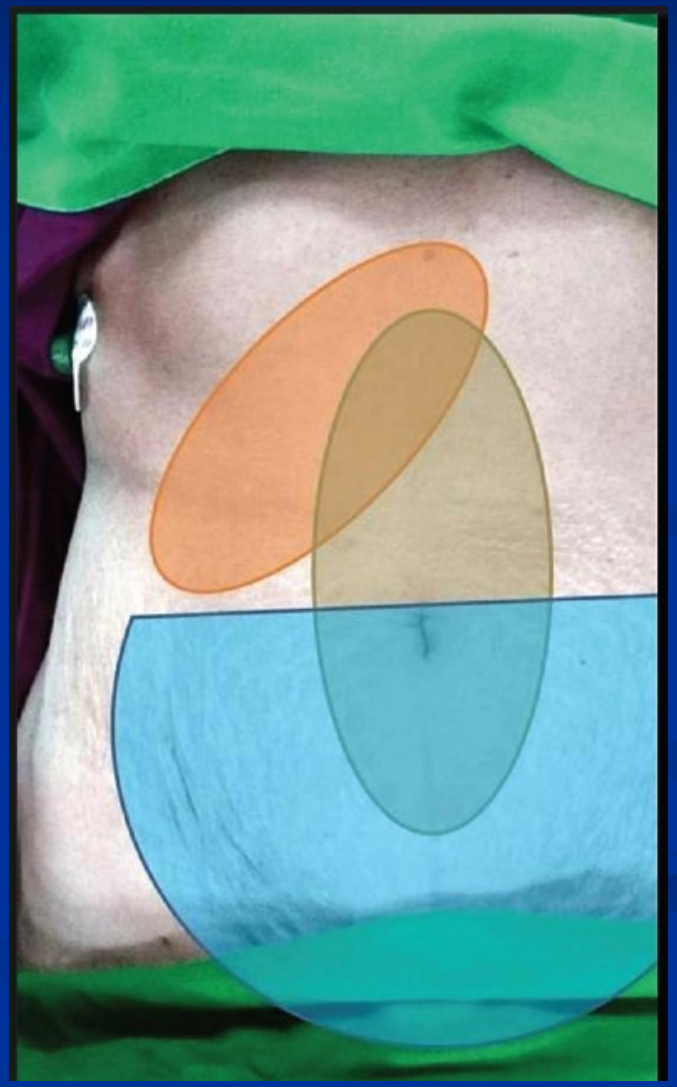


Abdominal Surgery

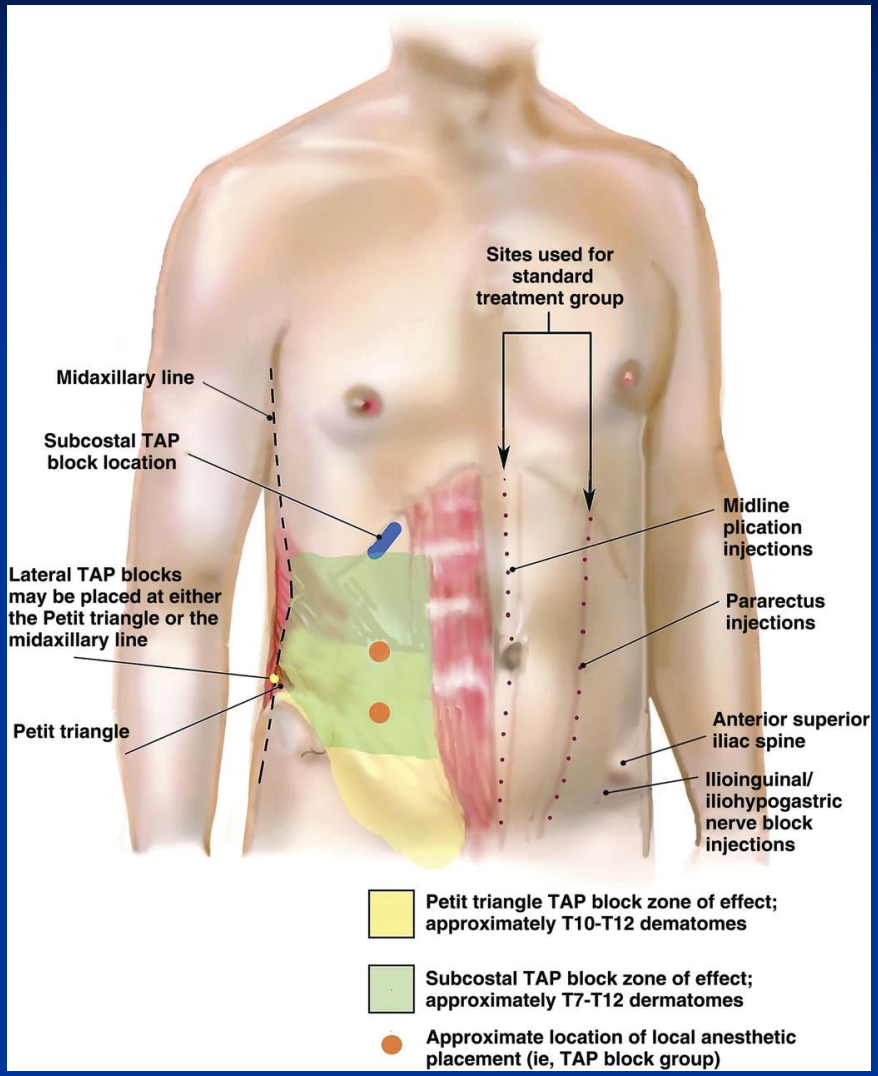


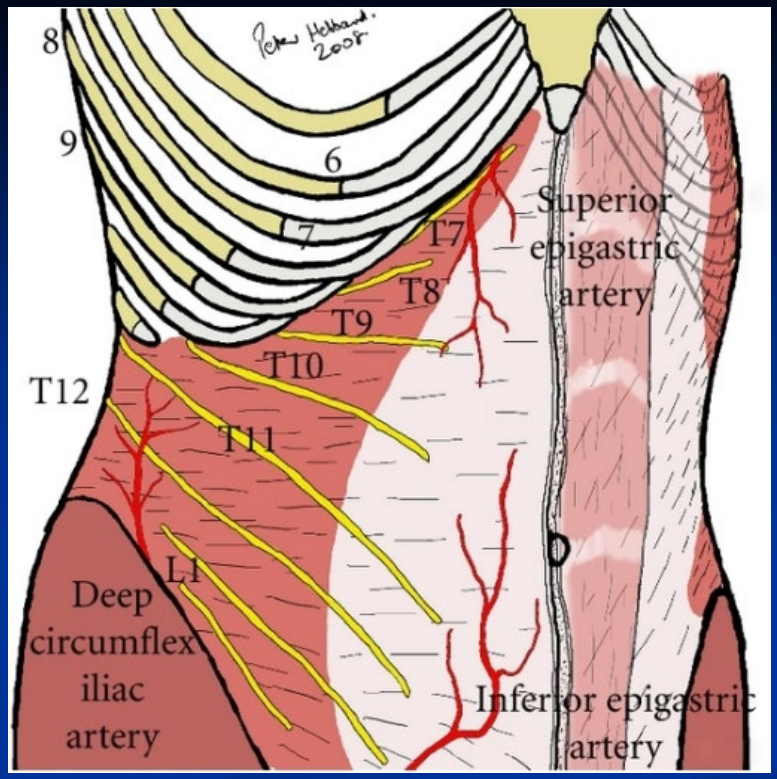
What kind of incision?



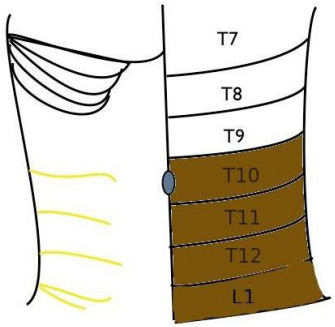


TAP Block

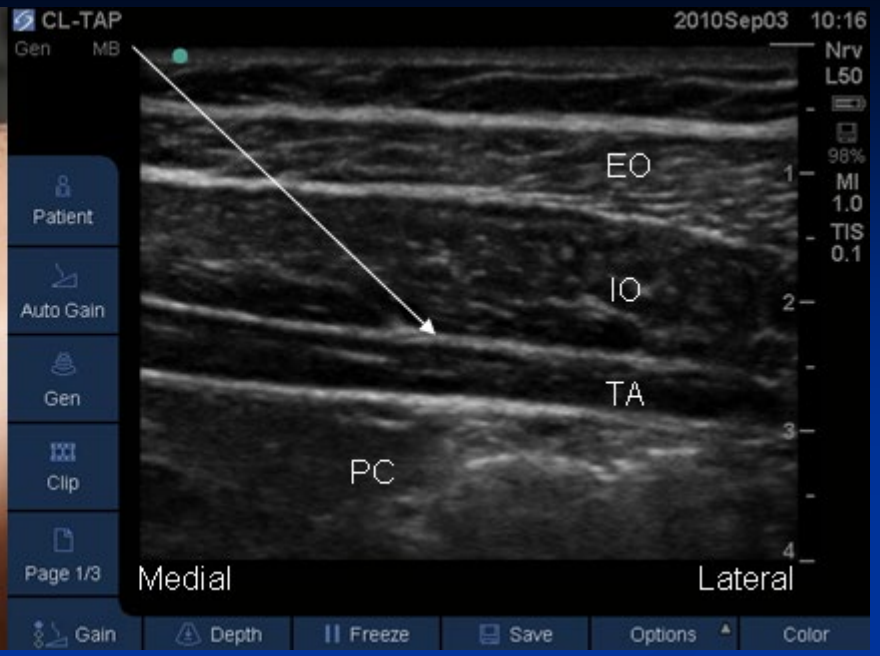




Anatomy



Cutaneous innervation of the abdominal wall . Coloured region is mostly blocked by a single injection posterior TAP block.


CL-TAP
2010Sep03 10:16
Gen MB
Nrv
L50
98%
MI
1.0
TIS
0.1
Patient
Auto Gain
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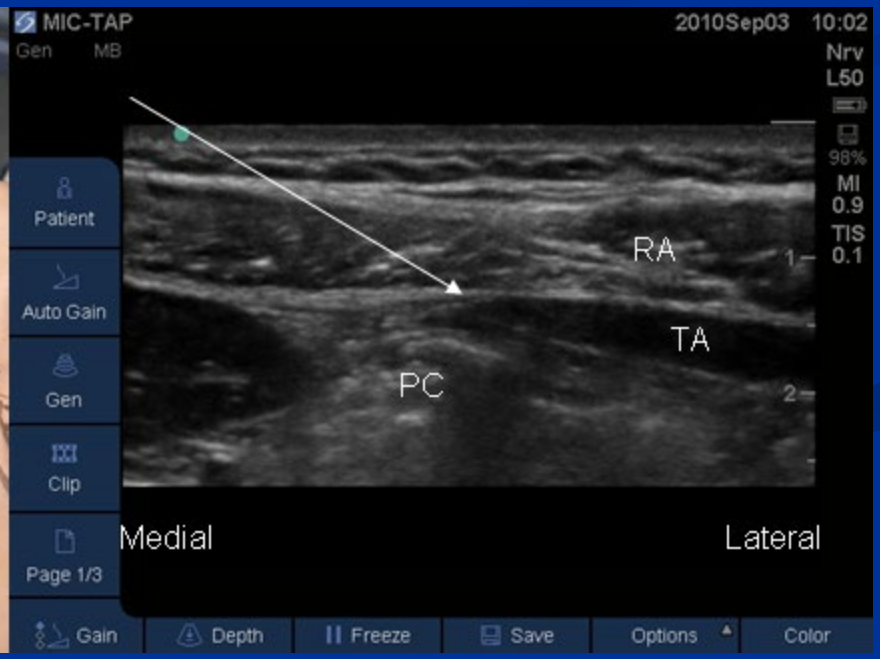
Save
Options
Color


MIC-TAP
2010Sep03 10:02
Gen MB
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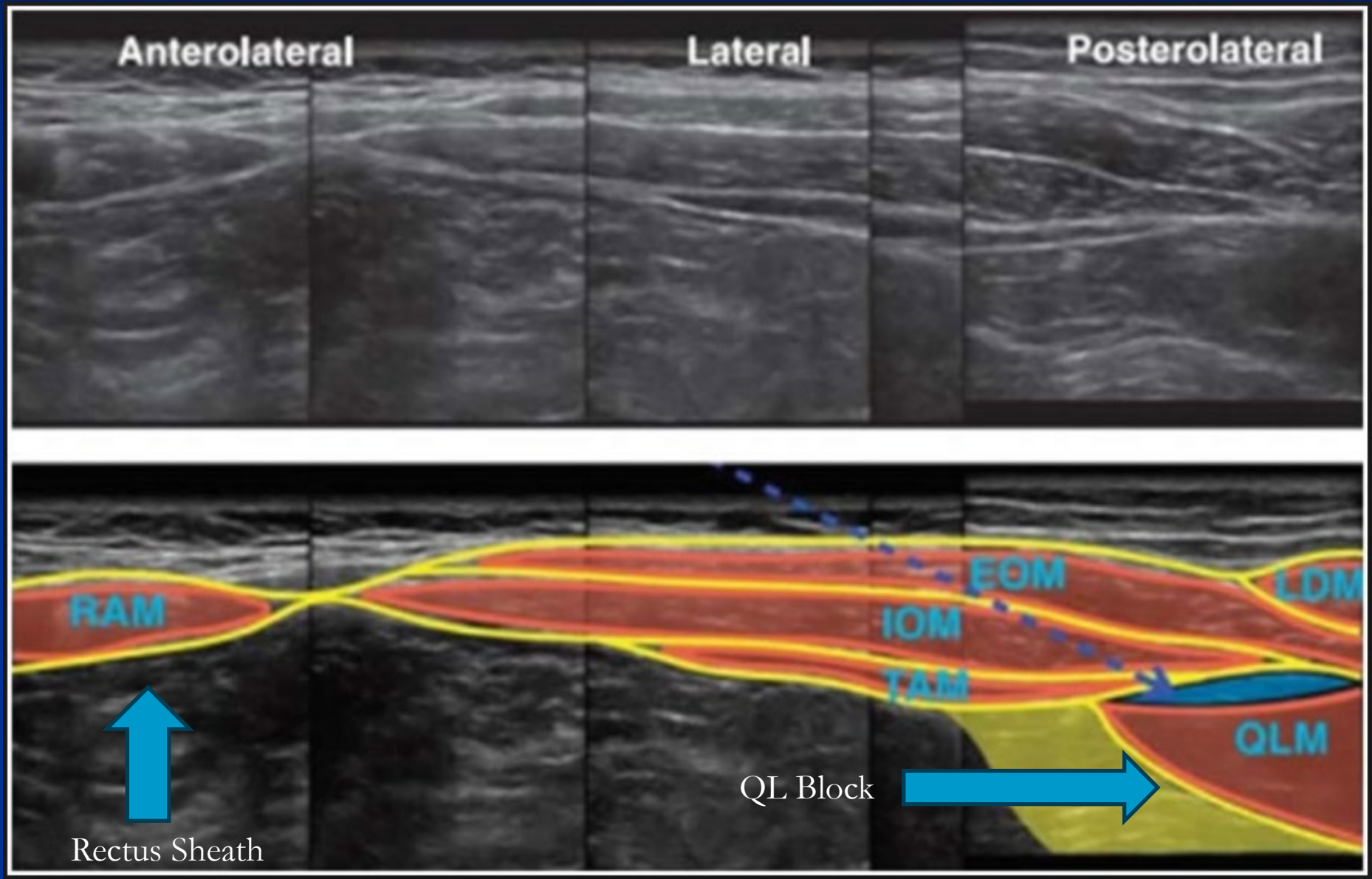
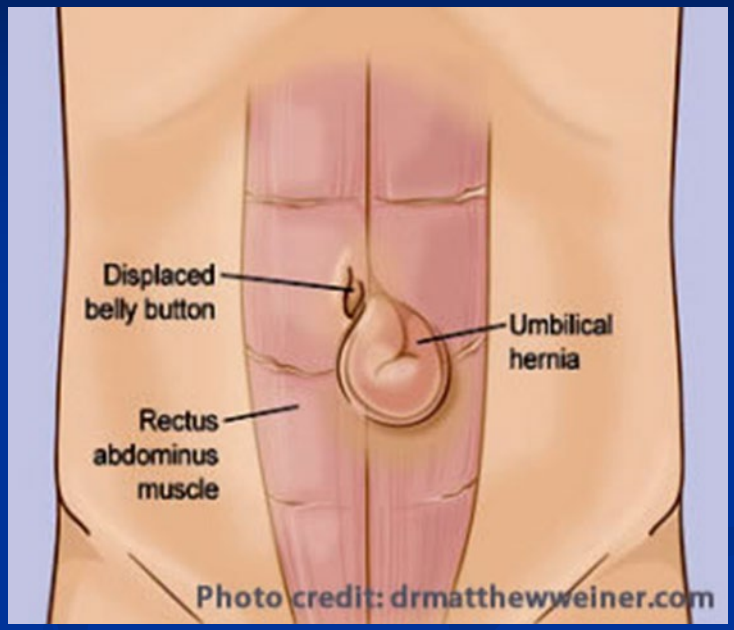
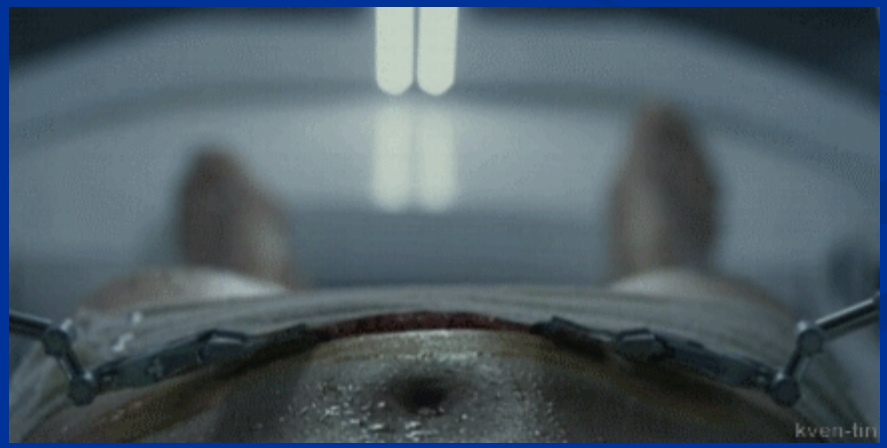
Next Generation of TAP Block: Rectus Sheath and Quadratus Lumborum Block



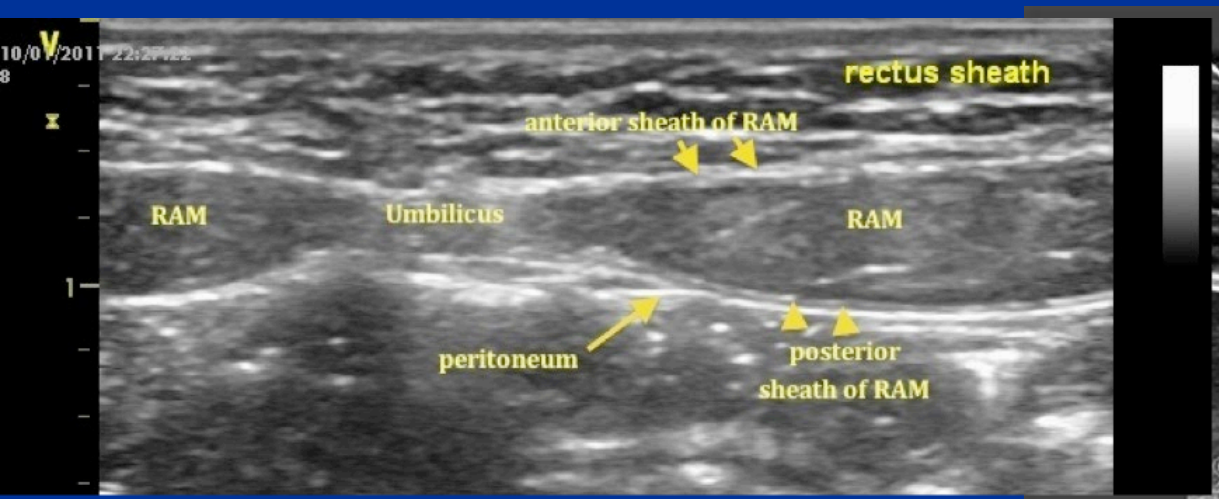
Rectus Sheath Block

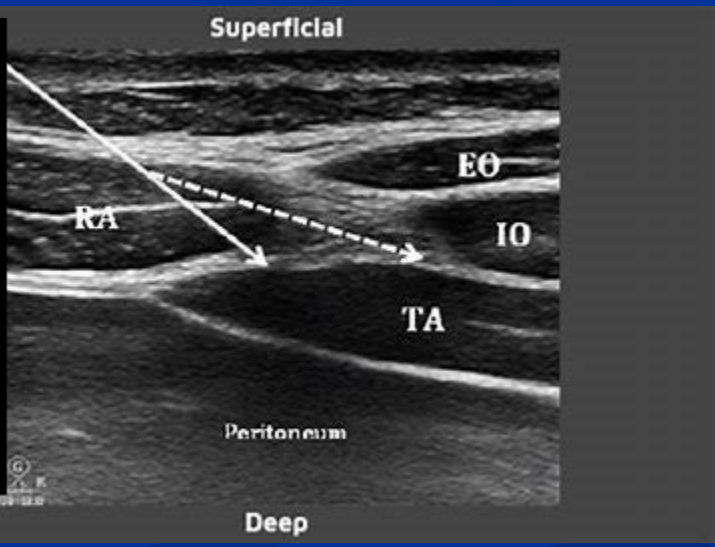


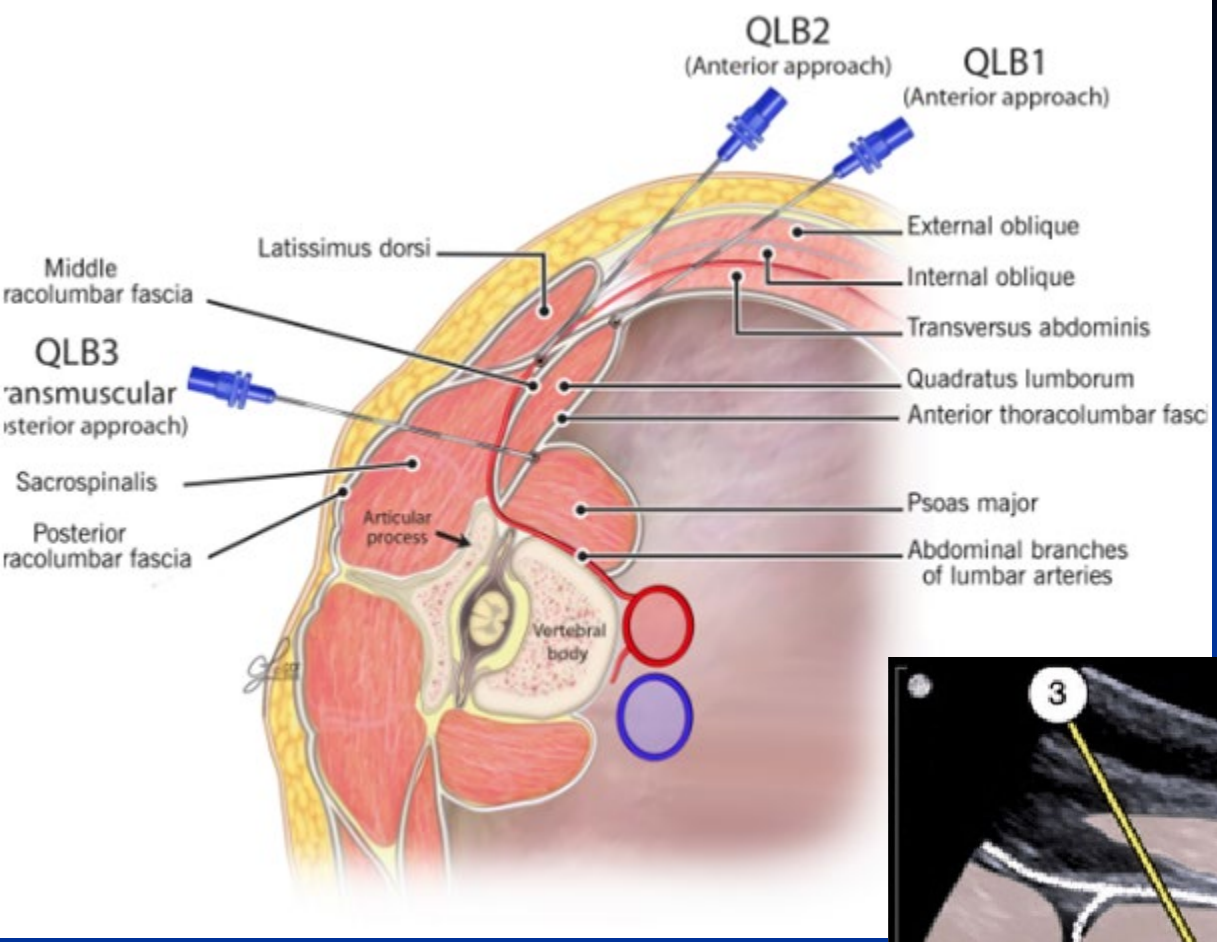


Anatomy of abdomen

Ultrasound Image

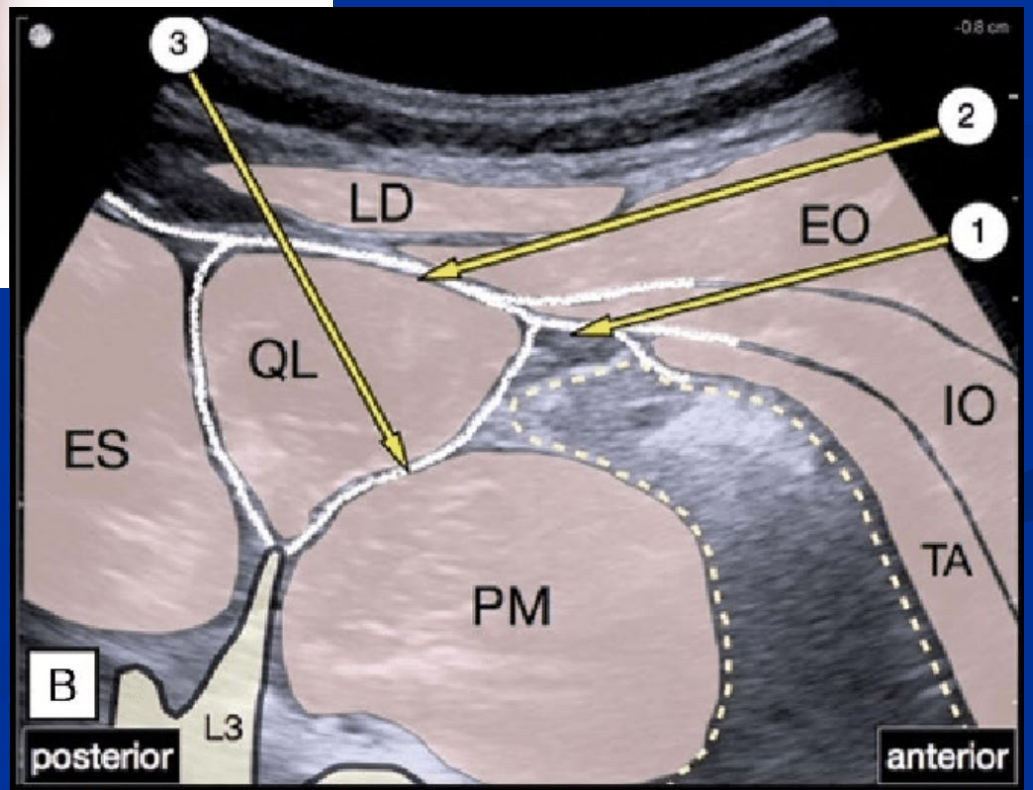


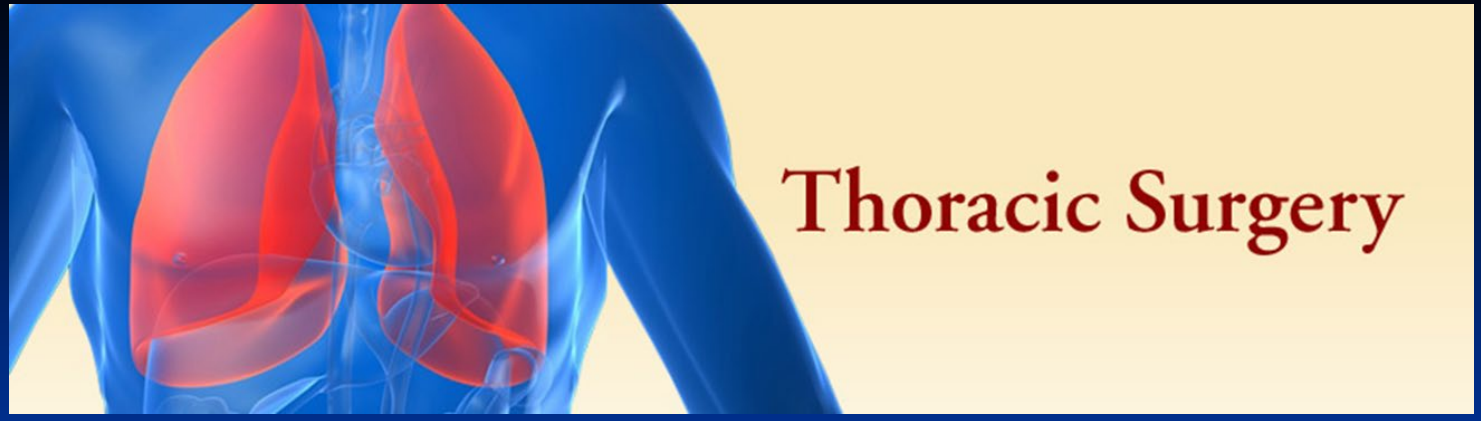




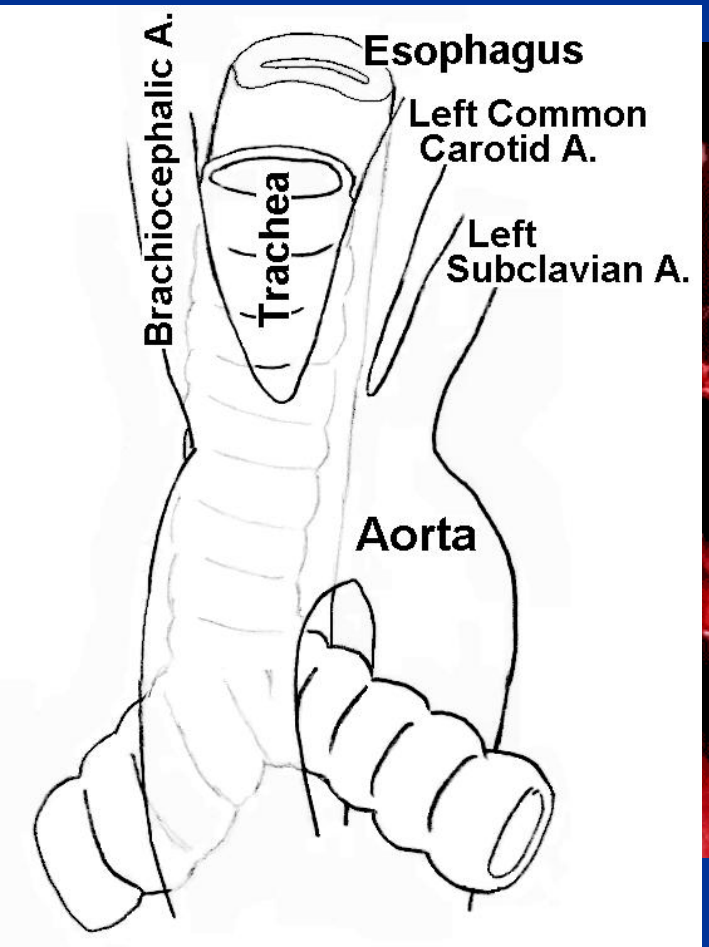
Wider dermatomal coverage (up to T6)
Visceral component
Analgesia laterally over the iliac crest

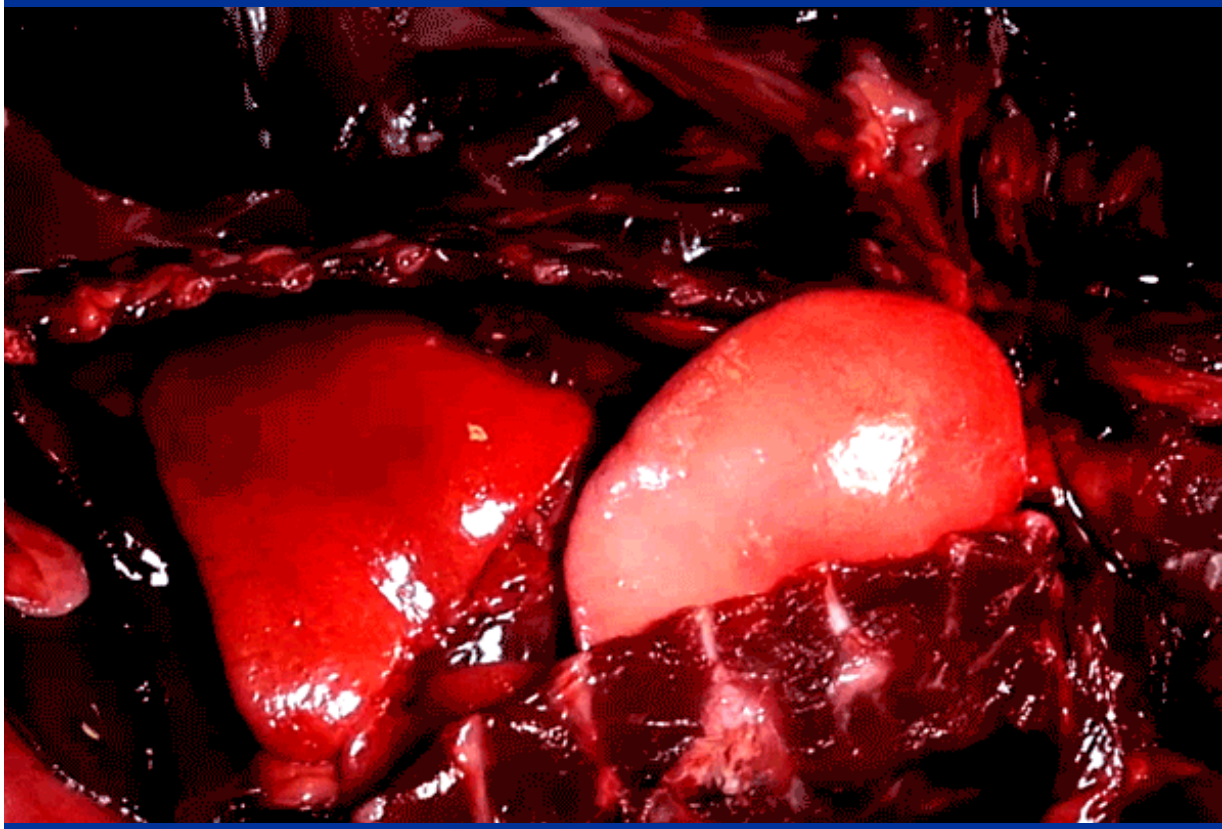
My favorite is the posterior approach QL (QL3)



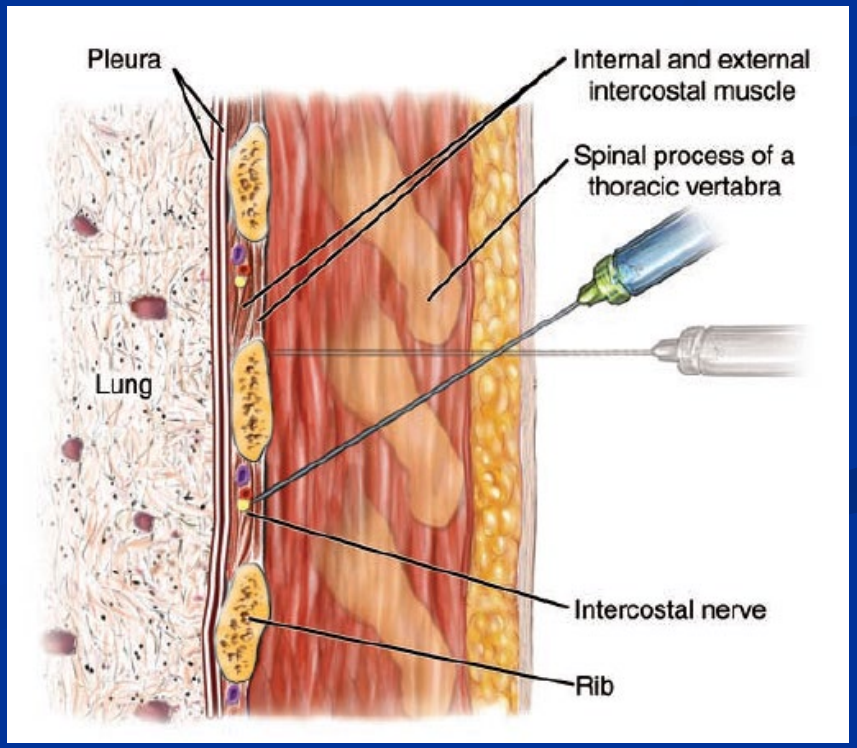


Thoracic Surgery

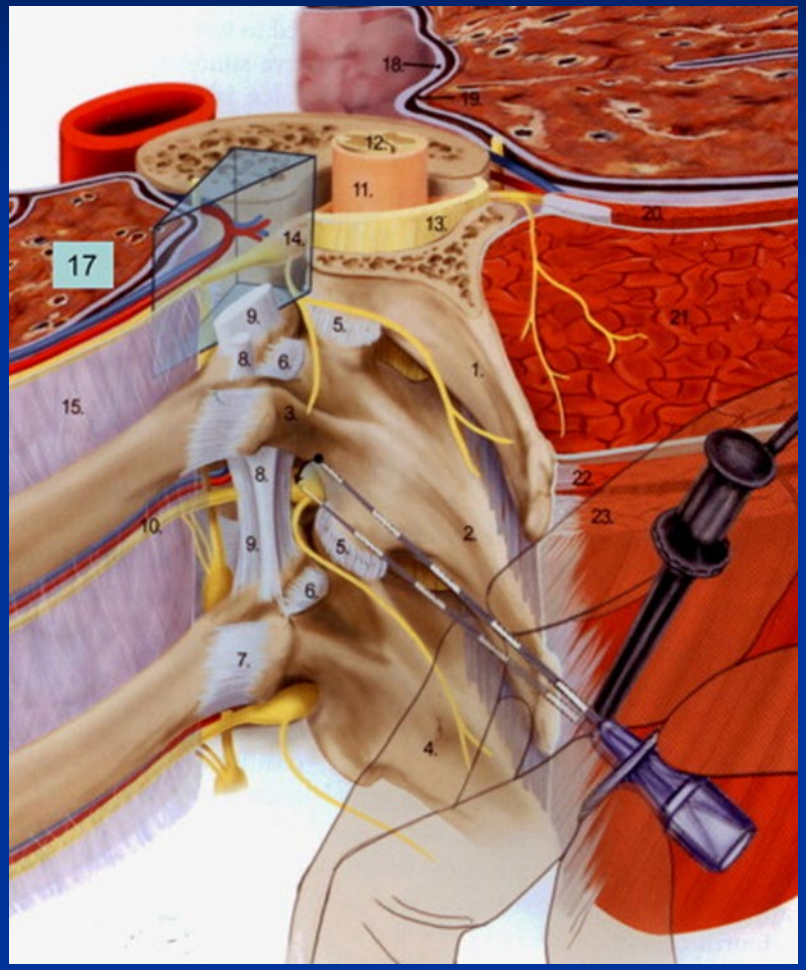


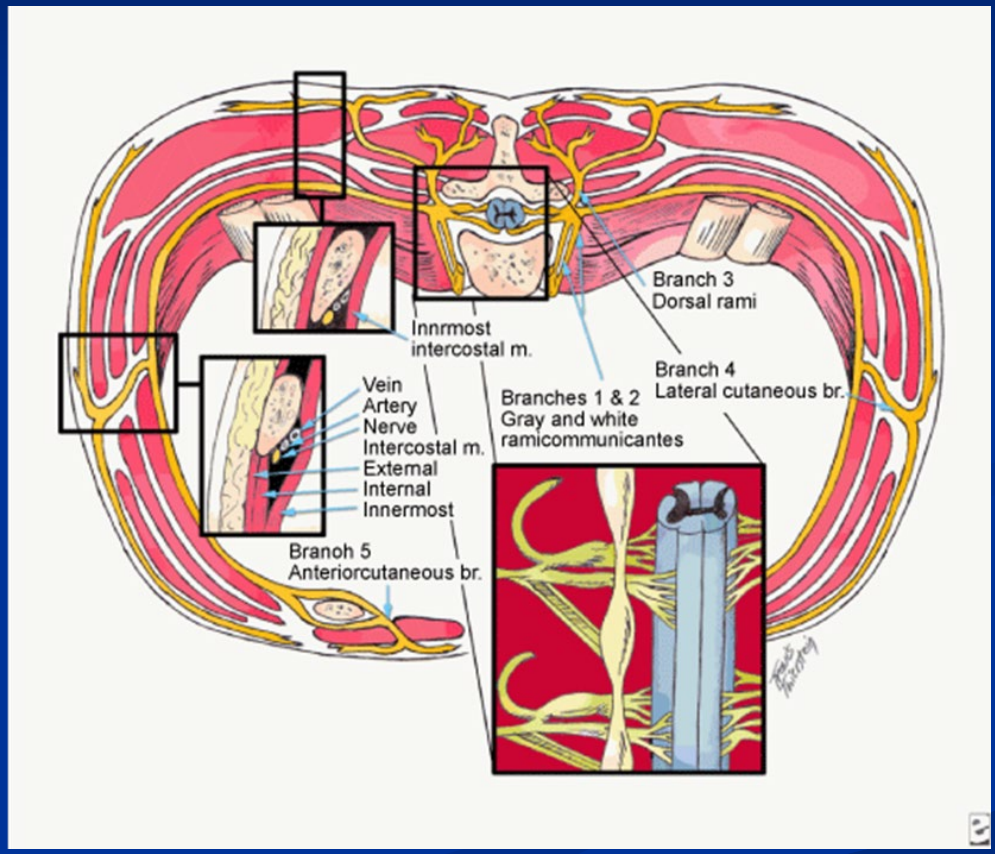


Intercostal Nerve Block - traditional

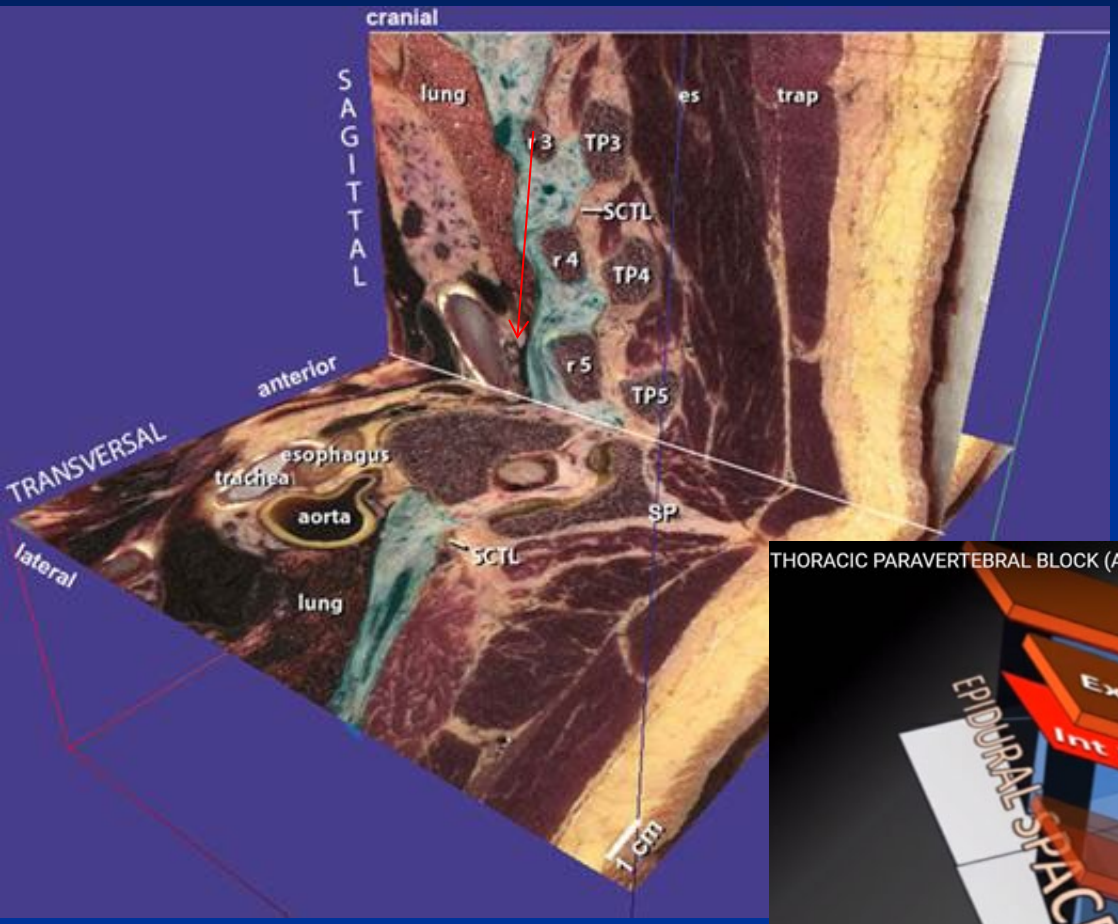


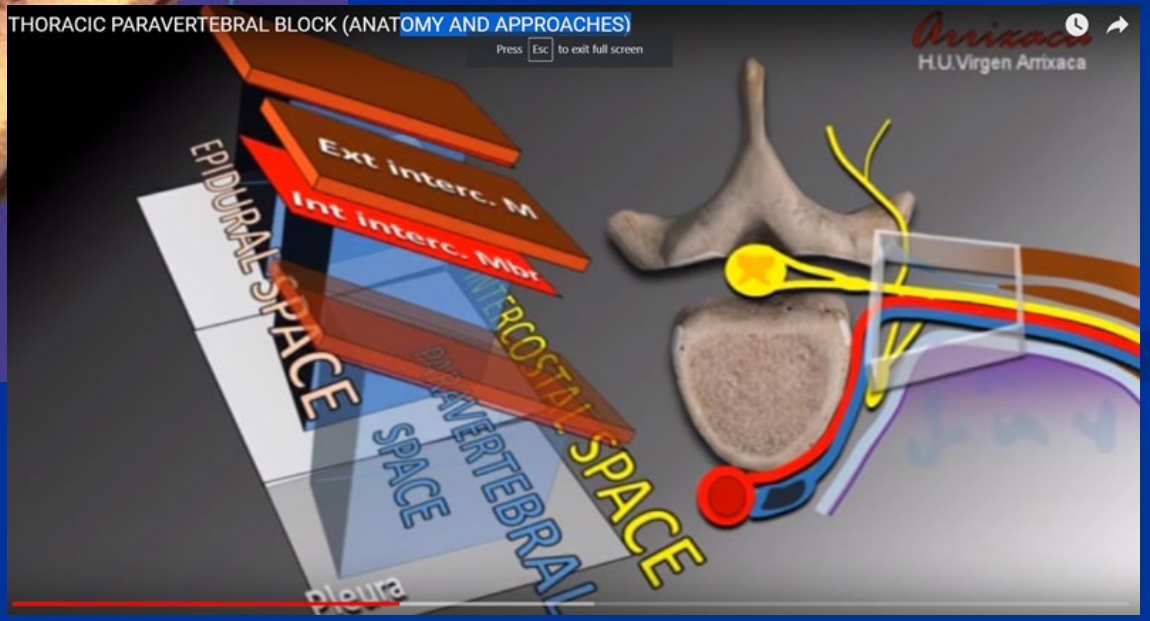
Paravertebral Block – spinal nerve



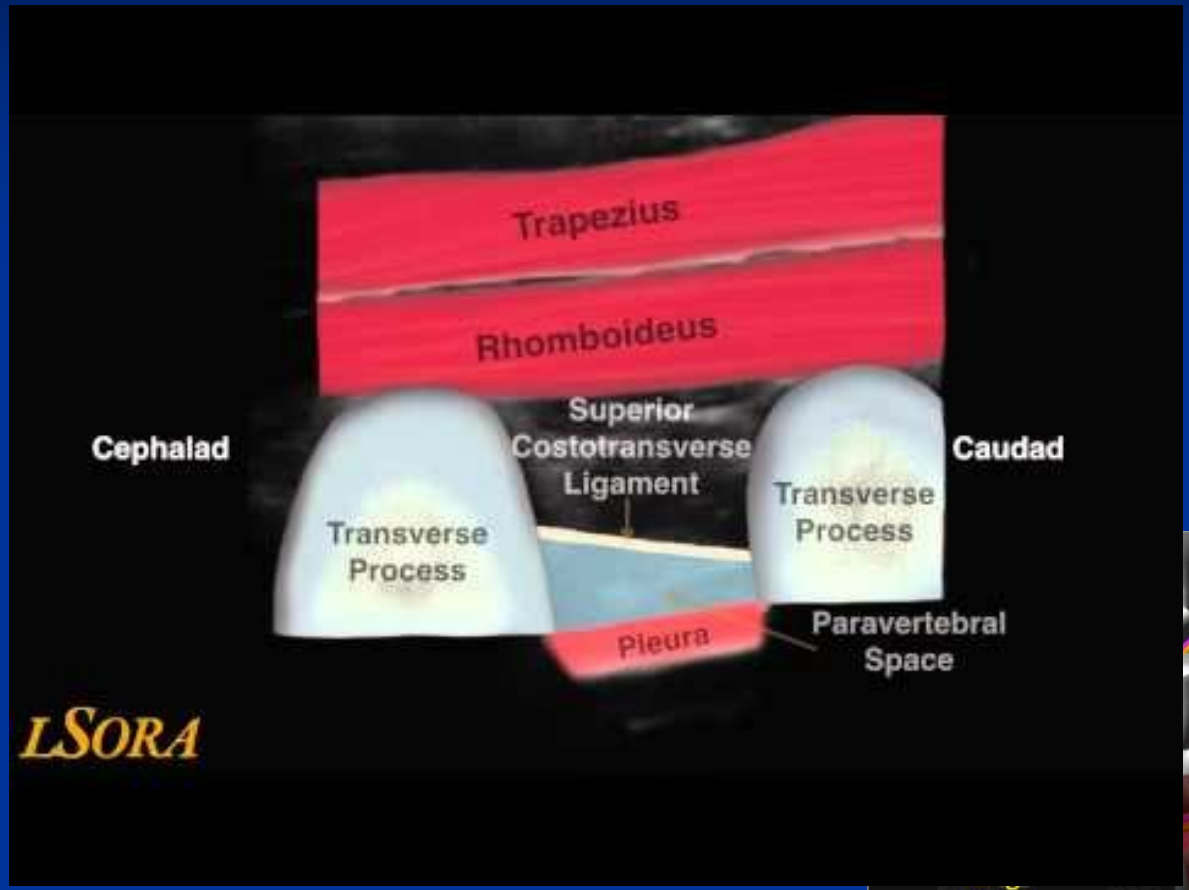


Paravertebral Block
(blue filled space)

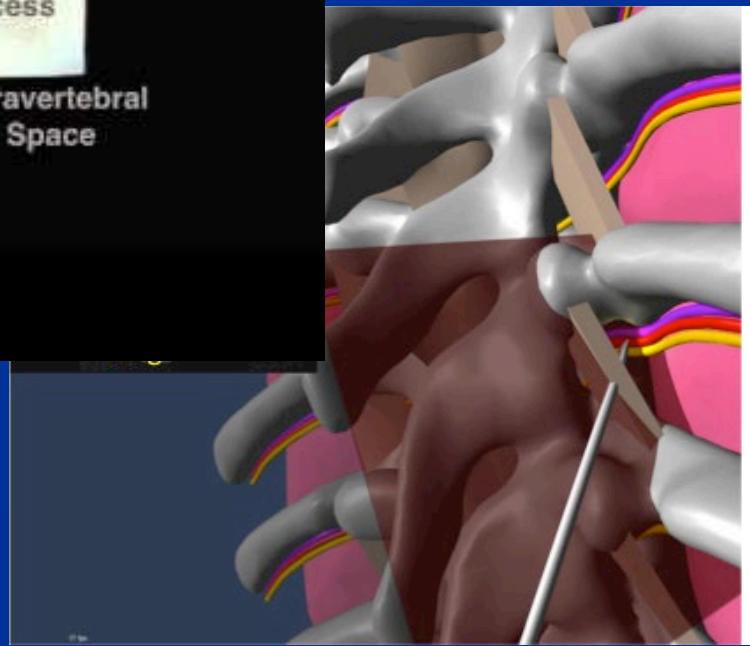




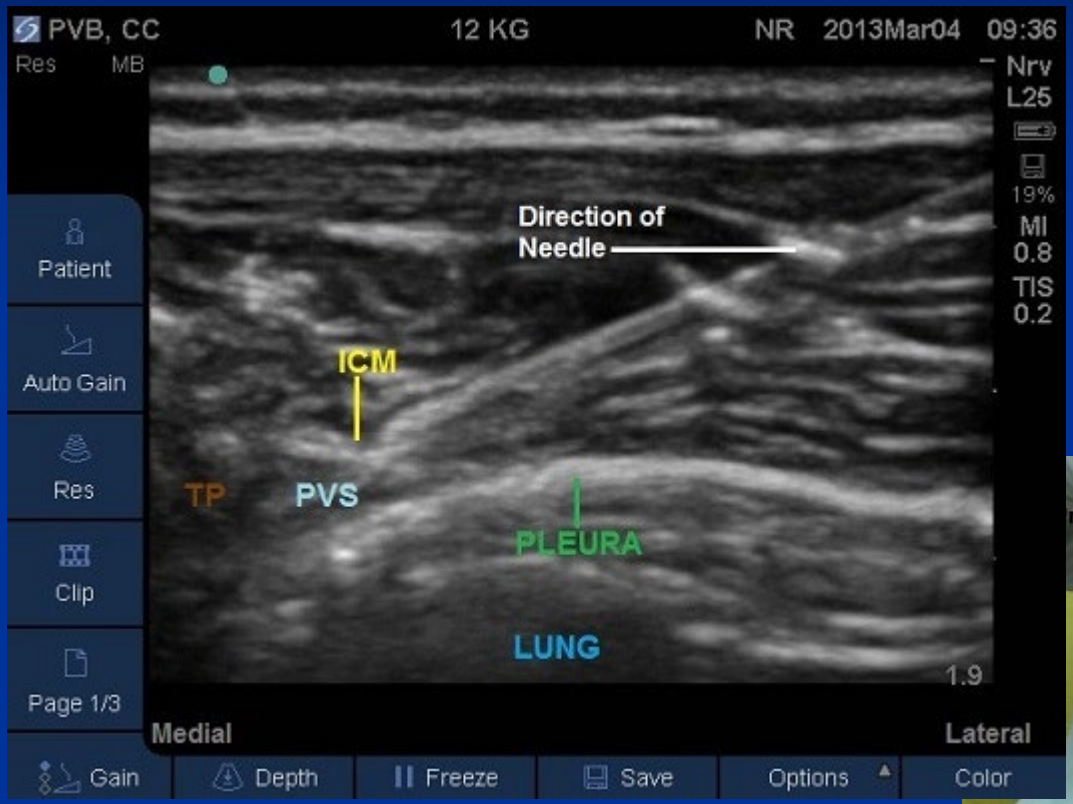
Paravertebral Block – sagittal approach

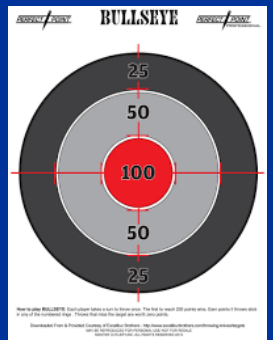


Adult technique I used in private practice

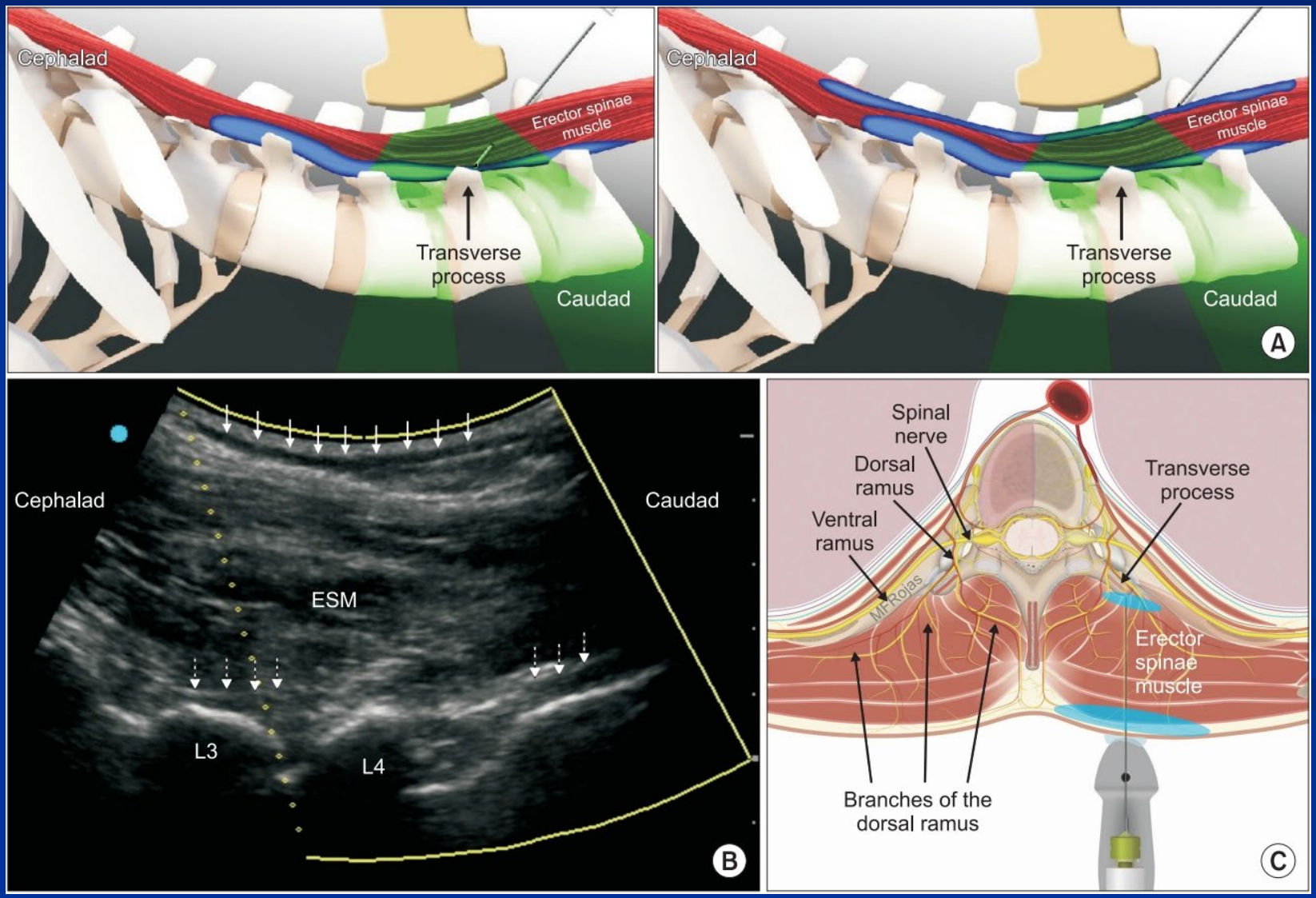


Paravertebral Block – transverse approach (safest approach for babies and children)

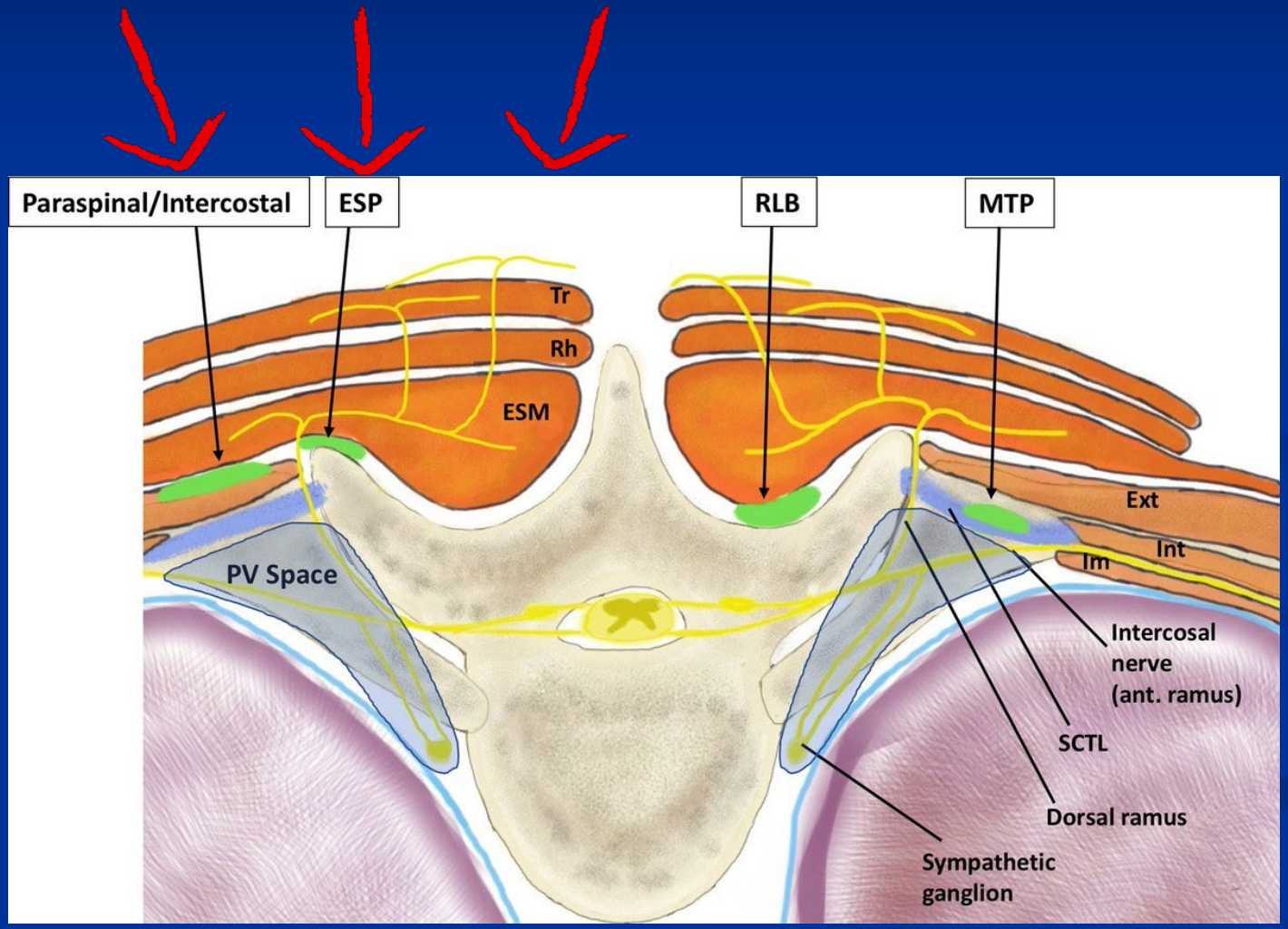




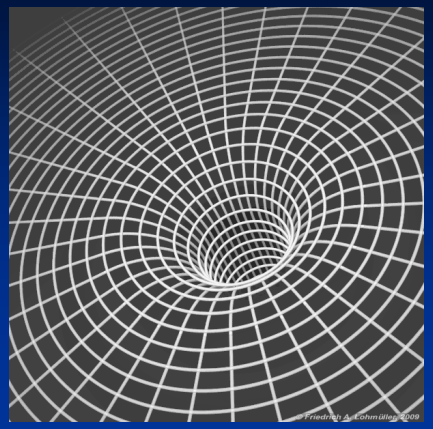
ESP - Paraspinal Blocks

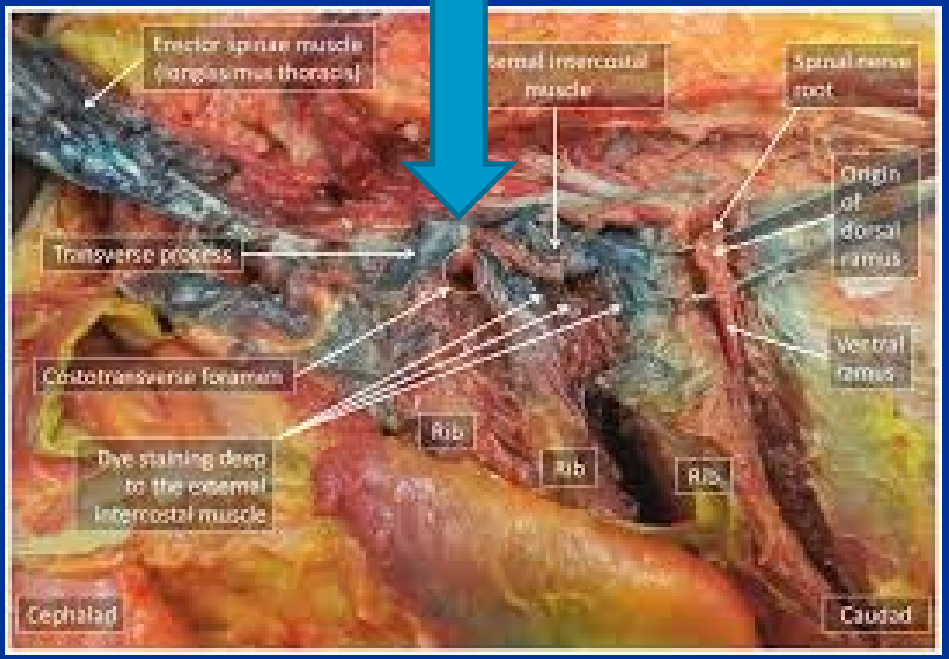


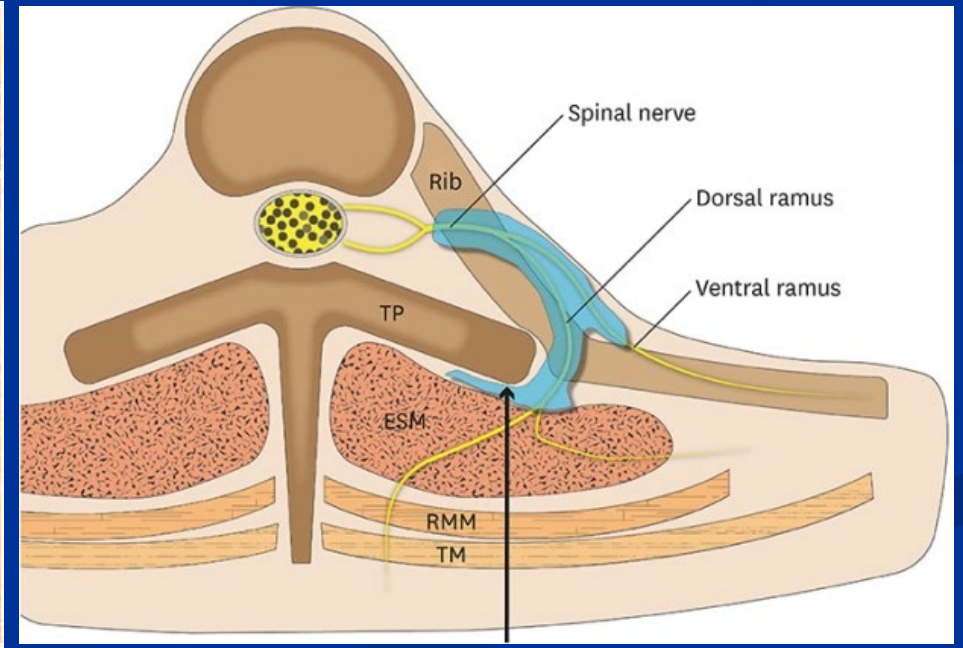
Different New Blocks - Anatomy of Injection Site



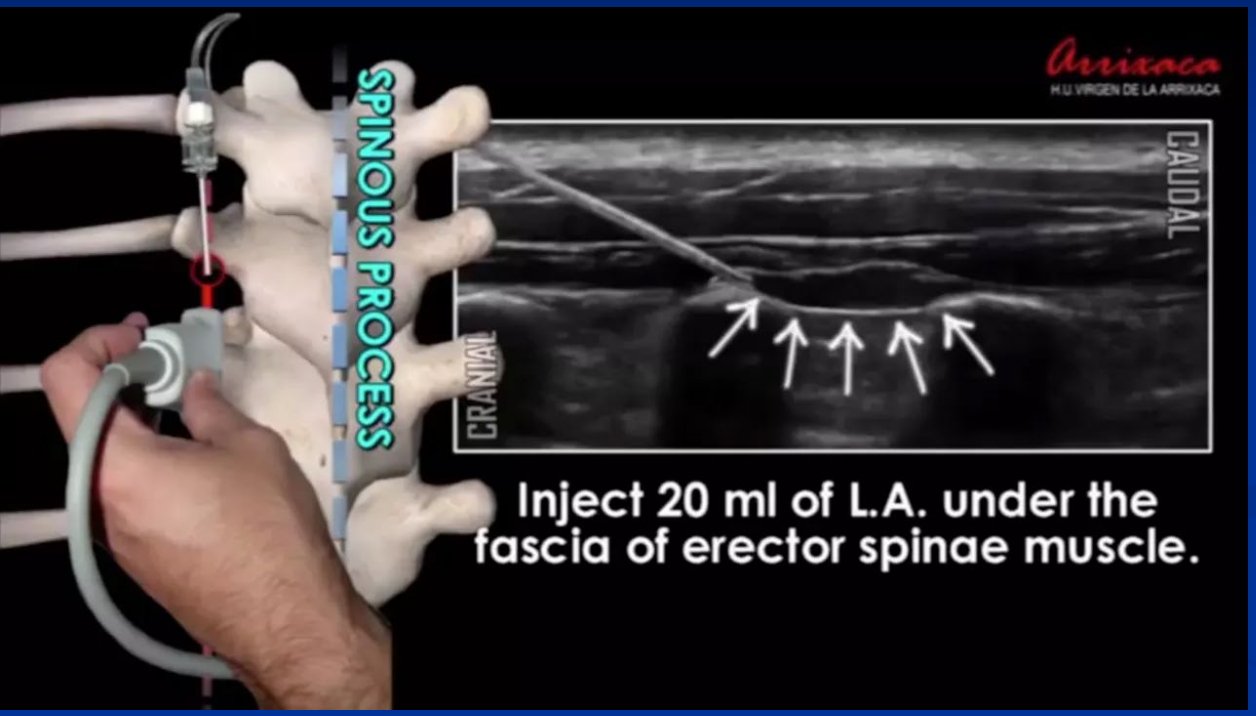
Costotransverse Foramen

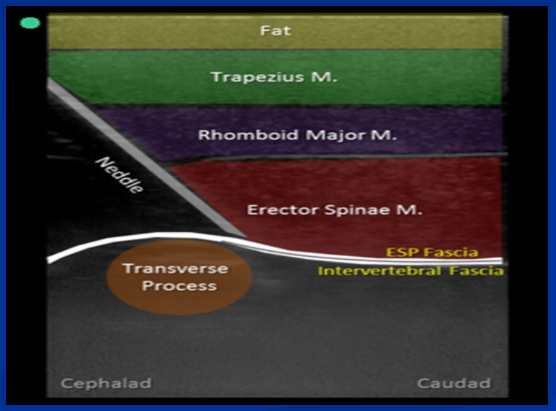


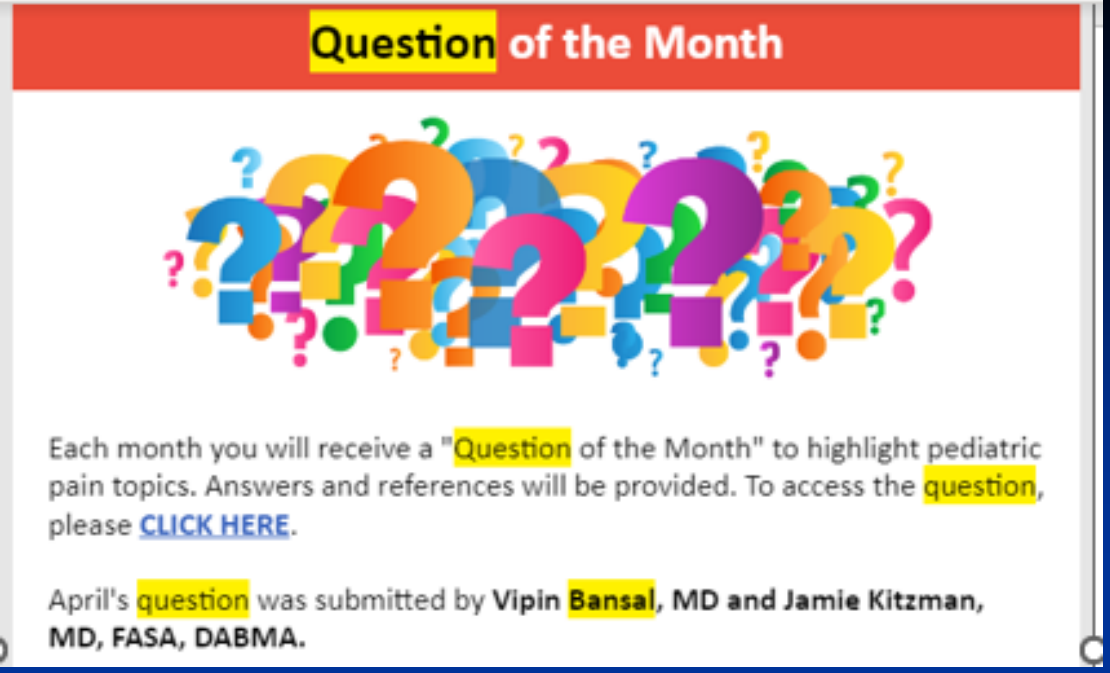




ESP Block


Arrixaca
H.U. VIRGEN DE LA ARRIXACA
SPINOUS PROCESS
CRANIAL
CAUDAL
Inject 20 ml of L.A. under the fascia of erector spinae muscle.


Fat
Trapezius M.
Rhomboid Major M.
Needle
Erector Spinae M.
ESP Fascia
Intervertebral Fascia
Transverse Process
Cephalad
Caudad



- A 5-year-old 16kg male (ex-24 week) with an

1) extensive history of abdominal surgeries

2) multi-level thoracic fractures.

3) superior mesenteric vein thrombus

that is managed on prophylactic enoxaparin.

What options do we have for this abdominal surgery?

Epidural – multiple thoracic vertebrae fracture ✗

TAP Block – multiple abdominal surgeries ✗

QL Block – risk of injuring transverse process ✗

EOI – surgical incision is of lower abdomen ✗

ESP -safe 

ESP Catheter at 4cc/hr

1) Zero pain for 4 days (until removal)

2) No additional drugs used: narcotics, ketamine, toradol.

ELMER PRESS

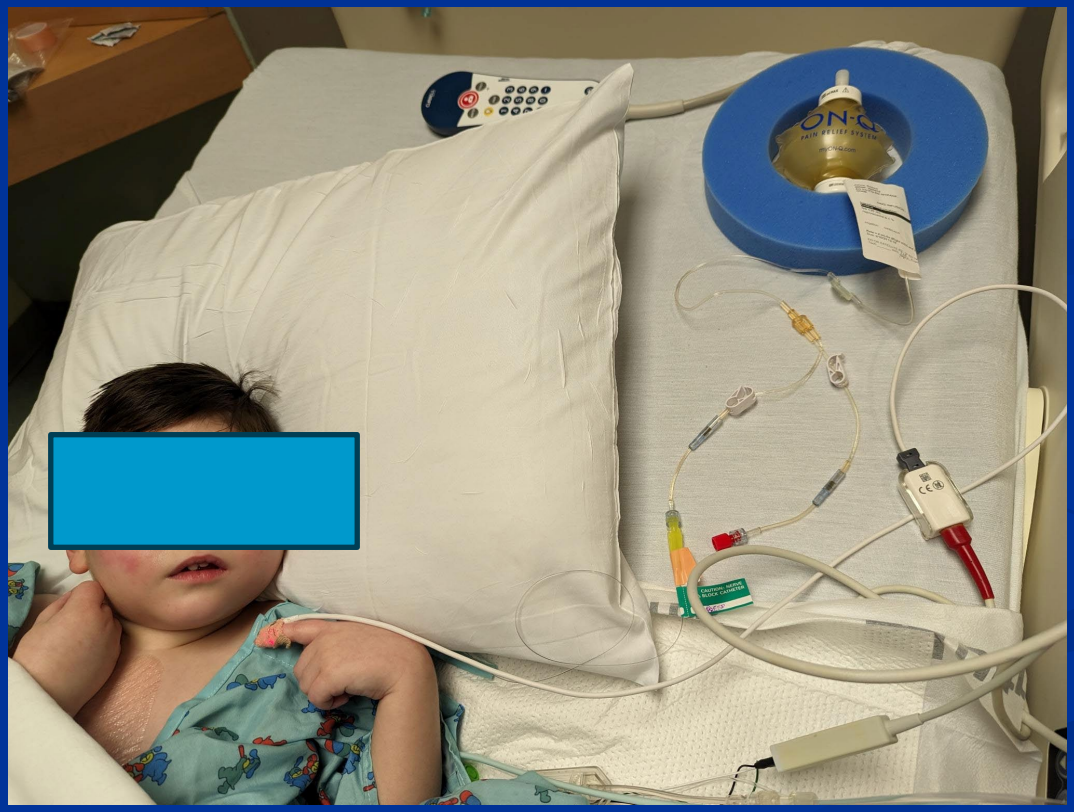
Check for updates

Case Report

J Med Cases. 2023;14(11):351-355

Epidural-Like Effect of a Continuous Right-Sided Erector Spinae Plane Blockade for Complicated Pediatric Abdominal Surgery

Neil Doshi[a], Vipin Bansal[b], Emmanuel Alalade[b, c]



Collaboration with Emory

Children's Healthcare of Atlanta

EMORY UNIVERSITY

The Lego-Brücke (Lego Bridge) of Wuppertal, Germany.

Shout out to:

1) Dr. Yawar Qadri
2) Dr. Brian Ilfeld

Both of them answered every phone call or email

Amazing colleague
-always ready to help

Brian Ilfeld, M.D., winner of the prestigious 2022 Gaston Labat Award from ASRA.

Future of Pain

DISEASE

Strep throat turns almost deadly for a teen, who had to have all 4 limbs amputated

After strep throat led to septic shock, Natalya "Nat" Manhertz needed to have her limbs amputated. While she struggles at times, she's optimistic about the future.

Jan. 24, 2024, 9:49 PM UTC / Source: TODAY

By Meghan Holohan

Scan me!

Hypotensive at outside hospital Started on ECMO practically on admission

Example of Limb Necrosis

Research | Open access | Published: 04 February 2012

Clinical experience with power-injectable PICCs in intensive care patients

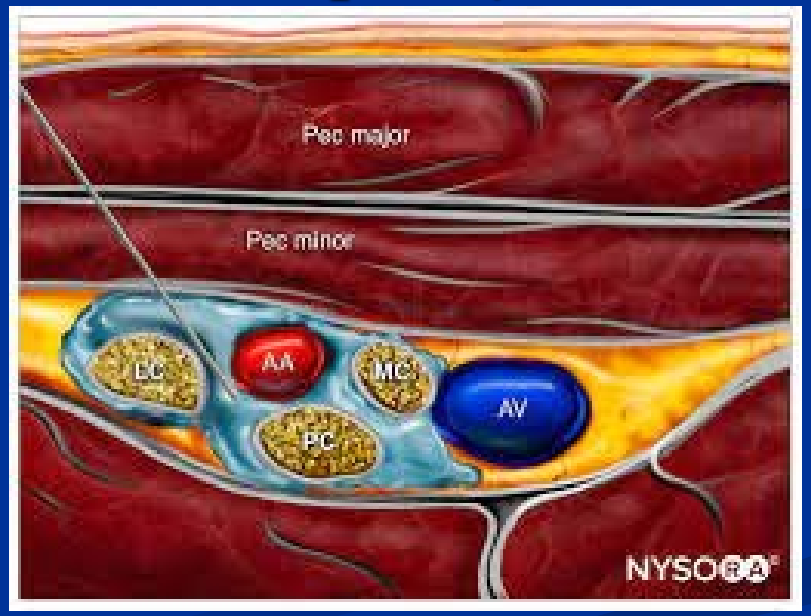
Mauro Pittiruti, Alberto Brutti, Davide Celentano, Massimiliano Pomponi, Daniele G Biasucci, Maria Giuseppina Annetta & Giancarlo Scoppettuolo

Critical Care **16**, Article number: R21 (2012) | Cite this article

Acute pain control

1) Lower leg amputation - Epidural

2) Upper Extremities – B/L infraclavicular blocks to avoid B/L phrenic nerve paralysis



Pain control

- Ketamine
- Methadone
- IV Tylenol
- Gabapentin
- Dilaudid PCA

STATPEARLS
CONTENT IS KING

Phantom Limb Pain

Aaron A. Hanyu-Deutmeyer; Marco Cascella; Matthew Varacallo.

Author Information and Affiliations

Last Update: August 4, 2023.

Phantom limb pain and Residual limb pain (RLP) present an important challenge in medicine, in terms of epidemiology and therapeutic difficulties.

Ninety-five percent of patients, indeed, report experiencing some amputation-related pain, with :

79.9% reporting phantom pain and 67.7% reporting RLP.

OPEN ACCESS

Percutaneous peripheral nerve stimulation for the treatment of chronic neuropathic postamputation pain: a multicenter, randomized, placebo-controlled trial

Christopher Gilmore,[1] Brian Ilfeld,[2] Joshua Rosenow,[3] Sean Li,[4] Mehul Desai,[5] Corey Hunter,[6] Richard Rauck,[1] Leonardo Kapural,[1] Antoun Nader,[7] John Mak,[4] Steven Cohen,[8] Nathan Crosby,[9] Joseph Boggs[9]

To cite: Gilmore C, Ilfeld B, Rosenow J, *et al*. *Reg Anesth Pain Med* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/rapm-2018-100109

Conclusions This work demonstrates that percutaneous PNS therapy may provide enduring clinically significant pain relief and improve disability in patients with chronic neuropathic postamputation pain.

Trial registration number NCT01996254.

INTRODUCTION

Chronic neuropathic pain is a common and challenging condition following amputation. There are approximately two million amputees in the USA, with nearly 200 000 amputations performed annually.[1] Postamputation pain includes residual limb pain indications is now Food and Drug Administration-cleared. The system uses a percutaneous fine-wire coiled lead designed to reduce lead migration and has been reported to have a significantly lower risk of infection than other neurostimulation electrodes.[17–21] The availability of such a system provides additional therapeutic options for the treatment of pain.

A previous study demonstrated the feasibility of percutaneously implanting fine-wire coiled PNS leads in proximity to the sciatic and femoral nerves in amputees with neuropathic pain.[18] In a series of 16 subjects, 14 (88%) obtained clinically significant relief of RLP and/or PLP. Nine subjects who

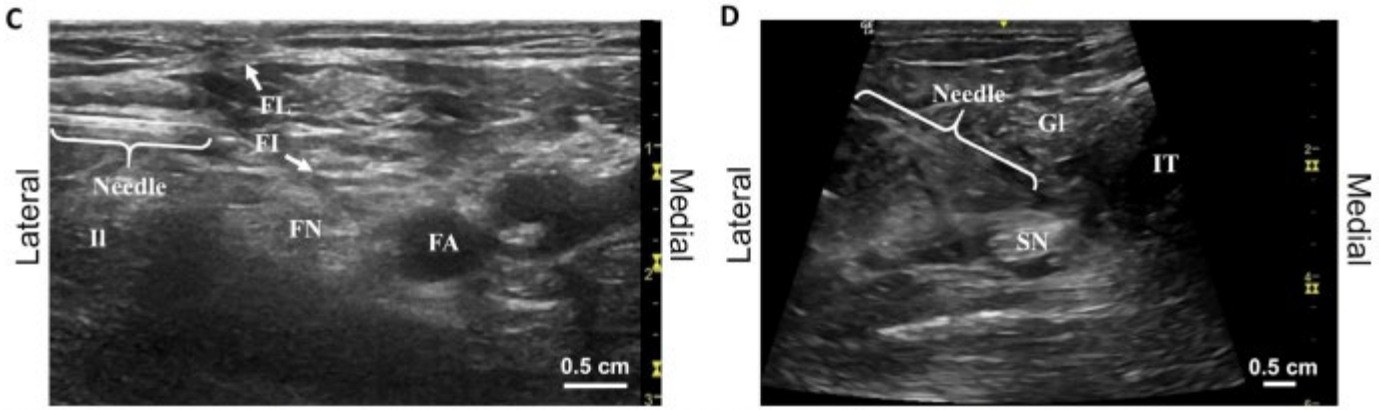


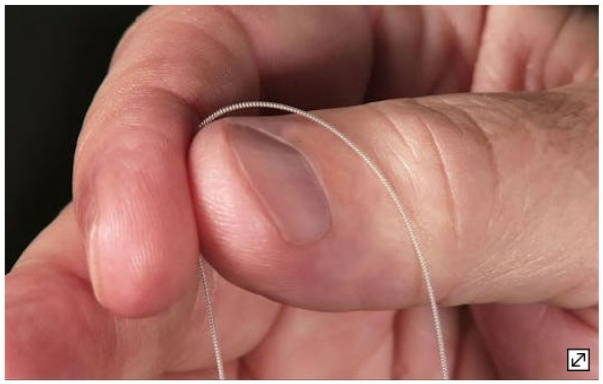
Figure 1 (A) Fine-wire coiled percutaneous peripheral nerve stimulation leads were implanted and (B) connected to external, body-mounted stimulators. A stimulating needle was used to identify the optimal lead location remote from the targeted (C) femoral and (D) sciatic nerves. FA, femoral artery; FI, fascia iliaca; FL, fascia lata; FN, femoral nerve; Gl, gluteus; Il, iliopsoas; IT, ischial tuberosity; SN, sciatic nerve.

Shout out to Dr. Jim Fortenberry for approving this device at CHOA:

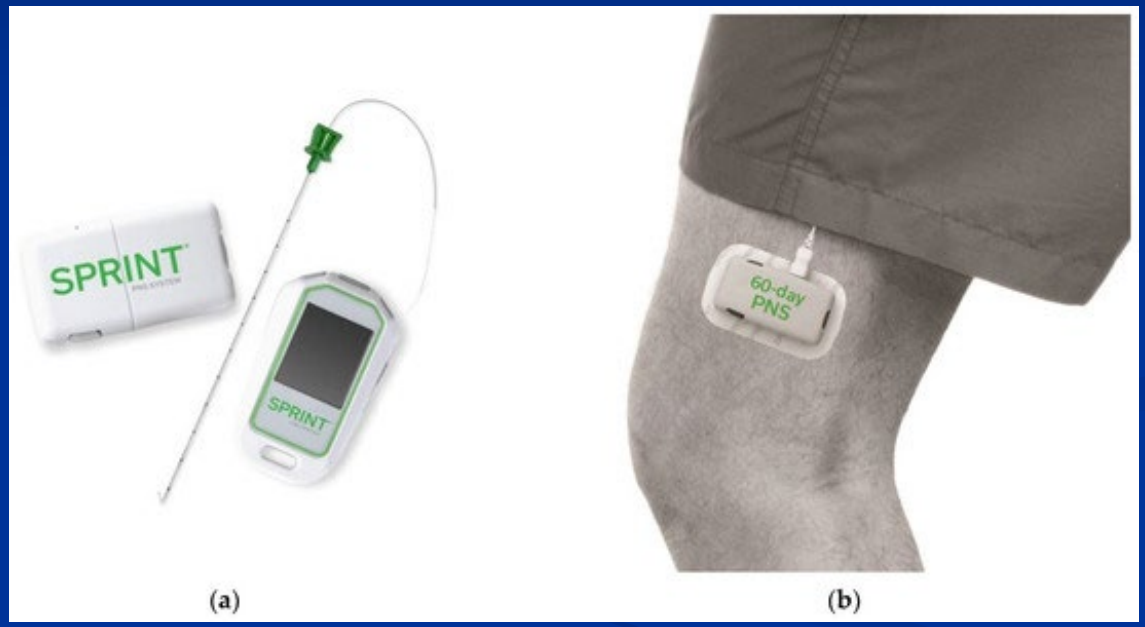
SPR Therapeutics' neuromodulation system treats phantom-limb pain

Minnesota-made system has created long-lasting pain relief in trials.

By Joe Carlson Star Tribune | JULY 7, 2019 — 2:00PM



SPR Therapeutics' Sprint peripheral nerve stimulation system is constructed using a tiny 100-micron wire, about the size of a human hair.



Pain scores after implant: 0-2 (first 60 days)

Pain scores after explant: 0-2 (last 2 years)

Peripheral Nerve Stimulator Device in 4 Limb Amputation: No Pain Since Implant/Explant

Vipin Bansal MD, Brandon Hou MD,
Yawar Qadri MD PhD
Children's Healthcare of Atlanta
Emory University School of Medicine

ASRA PAIN MEDICINE
49th Annual Regional Anesthesiology & Acute Pain Medicine Meeting
March 21-23, 2024 | San Diego, CA

Introduction

17-year-old with strep throat, subsequent multi-organ failure requiring ECMO.

- Hospital course complicated by renal failure and severe limb ischemia requiring amputation of all four limbs.
- For lower leg amputations, a lumbar epidural was placed at level of L2-L3 using landmark guidance.
- For upper extremity amputations, bilateral infraclavicular brachial plexus blocks were performed with ultrasound.
- After persistent lower left leg phantom pain, the family agreed to placement of peripheral nerve stimulator (PNS).
- Permission for this case report was obtained by patient and guardian for presentation at this conference. They have consented for publication of their own story in Today.com.

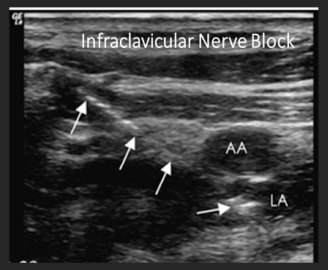
Patient's medical history, coagulation issues, and anatomy reviewed

Paperwork to place first PNS device in a children's hospital

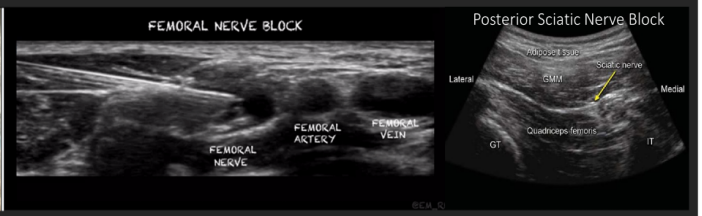
Placement of a PNS device targeting left femoral and sciatic nerves

Relief from PNS was assessed during implant (60 days) and 6 months later

Upper Extremity Nerve Block



Lower Extremity Nerve Block



Percutaneous peripheral nerve stimulation should be explored in children to treat phantom pain

Scan me!

Take a picture to download the paper from Today.com

Children's Healthcare of Atlanta

EMORY UNIVERSITY SCHOOL OF MEDICINE

Methods

- For acute pain involving lower leg amputations, we placed lumbar epidural at level of L2-L3 using landmark guidance.
- For upper extremity amputations, we chose to perform bilateral infraclavicular brachial plexus blocks.
- For the following month, we continued patient on ketamine infusion, methadone, gabapentin, and a dilaudid PCA.
- She continued to have phantom pain, so we decided to use PNS instead of intrathecal pump or spinal cord stimulator (SCS) to avoid concerns of neuraxial bleeding and infection. Our patient was on anticoagulation medications as well as antibiotics for an stump infection.
- Percutaneous PNS leads placed under ultrasound guidance to target the left femoral and sciatic nerves with motor or paresthesia verification as tolerated by patient.

Case History

- We had excellent acute pain control postoperatively with epidural and infraclavicular nerve blocks. Plans for long term catheter infusions were complicated because she was placed on anticoagulants to minimize potential complication of DVT. In addition, she was not a candidate for targeted muscle reinnervation (TMR) due to her active stump infection, which can reduce neuropathic pain.
- Despite multiple pain meds, patient complained of phantom and stump pain in her left leg. With PNS device in place, she received physical therapy and did not require any narcotics and had zero pain scores. Gabapentin was also stopped to avoid suicidal ideations.
- We are now several months from removal of PNS device and our patient has been pain-free and is currently not using any prescription pain medications.

Discussion

- Patient is healthy girl who recovered from devastating septic shock, underwent amputations of all four limbs, but was able to stay in good spirits despite all odds.
- We managed acute pain with neuraxial and regional nerve blocks, but subacute and chronic pain, such as residual limb and phantom pain, was more difficult to control with medical management. With PNS placement, her pain scores dropped to zero.
- Patient is back in school finishing her senior year. She is not on any pain meds. Our patient's success suggest that neuromodulation occurred at both peripheral and central level. We recommend PNS technology as a viable option for long term chronic pain control for pediatric patients.

References

1. Alviar MJ, Hale T, Dungca M. Pharmacologic interventions for treating phantom limb pain. Cochrane Database Syst Rev. 2016 Oct 14;10(10):CD006380.
2. Limakatso K, Parker R. Treatment Recommendations for Phantom Limb Pain in People with Amputations: An Expert Consensus Delphi Study. PM R. 2021 Nov;13(11):1216-1226.
3. Modest JM, Raducha JE, Testa EJ, Eberson CP. Management of Post-Amputation Pain. R I Med J (2013). 2020 May 1;103(4):19-22.
4. Ilfeld BM, Khatibi B, Maheshwari K, Madison SJ, Esa WAS, Mariano ER, Kent ML, Hanling S, Sessler DI, Eisenach JC, Cohen SP, Mascha EJ, Ma C, Padwal JA, Turan A; PAINfRE Investigators. Ambulatory continuous peripheral nerve blocks to treat postamputation phantom limb pain: a multicenter, randomized, quadruple-masked, placebo-controlled clinical trial. Pain. 2021 Mar 1;162(3):938-955.

Media Coverage

a.Interview with Today.com:
Strep throat turns almost deadly for a teen, who had to have all 4 limbs amputated, January 2024

b.Interview with Atlanta Journal Constitution, Inspire Atlanta,
Teen thrives despite having four limbs amputation, February 2024

c.Interview with WSB-TV Channel 2
GA teen graduates year after limbs amputated when strep throat sent her into septic shock. May 2024

d.Full 11Alive documentary (Christmas special)
Teen survives sepsis and four amputations. December 2025.
https://www.youtube.com/watch?v=FaMHatAZRjc

Trivia:


Reddit
The fact that darth maul actually has earrings because Park forgot to take them out is so funny....
Visit ›

OPEN ACCESS

Percutaneous auricular nerve stimulation (neuromodulation) for the treatment of pain following outpatient surgery: a proof-of-concept case series

Brian M Ilfeld ,[1] John J Finneran IV ,[1] David Dalstrom,[2] Anne M Wallace,[3] Baharin Abdullah ,[1] Engy T Said [1]

To cite: Ilfeld BM, Finneran IV JJ, Dalstrom D, *et al*. *Reg Anesth Pain Med* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/rapm-2022-103777

INTRODUCTION

The moderate-to-severe pain many patients experience following surgery is often treated with opioids, which are associated with side effects such as nausea, vomiting, sedation, and respiratory depression (and a risk of misuse, dependence, and diversion). Potent site-specific analgesia with fewer side effects may be provided with peripheral nerve blocks. However, multiple therapeutic uses, including treating neurological (eg, epilepsy), inflammatory, and cardiovascular disorders; metabolic syndromes; psychiatric symptoms and disorders (eg, anxiety, depression, autism),[9] as well as multiple pain conditions.[4]

A percutaneous auricular neuromodulation device is currently cleared by the US Food and Drug Administration (FDA) to reduce symptoms associated with opioid withdrawal for up to 5 days (NSS-2 Bridge, Masimo, Irvine, California, USA; figure 1).[10–12] Three small non-randomized studies

Figure 1 A percutaneous auricular nerve stimulation system (NSS-2 Bridge, Masimo, Irvine, California, USA). Each of the three electrodes has a 2 mm long integrated needle/lead (inset) and the ground electrode has four 2 mm long integrated needles/leads (inset). Used with permission from BMI.

suggest that this device may also provide analgesia in hospitalized

Table 1 Anthropometric patient characteristics

Age (years)	54 (17)
Female sex (#)	5 (71%)
Height (cm)	173 (7)
Weight (kg)	74 (13)
Body mass index (kg/m^2)	25 (3)

Data presented as mean (SD) or number of patients (percentage).

CASE DESCRIPTION

Following moderately painful orthopedic and breast surgery, seven patients (table 1) were offered, and consented for, postoperative administration of percutaneous auricular neuromodulation (figure 2). The University's Institutional Review Board (University of California San Diego, San Diego, California, USA) waives any review requirements for case reports or short series; but these patients provided both verbal and written consent to receive auricular neuromodulation for the off-label use of postoperative pain control and publish these deidentified case reports and non-identifiable photos.

Patients having orthopedic and breast surgery received ultrasound-guided single-injection popliteal-sciatic and paravertebral nerve blocks, respectively, with ropivacaine 0.5% and epinephrine prior to surgery (table 2). Following surgery in a semirecumbent position within the recovery room, each patient received intravenous fentanyl 25 µg and the application locations were wiped with an alcohol pad and benzoin over the mastoid process for the pulse generator and at the four points of electrode placement (figure 2).[16]

taVNS for Rhematoid Arthritis

THE COLTON CONSORTIUM
FOR AUTOIMMUNITY

COLTON CONSORTIUM
VIRTUAL SPEAKER SERIES

Development of a Vagus Nerve-Mediated Neuroimmune Modulation Therapy for Rheumatoid Arthritis

Yaakov Levine, PhD

Vice President of Research, **SetPoint Medical**
Associate Professor of Molecular Medicine, **Hofstra University**
Associate Professor of Bioelectronic Medicine, **The Feinstein Institutes for Medical Research**
Affiliated to Research (Cardiovascular Medicine), **Karolinska Institutet**

February 17, 2026 | 11:00 a.m. ET

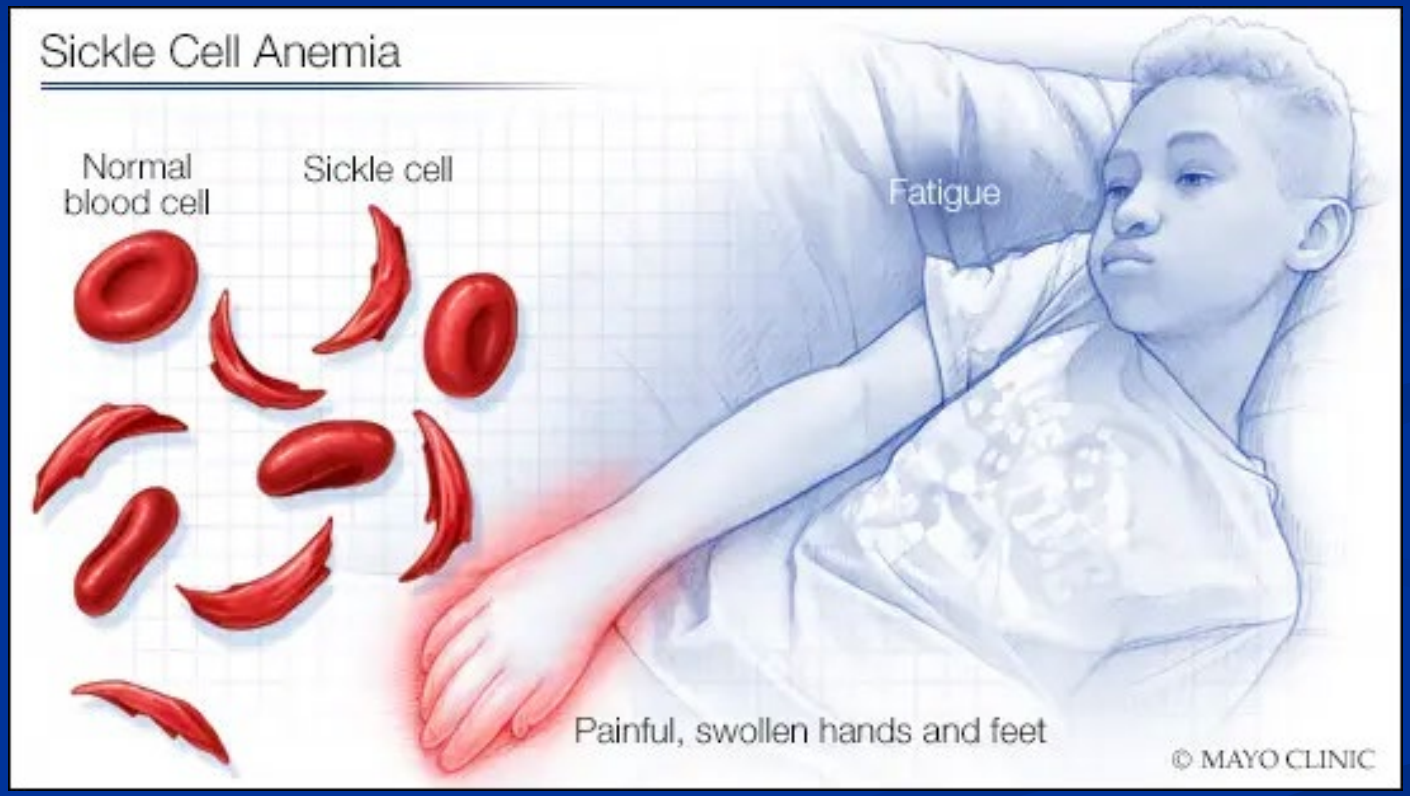
Registration Required

Congratulations!

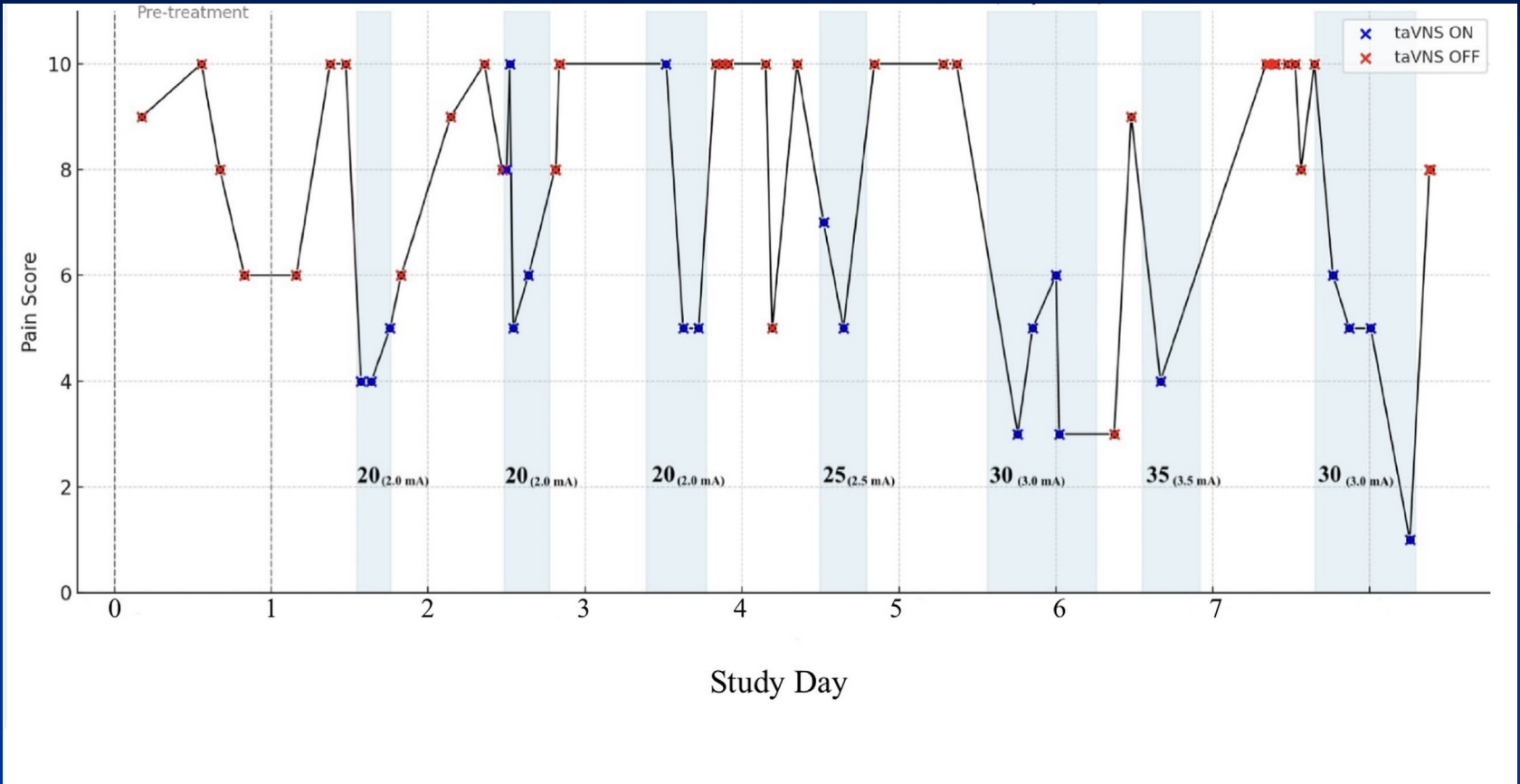
Anna Woodbury, MD

Dr. Woodbury received a notice of intent to fund her 4-year project "Auricular Neuromodulation in Veterans with Fibromyalgia: A Randomized Sham-Controlled Study" through the VA's Rehabilitation Research & Development Service (RR&D) Merit mechanism. Her team will enroll 240 veterans with fibromyalgia for treatment with percutaneous electrical nerve field stimulation (PENFS). This builds off her prior work in this field

Feasibility study using taVNS in Sickle Cell patients



Pilot Patient

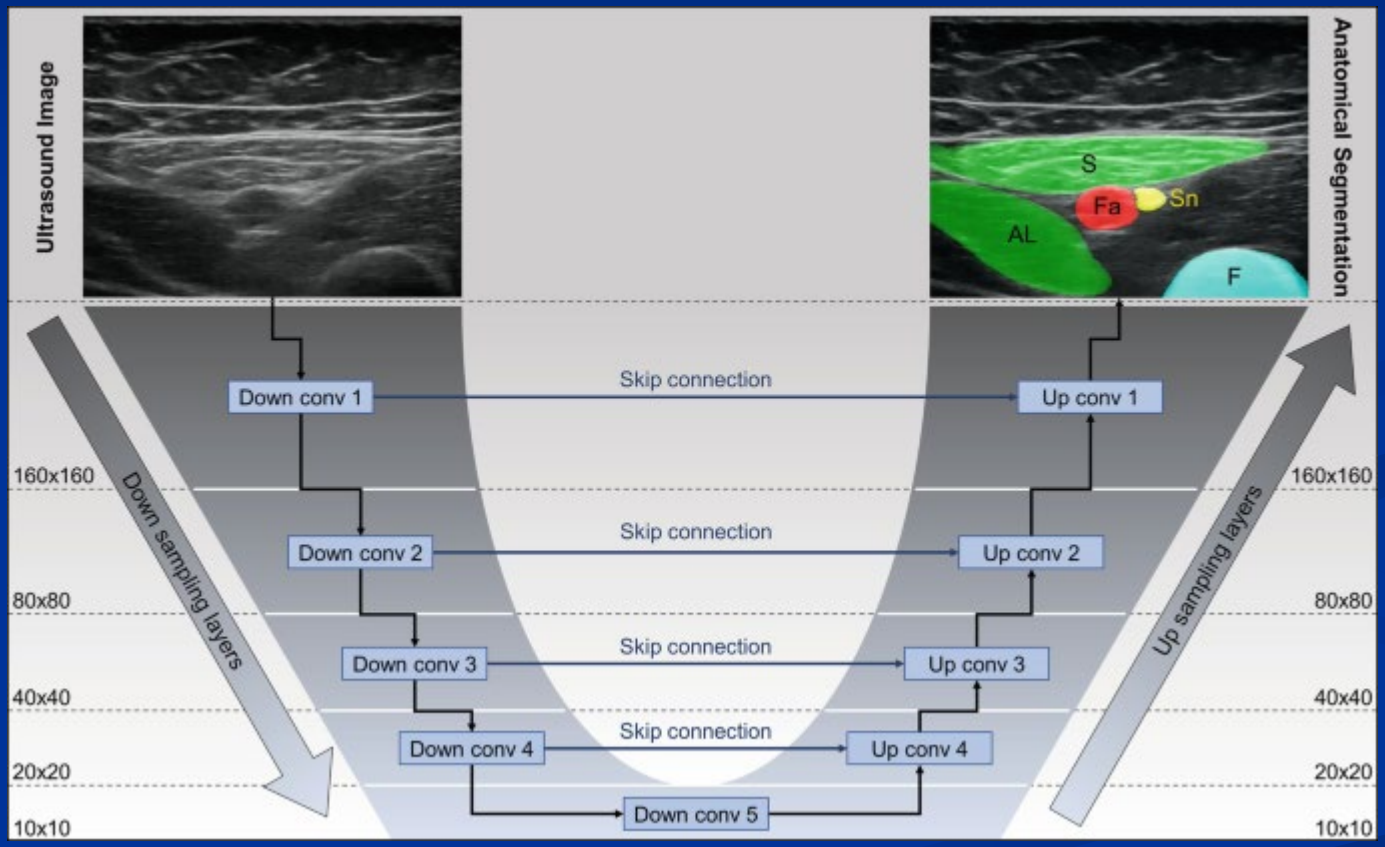


White zones: baseline pain scores

Blue zones: pain scores with device

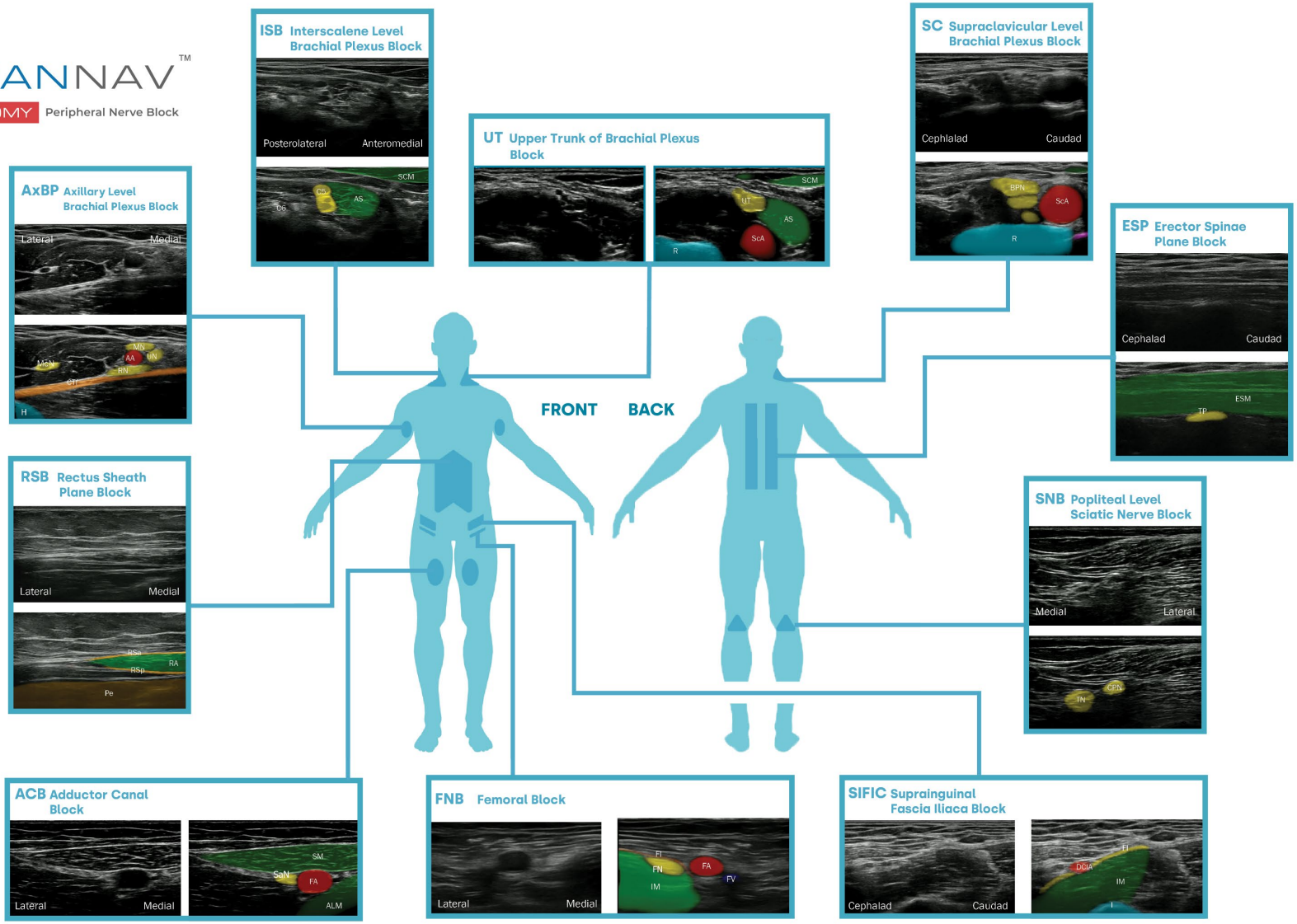
The future of Artificial Intelligence

Artificial Intelligence –not robots, but machine learning.

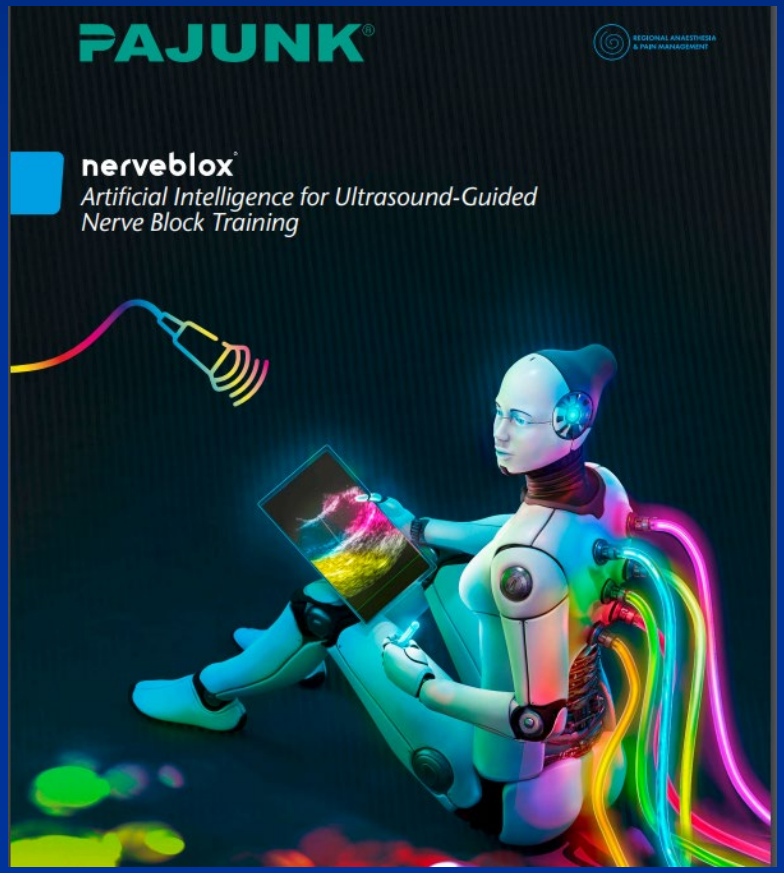


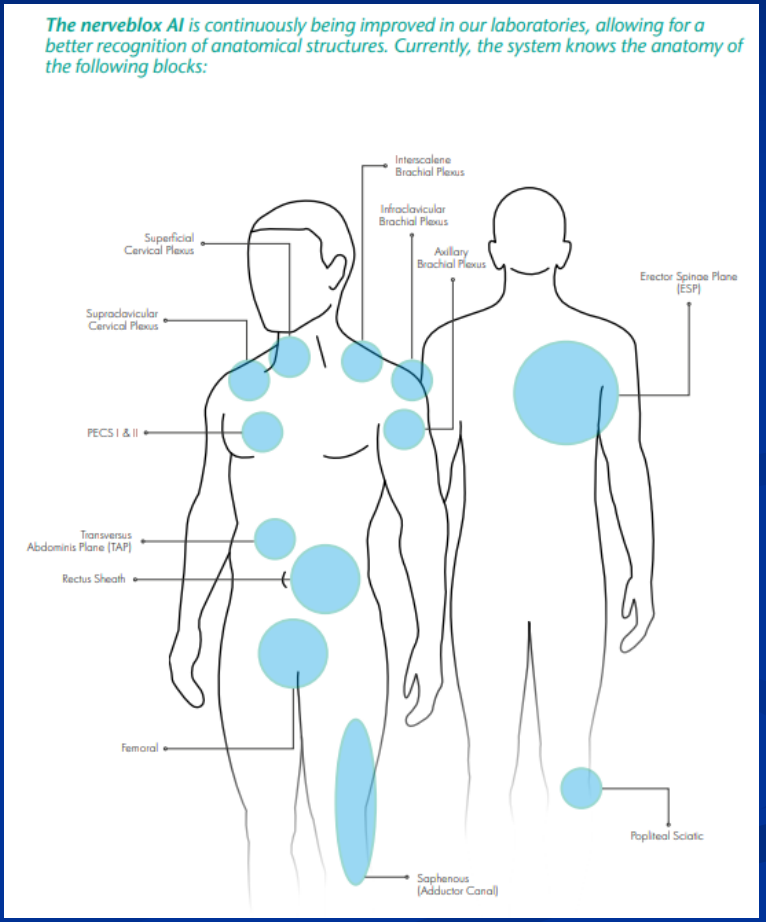
SCANNAV™

ANATOMY Peripheral Nerve Block

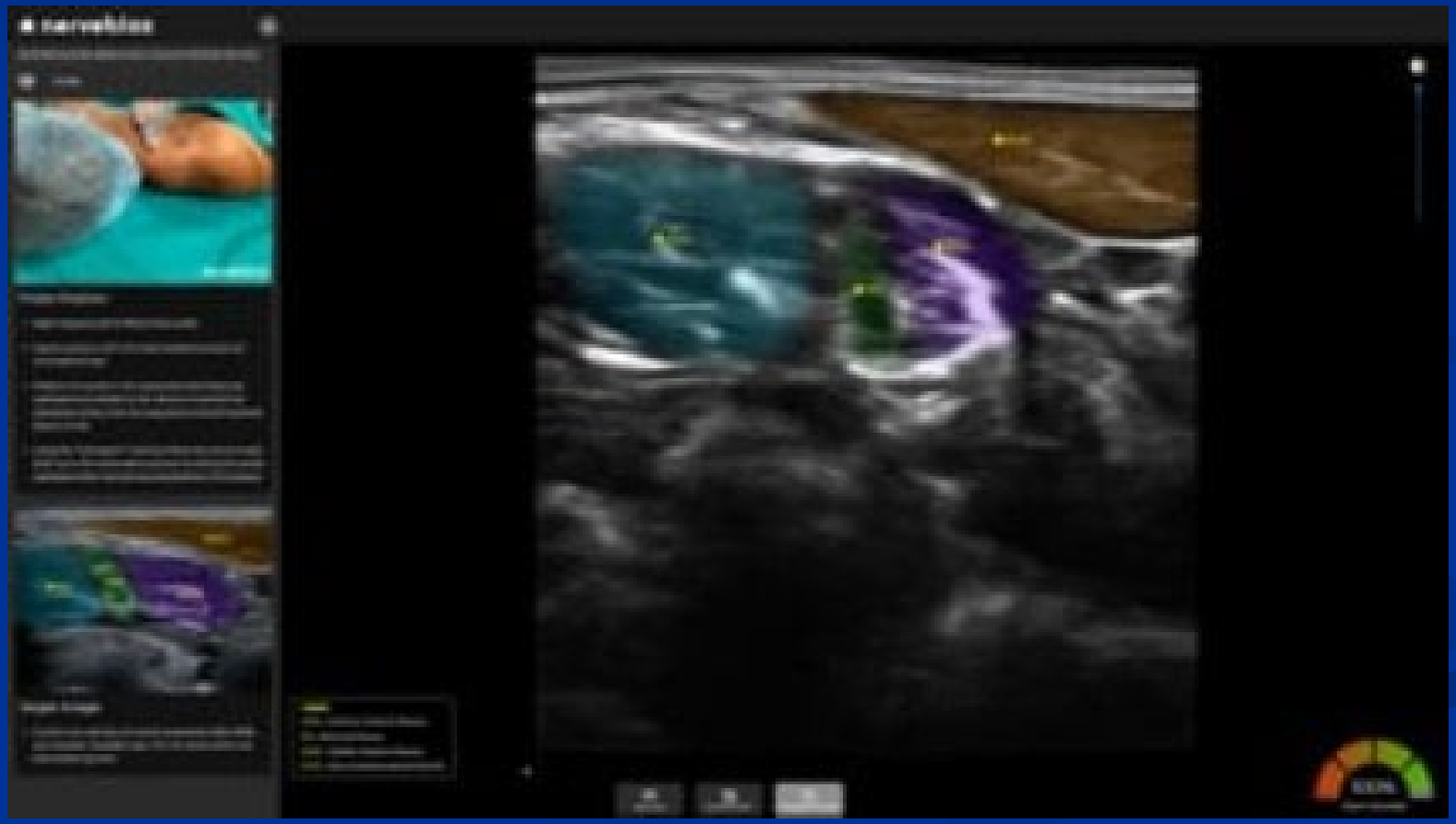


NerveBlox program





Interscalene block

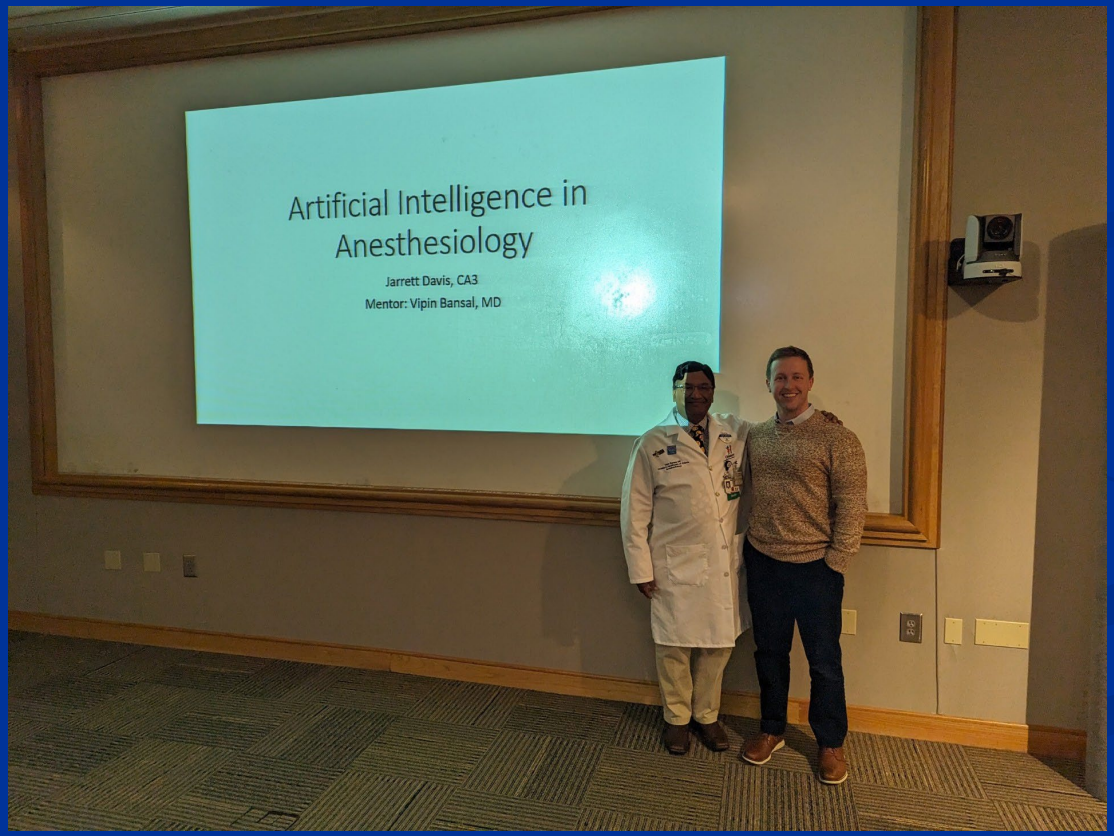


Teaching tool

Compare sonoanatomy recognition with AI training vs. NYSORA web based learning

-pretest

-post-test



Final words of advice:
Don't give up

Words of inspiration:

You will make new discoveries.

You can change the future.

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PACU Efficiency and Perioperative Patient Flow

David F. Nelson MD, MBA

Georgia Society of Anesthesiologists Winter Forum
Saturday, February 7th, 2026

Learning Objectives

- Describe common PACU throughput constraints, including Phase I recovery delays, discharge bottlenecks, and boarding patterns, and explain their downstream effects on turnover time, operating room utilization, patient satisfaction, and case cancellations.
- Interpret perioperative operational metrics--including time on PACU-level care, boarding hours, staffing ratios, and OR hold statistics to identify system-level contributors to perioperative flow inefficiencies.
- Evaluate PACU length of stay, case mix index, and financial performance data to identify patient populations and surgical services at increased risk for PACU boarding and downstream impacts to hospital economics and overall length of stay.

Learning Objectives

- Describe how CMS Conditions of Participation, Joint Commission standards, and other regulatory requirements govern anesthesia-led care in the PACU and apply these requirements to the development of compliant recovery workflows, staffing models, and discharge processes.
- Apply perioperative flow interventions (e.g. discharge timing optimization, electronic PACU dashboards, demand-triggered flexible staffing strategies and downstream bed-capacity management strategies) to prioritize initiatives that mitigate OR holds and PACU boarding and improve perioperative patient flow.

- NO FINANCIAL DISCLOSURES

Part I: Intro to PACU

- Transition between intraprocedural anesthesia care to PACU RN
- Recovery of consciousness, airway reflexes, ventilation, and hemodynamic stability
- Phase I PACU acuity often exceeds ward-level care and may require ICU-level vigilance for short intervals.
  - Can be a full-fledged ICU (sorta...)

More than a Recovery Room…

- PACU is the interface between **OR throughput** and **downstream capacity.**
- The "pop-off valve" for the hospital
  - Serves as a buffer for OR, ER, ICU, "Rapid Response" patients,
  - Mismatches between capacity and demand of other units
  - Pandemic surge

PACU patient flow definitions and goals

- **Phase I**: Anesthesia STOP → PACU CARE COMPLETE (AKA discharge criteria met)
  - Vizient (academic medical center) *average* **~60 minutes**
- **Boarding/Phase II**: After CARE COMPLETE, but before wheels out of PACU
  - Vizient *average* **~17 minutes**
- **Total PACU LOS:** Total PACU wheels in→wheels out time
  - Includes Phase I and *boarding* (time between PACU Care Complete and transport)
  - Vizient *average* **~77 minutes**

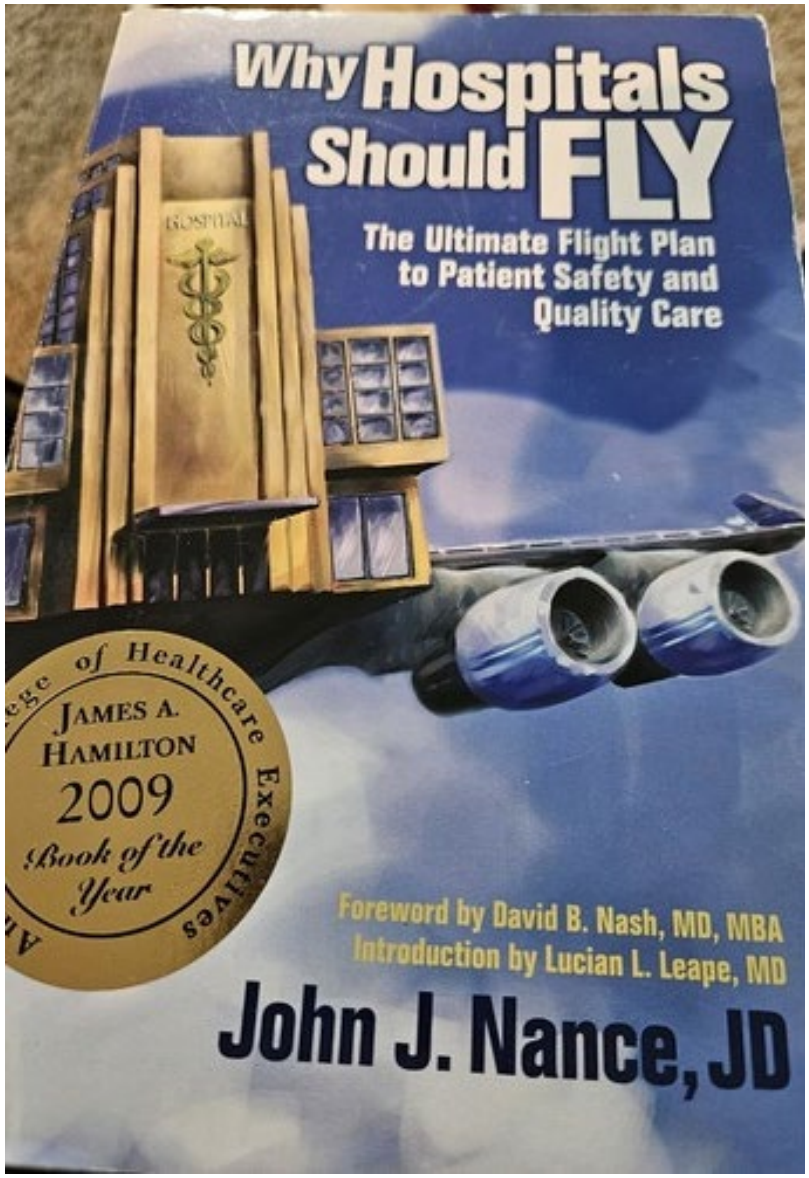
Common PACU Throughput Constraints

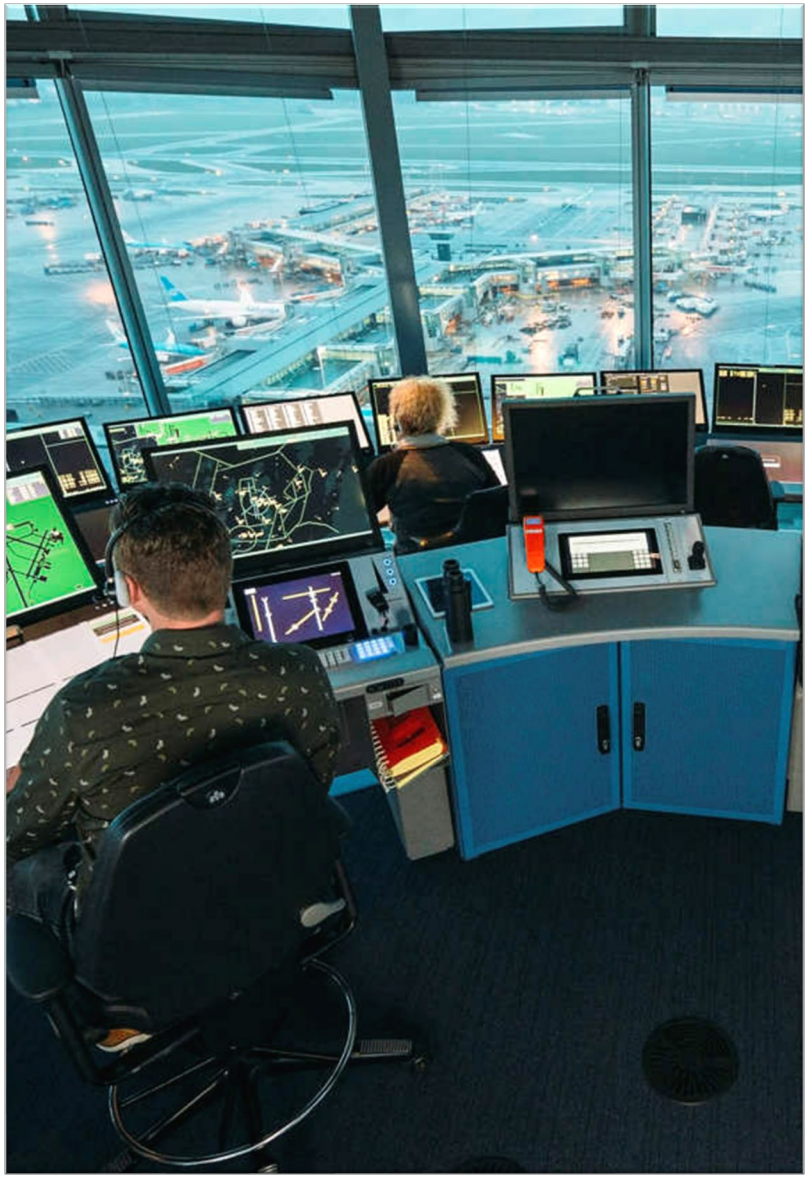
- Phase I recovery variability
  - **Actual** clinical recovery variability
    - Surgery type, case-mix index, and local practice patterns
  - **Subjective** assessment of recovery
    - Aldrete score vs "eyeball test"
  - "iatrogenic" variability
    - Requests to await certain laboratory results, radiographic studies, or arbitrary "minimum" time
- Delayed discharge decisions
  - Awaiting Anesthesia "sign-out"
  - Surgeon/proceduralist dispo.

Common PACU Throughput Constraints cont.

- **Physical** PACU space constraints
  - All qualified perioperative bays/spaces occupied
- **Staffed** PACU bed availability
  - RN staffing misaligned with demand
  - Nurse:Patient ratio limiting factor
- **Downstream** bed unavailability
  - Most **common** reason
  - ICU's fully occupied
  - floor discharges later in day, i.e. rounding after first cases

"PACU inefficiency is often misdiagnosed as a nursing or bed problem—when it is usually a systems problem."


Why Hospitals Should FLY
The Ultimate Flight Plan to Patient Safety and Quality Care
HOSPITAL
College of Healthcare Executives
James A. Hamilton
2009
Book of the Year
Foreword by David B. Nash, MD, MBA
Introduction by Lucian L. Leape, MD
John J. Nance, JD



What Is PACU Boarding?

- Patient **clinically** ready to leave PACU
  - No inpatient bed available (inpatients) or staffed Phase II bed (outpatients)
  - No transporters
- Must remain in PACU *after* Phase I complete
  - **Distinct** from prolonged Phase I recovery
  - **Downstream externality** to *clinical* care in PACU
  - Commonly referred to as "Off PACU-level care" as a lag-metric

"Boarding reflects system-level constraints, not PACU failure"

“Medically ready ≠ operationally possible.”

“Phase I recovery is physiology.
Phase II recovery is logistics.”

Part II: Why PACU Efficiency Matters

- Directly affects...
  - The main **revenue-earning unit** in the hospital
    - Contribution margin per case (profitability)
    - OR holds, turnover, and utilization
  - Patient satisfaction
  - Case cancellations
    - High profile events
    - "I'm calling the CEO!"
  - **Staff burnout**
  - **Length of stay** and cost of care

Financial Impact of PACU Congestion

- OR Holds
  - Increased cost per case. Fixed vs. Variable
  - OR time ≈ **$36–$37/min***
  - Opportunity costs ≈ **$1,592 per lost hour+**
- PACU labor costs
  - Direct and indirect
    - **Shifted vs hourly/overtime**
    - Often unreimbursed

*Childers CP, Maggard-Gibbons M. Understanding Costs of Care in the Operating Room. JAMA Surg. 2018 Apr 18;153(4):e176233. doi: 10.1001/jamasurg.2017.6233. Epub 2018 Apr 18. PMID: 29490366; PMCID: PMC5875376.

+ Ruiz Patiño, Alejandro & Acosta, Laura & Rueda, Juan-David. (2016). Solving the negative impact of congestion in the PACU: a cost of opportunity analysis. Journal of Surgical Research. 210. 10.1016/j.jss.2016.11.003.

Contents lists available at ScienceDirect

Perioperative Care and Operating Room Management

journal homepage: www.elsevier.com/locate/pcorm

Length of stay and cost of care differences between postoperative patients who board in PACU and those that proceed directly to inpatient bed

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ARTICLE INFO

Keywords:
Post-anesthesia care unit
Boarding
Costs
Length of stay
Perioperative

ABSTRACT

Background: Bottlenecks in PACU throughput are frequently encountered challenges that OR managers must face. This study seeks to examine the impact of extended PACU stay (e.g. boarding) on both total hospital length of stay and overall cost of care.

Methods: A total of 4,740 patients were studied having same-day admit surgeries for seven procedure types including: arthroplasty total knee, arthroplasty total hip, fusion spine transforaminal interbody lumbar, revision arthroplasty total knee, revision arthroplasty total hip, posterior cervical fusion, and anterior cervical fusion. 4,471 were identified as non-PACU boarders and 269 as PACU boarders (>6 h in PACU). Included in the analysis were demographics, date of admission, surgical procedure, PACU and hospital length of stay (HLOS), hospital direct costs, case mix index (CMI), and ASA status.

Results: The median (IQR) PACU times in minutes were 57.00 (80) and 488.00 (453.50) minutes for PACU non-boarders and boarders ($p < 0.001$). HLOS was significantly ($p < 0.001$) more elevated in PACU Boarders compared to PACU Non-boarders: median (IQR) 2.00 (2.00) and 2.00 (3.00), (mean HLOS 3.16±2.83 vs 2.60 ±2.71 days). Median direct costs were ≈14.36% higher ($p = 0.008$) for the PACU boarders compared to Non-boarders. Direct costs were also not significantly different when using a 4-hour criteria for PACU boarders (14.39% higher median direct costs, $p = 0.004$).

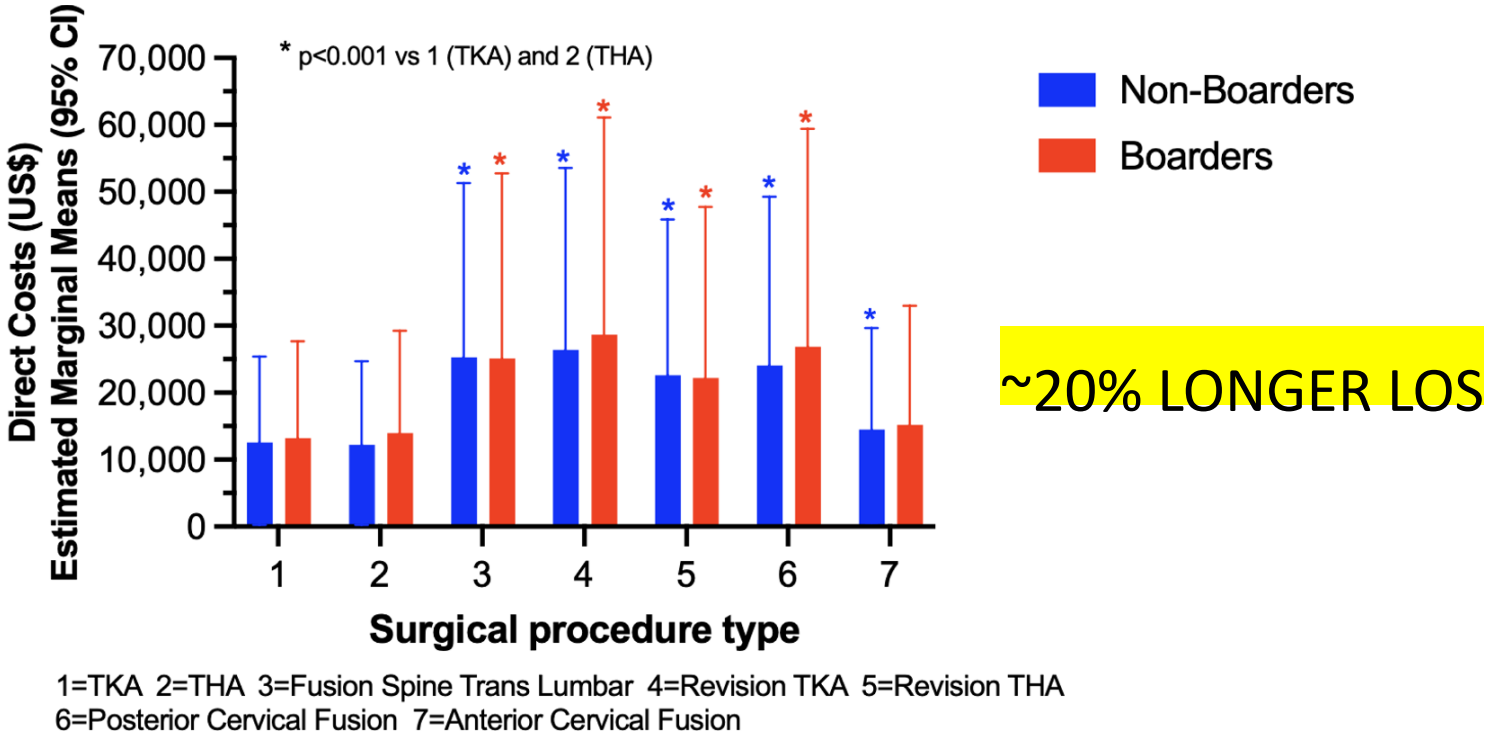
Conclusions: PACU boarding (>4 h) is associated with a statistically significant increased length of stay as well as direct costs compared with non-boarders across a variety of elective orthopedic and spine procedures. Thus, when frequent PACU boarding occurs, OR managers should consider the potential impact to patient care and hospital margins.

Study Design

- Retrospective cohort study
  - 7 common orthopedic procedures
  - Two groups each: “Boarders” (>6h off PACU-level care) and “non-boarders”

- Outcomes: hospital LOS and direct cost of care

Impact on Length of Stay



~20% LONGER LOS

Fig. 2. The figure shows the estimated marginal means with adjusted 95% CI of direct costs by surgical procedure. There was a statistically significant (p <0.001)
difference in direct costs between the surgical procedures with the lowest costs attributable to TKA and THA procedures while revision TKA procedures incurred the
highest costs.

Impact on Cost of Care

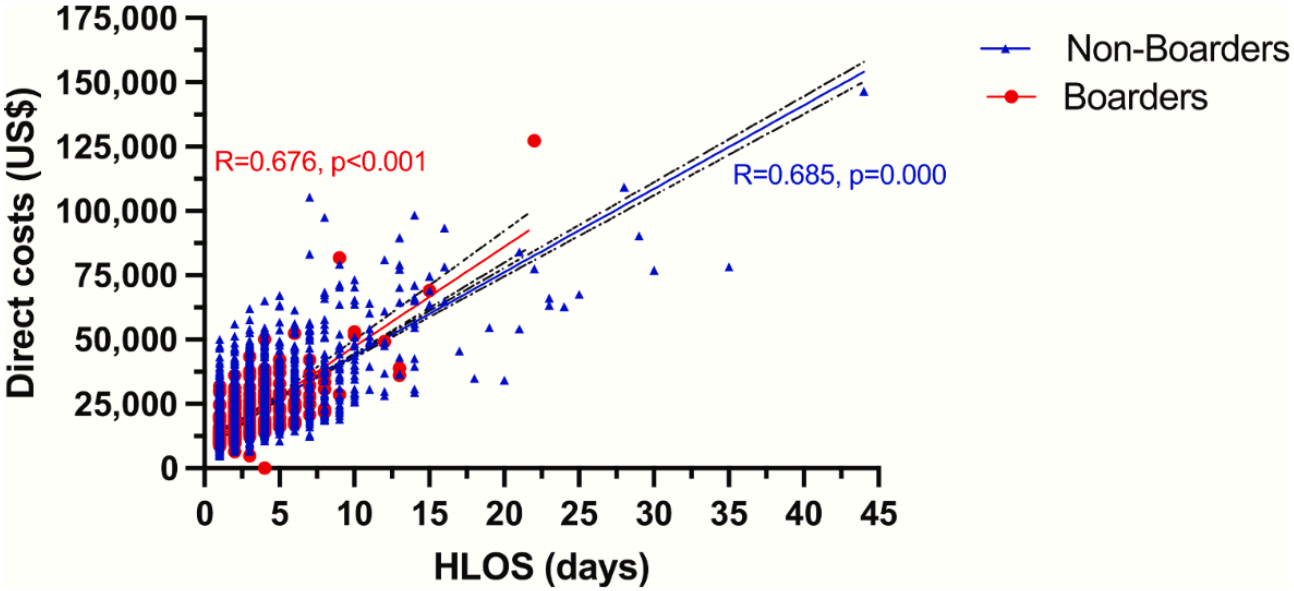


Fig. 3. Correlation plot illustrating significant relationships between HLOS and direct costs according to boarder vs non-boarder status.

14% higher cost of care

Part III: What Can We do?

- Regulatory Considerations
  - What are the ground rules?
  - Compliance and efficiency can co-exist

Regulatory requirements that actually govern PACU recovery & discharge – Centers for Medicare and Medicaid Services

<u>CMS 42 CFR §482.52</u>:

-Anesthesia service oversight

-Post-anesthesia eval ≤48h by "qualified anesthesia practitioner"

-Policies **medical staff-approved** and aligned to standards.

The Joint Commission

TJC:

-Assessment/discharge based on **medical staff–approved criteria**;

-Sedation/anesthesia requires **rescue competency**.

American Society of Anesthesiologists

"STANDARD V: A Physician is responsible for the discharge of the patient from the PACU"

ASA standards place responsibility for PACU discharge with a physician, but they also support **criteria-based** discharge pathways when those criteria are **physician-approved** and built into local protocols.

American Society of Anesthesiologists

The American Society of PeriAnesthesia Nurses (ASPAN)

-Recommends RN "discharge by criteria" to reduce LOS when medically governed and standardized

-Staff to **acuity and volatility**,

ICU-level care – typically 1:1, "facility-specific ICU guidelines"

Phase I – 1:2, but 1:1 on arrival and with instability

Phase II – generally 1:3, possibly 1:2 on arrival

CAN cohort "Boarding" patients in PACU

ASPAN
American Society of PeriAnesthesia Nurses

Regulatory Take-aways

- Compliance and efficiency can co-exist
- Knowing the guardrails is liberating
- Opportunities to **leverage built-in vagaries** in regulatory language so long as done in **SAFE way**

What Can We Do? Continued…

1. Use **anesthesia** approved, **RN-driven,** criteria-based Phase I discharge protocol based on **clinical milestones**
   - Reduces variability on multiple fronts
   - Physician oversight, approval, and involvement
   - Anesthesia post-evaluation note shall be completed *no-later* than 48 hours after surgery
     - Does NOT have to be completed prior to Phase I completion or even PACU wheels-out

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POLICY TITLE: Discharge Criteria from Post Anesthesia Care Unit (PACU)	
APPLICABLE FACILITIES: ☐EHC ☒EDH ☒EHH ☐EHI ☐EHN ☒EJCH ☒ELTAC ☒ESJH ☒EUH ☒EUHM ☐EUHS ☒EUOSH ☐EWWH ☐RJV-ERH ☐RJV-ESOP ☐TEC/ESA	
EFFECTIVE DATE: 03/03/2023	**ORIGINATION DATE:** 06/29/2017

SCOPE:
Emory Healthcare Post Anesthesia Care Unit (PACU) areas.

PURPOSE:
To establish discharge criteria of patients from PACU I area to Phase II area of PACU or to a different level of care within Emory Healthcare.

POLICY STATEMENT:
Continuous care to post-anesthesia patients of Emory Healthcare surgical/procedural patients within the different levels of PACU in preparation for discharge from the facility will be provided.

PROCEDURE:

1. Each patient in the PACU is evaluated for discharge from Phase I to another level of care (phase II or inpatient status).

2. Criteria for discharge from PACU Phase I includes:
   a. Patient has regained consciousness or returned to preoperative neurological status
   b. Vital signs are stable and within preoperative range
   c. Airway is patent with respirations even and unlabored
   d. Patient maintains adequate oxygenation
   e. Moving all extremities or expected movement (based upon preoperative status or procedure)
   f. Temperature is 36 degrees C or greater
   g. Tolerable pain/comfort control
   h. Dressings/drains have no excessive bleeding or drainage noted
   i. Anesthesia assessment and sign-out required by the anesthesiologist prior to discharge from Phase I
   j. Aldrete score greater than 9 or baseline
   k.

3. Criteria for discharge from PACU Phase II includes:
   a. Patient must meet criteria as outlined in Phase I
   b. Patient has regained consciousness and is oriented to time, place and person; or pre-op neurological status
   c. All pre-operative levels of sensory and motor function are appropriate in conjunction with preoperative status
   d. Vital signs are stable and within preoperative range (15% to 20%)

EMORY HEALTHCARE

   e. Condition of dressing/surgical site or procedural site has no excessive bleeding or drainage noted
   f. All drainage tubes are patent and functioning
   g. Patient is able to swallow
   h. Patients urinary status is assessed and void if ordered by the attending provider
   i. Patient is able to tolerate oral fluids with minimal nausea or vomiting unless otherwise indicated by the attending provider
   j. Patients receiving any reversal agent (i.e. naloxone, flumazenil, neostigmine) must remain in the PACU a minimum of 60 minutes after receiving the medication prior to discharge from the facility
   k. Aldrete score greater than 9 or baseline

4. Patient preparation for discharging from PACU
   a. Patients may be discharged by the attending provider of the procedure or anesthesiologist
   b. A discharge assessment is completed including disconnecting any equipment and removal of temporary intravenous access catheters
   c. Electronic or written (used during EeMR downtime) discharge instructions are obtained from the provider and provided to the patient/accompanying responsible party
   d. A thorough explanation of discharge instructions is performed with the patient and accompanying responsible party
   e. Outpatients are discharged accompanying a responsible party via a private vehicle, public transportation, Uber, etc. unless otherwise indicated by the individual facility
   f. Documentation of understanding of discharge instructions can be found in the patient's EeMR.
   g. Patients are escorted to the designated exit via wheelchair

RELATED DOCUMENTS AND LINKS:
Lippincott: Discharge from the PACU
Lippincott: Discharge Ambulatory Surgery
Lippincott: General anesthesia care of a patient, PACU
Lippincott: Postoperative assessment, PACU

DEFINITIONS:
Phase I – Immediate post anesthesia period following the conclusion of a procedure utilizing anesthesia ASPAN, 2023-2024

Phase II – Area in which preparation for the care of the patient at home or in an extended care environment is performed by a nurse ASPAN, 2023-2024

REFERENCES AND SOURCES OF EVIDENCE:
American Society of PeriAnesthesia Nurses (ASPAN) Standards, Practice Recommendations and Interpretive Statements (20239-2024).

Meeting institutional discharge criteria

=

Phase I complete

Patients should be marked PACU Care Complete the moment they meet discharge criteria.

What Can We Do? Continued…

2. Match staffing to **acuity** and **volatility**
   - 1:2 for most Phase I patients
   - 1:3 to cohorted boarders
   - Supported by ASPAN

3. Match staffing and **OR case sequencing** to expected demand
   - Predictable admission surges by time of day

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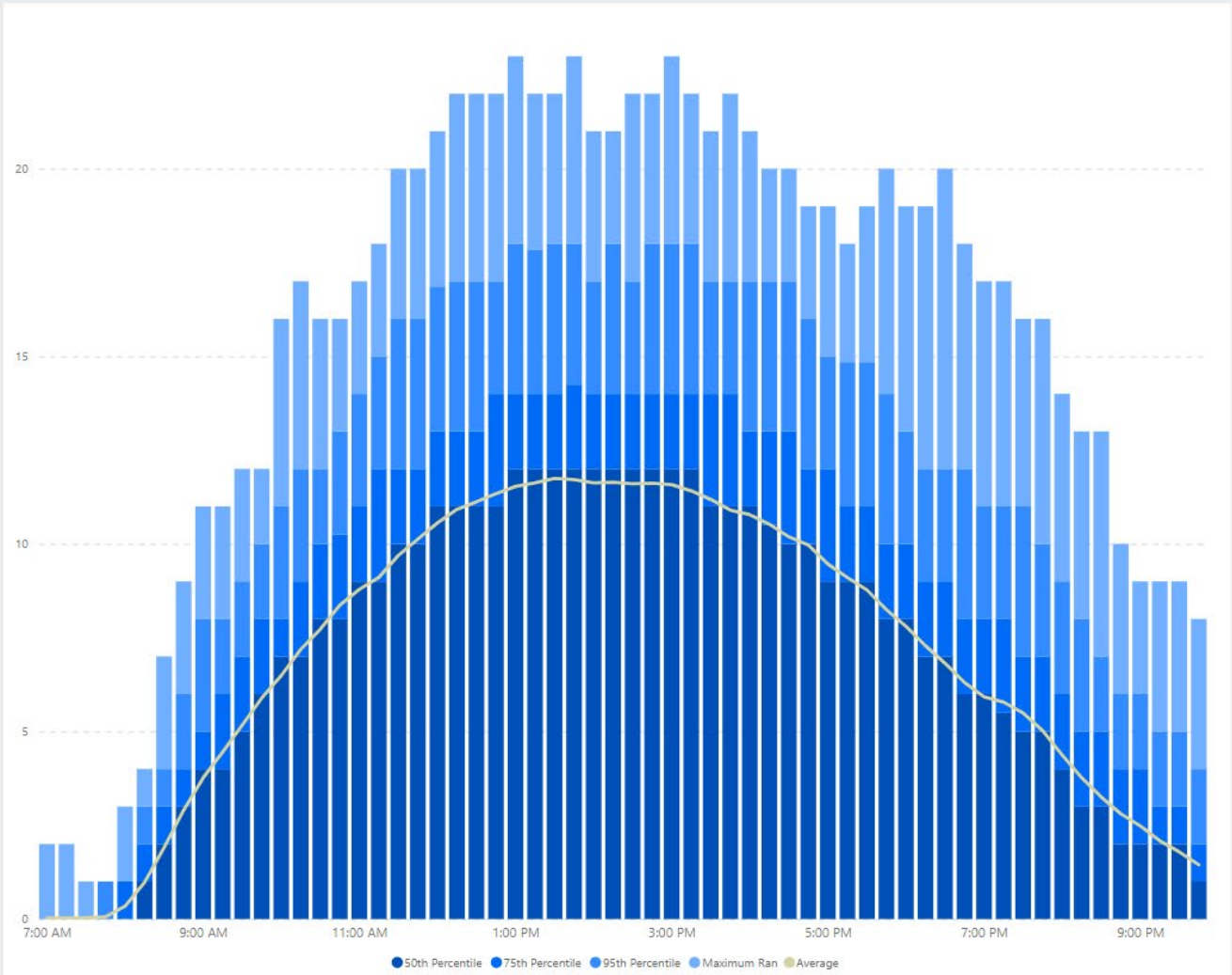
PACU Beds Running

Displays number of occupied PAC beds in percentiles for the given area and time period. A bed is considered 'running' if it has >7.5 minutes PACU In Recovey to PACU Out of Recovery in any given 15 minute time band. Only OR Log events are considered

10/1/2022 | 7/30/2024

*This analysis excludes holidays and includes standard operating days where no cases were performed. No TOT is added.



Surgical Area

- (Blank)
- ASC Dunwoody PACU
- ASC EAC PACU
- ASC Endo Decatur PACU
- ASC Endo PACU
- ASC Endo Urology PACU
- ASC LaGrange PACU
- ASC Main PACU
- ASC MSK PACU
- ASC Spivey PACU
- EDH PACU
- EHH PACU
- EJCH PACU
- ESJH PACU
- EUH PACU
- EUHM PACU
- EUOSH PACU
- WEM PACU

Day (ctrl click for multiple)

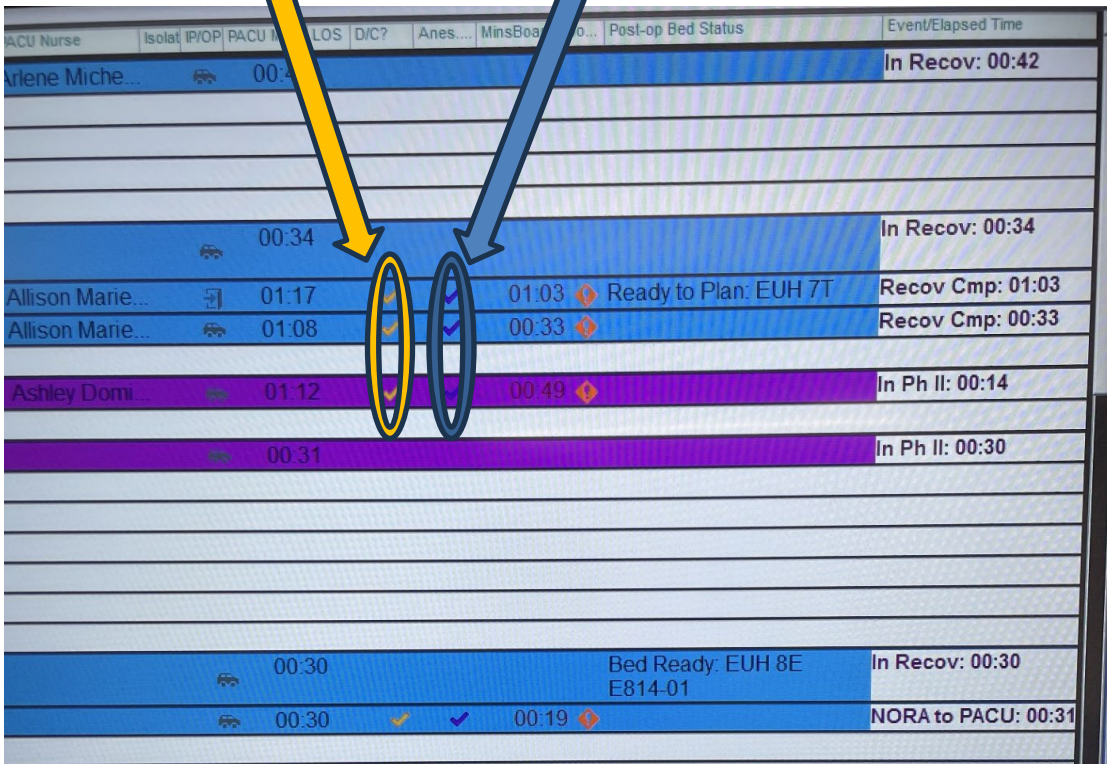
- Select all
- Friday
- Monday
- Saturday
- Sunday
- Thursday
- Tuesday
- Wednesday

What Can We Do? Continued…

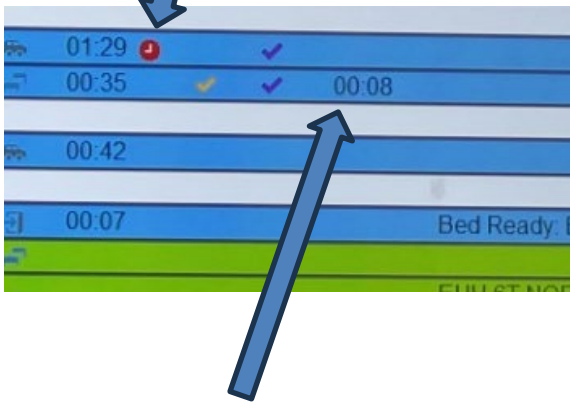
4. Distinguish between **clinical recovery** delays and **boarding** and manage them differently
   - Clinical delays are amenable to protocol optimization, practice pattern changes
   - Boarding reflect downstream systems issues and requires different escalation strategies
5. Utilized dashboards **designed to track** perioperative patient flow

PACU CARE COMPLETE

Anesthesia "sign-out" note completed



>60 minutes and no PACU CARE COMPLETE



Time elapsed since PACU CARE COMPLETE (Boarding)

What Can We Do? Continued…

6. Implement dashboards **designed to track** perioperative patient flow
   - Distinguish between Phase of Care and show clinical progress towards discharge
   - Boarding Hours
   - OR Holds attributable to PACU
   - Real-time data is actionable and tells the true cause of upstream disruptions in flow
     - Allocate resources in real-time and inform long-term strategic planning

What Can We Do? Continued…

7. Implement Fast-tracking/**Phase I bypass** where appropriate
   - Common in ophthalmology, endoscopy, interventional radiology, and other minimal sedation cases
   - Implement ERAS protocols
   - Limit access to PACU to those that need it most
     - Direct transfer from OR→ ICU for those that have a bed
     - Utilize procedural recovery/discharge areas
     - Separate Phase II area

What Can We Do? Continued…

7. Establish **surge plan** for when PACU boarding or **hospital census** reach critical thresholds
   - Escalation strategies most effective when activated early
   - RN "**pool**" nursing
   - Downstream "**Capacity Management**" strategies and interventions
   - Don't normalize…
     - Listen to how patients, families, and staff are impacted in real-time!

Leadership model

- Physician leadership
  - Anesthesiologist as Medical Director of the PACU
- Nurse leadership
  - RN Manager, operational Lead/Facilitator

Relationship and rapport with system leaders is critical

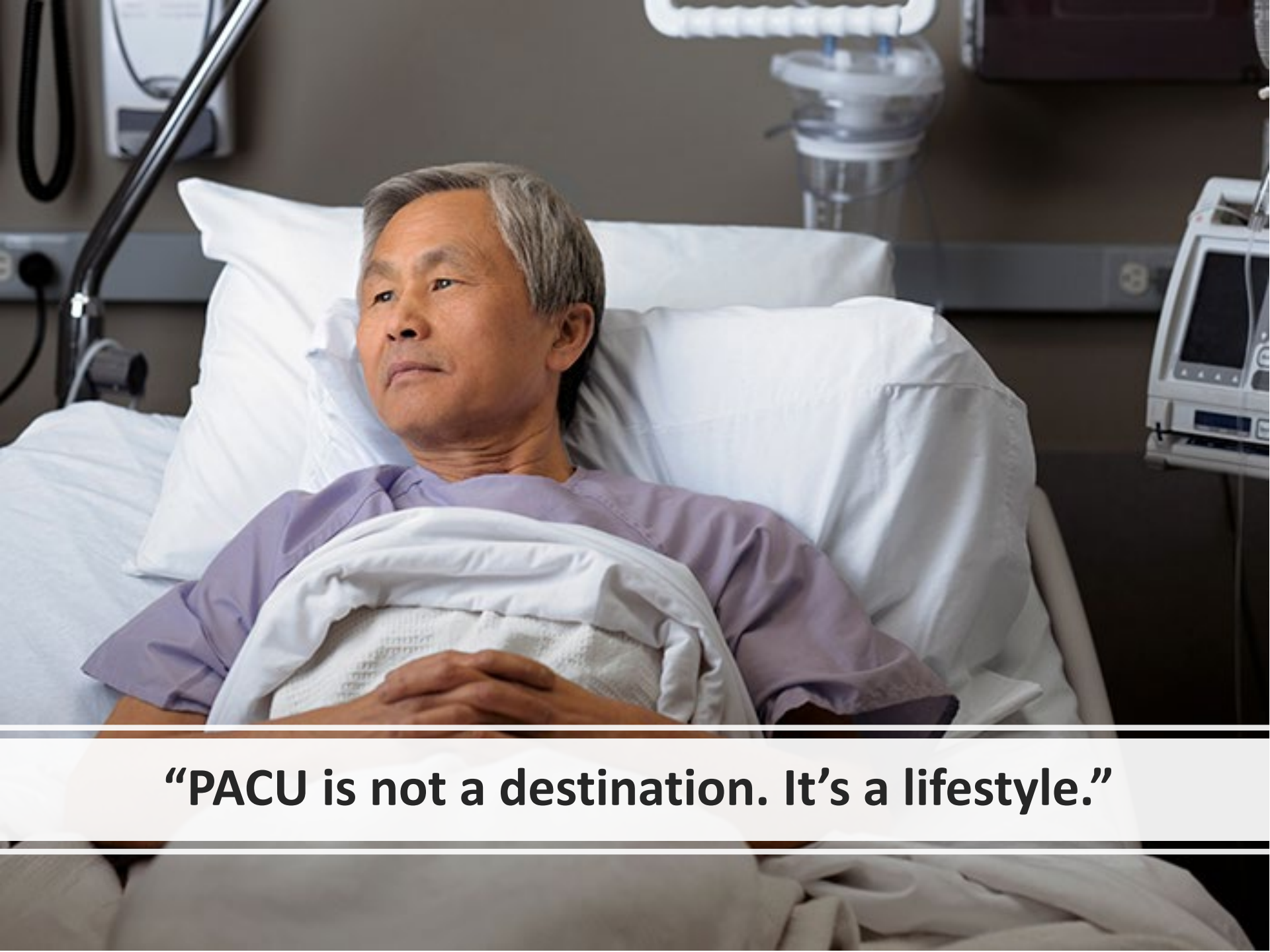
"If the operating room is the engine of surgical care, the PACU is its transmission—and anesthesiologists must be the ones designing how power is delivered."

Key Takeaways

PACU congestion propagates upstream (OR holds, late starts) and downstream (LOS, cost)

PACU boarding is measurable, predictable, and modifiable

Anesthesiology leadership is essential. You can make a difference!



“PACU is not a destination. It’s a lifestyle.”

Questions?

Thank you for your time!

Transitional Pain Service

Bridging the Pain Gap

Nan Xiang, MD

Assistant Professor, Department of Anesthesiology

Emory University School of Medicine

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Disclosures

- I have no conflicts of interest or financial disclosures in relation to the contents of this presentation.

- Images included in this presentation have been generated by AI based on prompts that relate to its content.

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Learning Objectives

1. *Define chronic post-surgical pain (CPSP) and describe its impact on patient quality of life.*
2. *Identify patient-specific risk factors for the development of CPSP and persistent postoperative opioid use (PPOU).*
3. *Describe the common challenges that patients encounter in managing postoperative pain following hospital discharge.*
4. *Explain the role of a transitional pain service (TPS) in improving postoperative pain outcomes and continuity of care.*
5. *Identify system-level barriers to establishing a transitional pain service within a hospital setting.*
6. *Formulate a strategic framework for the establishment of a transitional pain service at a medical institution.*

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Operating Room

Inpatient Care

Pain Clinic

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The Patient

- 45-year-old patient with a one-month history of low back pain that radiates down the right leg who now presents for a scheduled L4-5 laminectomy.
- Surgery is successful in relieving the radicular pain but he has significant post-surgical pain during his inpatient stay.
- Following discharge, he has a difficult time weaning down his opioid regimen and is struggling to participate in physical therapy.

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And other challenging scenarios…

52-year-old patient on suboxone for substance abuse presenting for colon resection.

60-year-old patient with a history of peripheral arterial disease presenting for a below the knee amputation.

27-year-old patient with sickle cell disease complicated by avascular necrosis presenting for total hip arthroplasty.

35-year-old patient with multiple allergies to opioids, NSAIDs, and gabapentin presenting for elective ventral hernia repair.

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Patient Challenges - Preoperative

- Unclear expectations regarding surgical outcomes and expected level of pain
- May not be aware of possible perioperative regional anesthesia options
- Unaddressed patient concerns for adequate pain control
- If pre-existing chronic pain medications, lack of clear plan of medication adjustments before and after surgery

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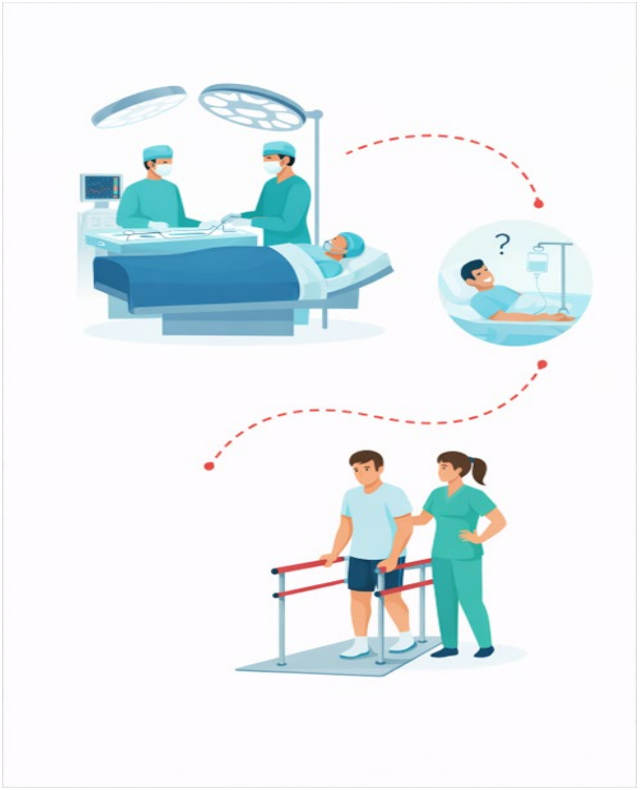
Patient Challenges – Intraoperative/Inpatient

- Anesthesiologist meeting the patient for the first time and unfamiliar with their history
- Variability of intraoperative analgesic plan based on assigned provider
- Unfamiliarity with regional anesthetic options may result in the patient declining a nerve block procedure
- Inappropriately managed preoperative pain medications may limit options available to the acute pain service



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Patient Challenges – Discharge and Beyond

- Effectiveness of pain management during inpatient stay and oral morphine equivalents at the time discharge
  - Was the patient's pain controlled on the regimen provided at discharge?
  - Is there a clear weaning plan?
- Is there a chronic pain physician involved and aware of the plan?
- When is the next follow up and assessment of pain regimen effectiveness?
- If longer treatment is needed, who does the patient follow up with?

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Chronic Post-surgical Pain (CPSP)

- Definition: Chronic pain that develops following a surgical procedure and persist for 3 months or longer
- *Incidence of CPSP varies across studies, 14.6% at 3 months and 10.6% at 6 months (Martinez 2024) and 3.3% at one year (Khan 2021)
- Of the patients seeking care at a chronic pain clinic, 22% are for CPSP.
- Prevalence of CPSP by surgery type
  - Vein surgery 4%
  - Hernia repair 7%
  - Breast surgery 31%
  - Total hip or knee arthroplasty 20%
  - Cardiac surgery 16-37%
  - Thoracic surgery 43-58%

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Consequences of CPSP

- Functional: Unable to fully progress in physical therapy, impairment of ADLs and IADLs
- Psychological: Depression, anxiety, feeling of loss and hopelessness
- Quality of Life: Unable to be actively participate in life, enjoy time with loved ones, social isolation, side effects from medications, financial stressors

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Economic Implications

- Contributes to long-term disability and decreased quality of life
- Estimate from 2013 in annual costs associated with post-traumatic/post-surgical neuropathic pain was over $41,000 for direct and indirect costs
- A separate cohort study from 2017 in the UK examined over 10,000 who underwent lumbar surgery
  - 17.2% met their criteria for persistent pain
  - 2x more likely to have two or more inpatient stays within 2 years postop
  - Higher costs including 3x pain medication, total care inpatient/outpatient/PCP
  - Average difference due to persistent pain was **£5383** over 2 years
  - Cost estimates projected to **£10,195** at 5 years and **£14,318** at 10 years

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Persistent Post-Operative Opioid Use (PPOU)

- Definition: Continuation of opioid use at ≥ 90 days following surgery
  - Definitions variable (eg 120 opioid days, 10 opioid prescriptions, opioid naïve only, etc)
- Prevalence estimated between 3%-10%, but varied widely across studies and types of surgery (2% to 65%)
- Opioid naïve patients developed PPOU 2% compared to opioid tolerant patients at 13.8%

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Risk Factors for Chronic Postsurgical Pain

- Largest effect sizes seen with psychiatric disorders and depression
  - Other mental health factors include stress and catastrophizing
- Protective factors included use of regional anesthesia and minimally invasive approach

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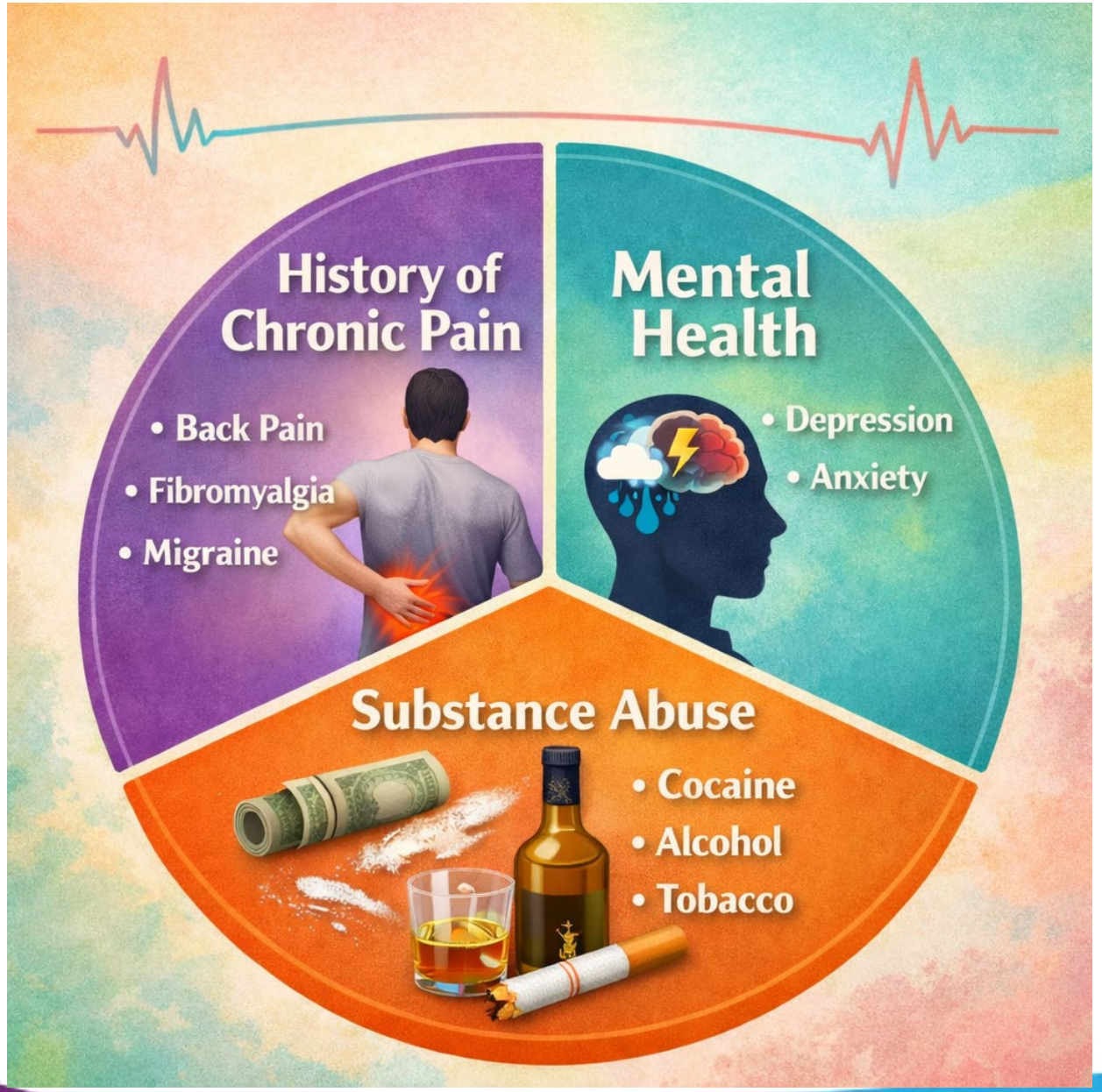
Risk Factors for Persistent Postoperative Opioid Use



Transitional Pain Service (TPS)

- Multi-specialty and patient-centered perioperative program
  - Surgeons, anesthesiologist, pain specialist, mental health providers, PT, etc.
- Involves planning preoperatively, management intraop/inpatient, and post-surgical follow up
- Main Goals:
  - Prevent an acute surgical pain from becoming a chronic issue
  - Reduce the use of opioids, particularly chronic use
  - Foster postoperative physical and psychological wellbeing

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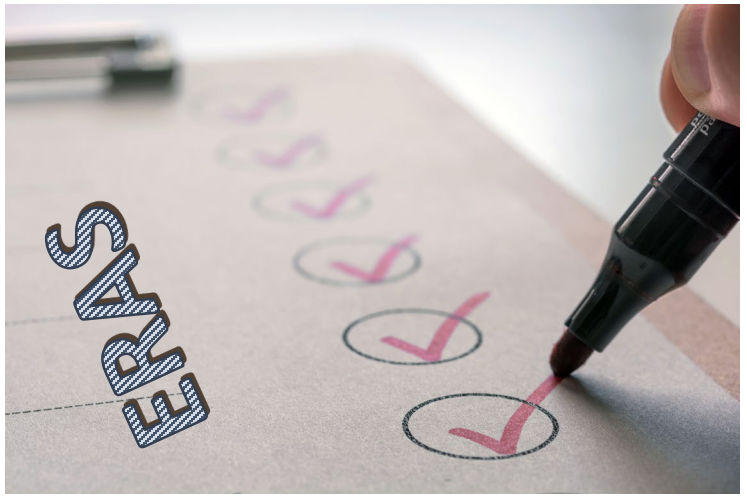
ERAS Framework



- Enhanced Recovery After Surgery protocols
  - Reducing the physiologic stress responses
- Multi-disciplinary collaboration
- Multiple time points
  - Preoperative: Counseling, expectation setting, avoiding prolonged fasting
  - Intraoperative: Minimal invasiveness of surgeries, goal directed fluid management, maintenance of temperature and blood glucose, multimodal analgesia including regional
  - Postoperative: Early mobilization, oral nutrition, N/V prevention, minimize opioid use, DVT prophylaxis
- Goal is to improve outcomes
  - Hospital length of stay, complication rate, readmission rate, and healthcare costs

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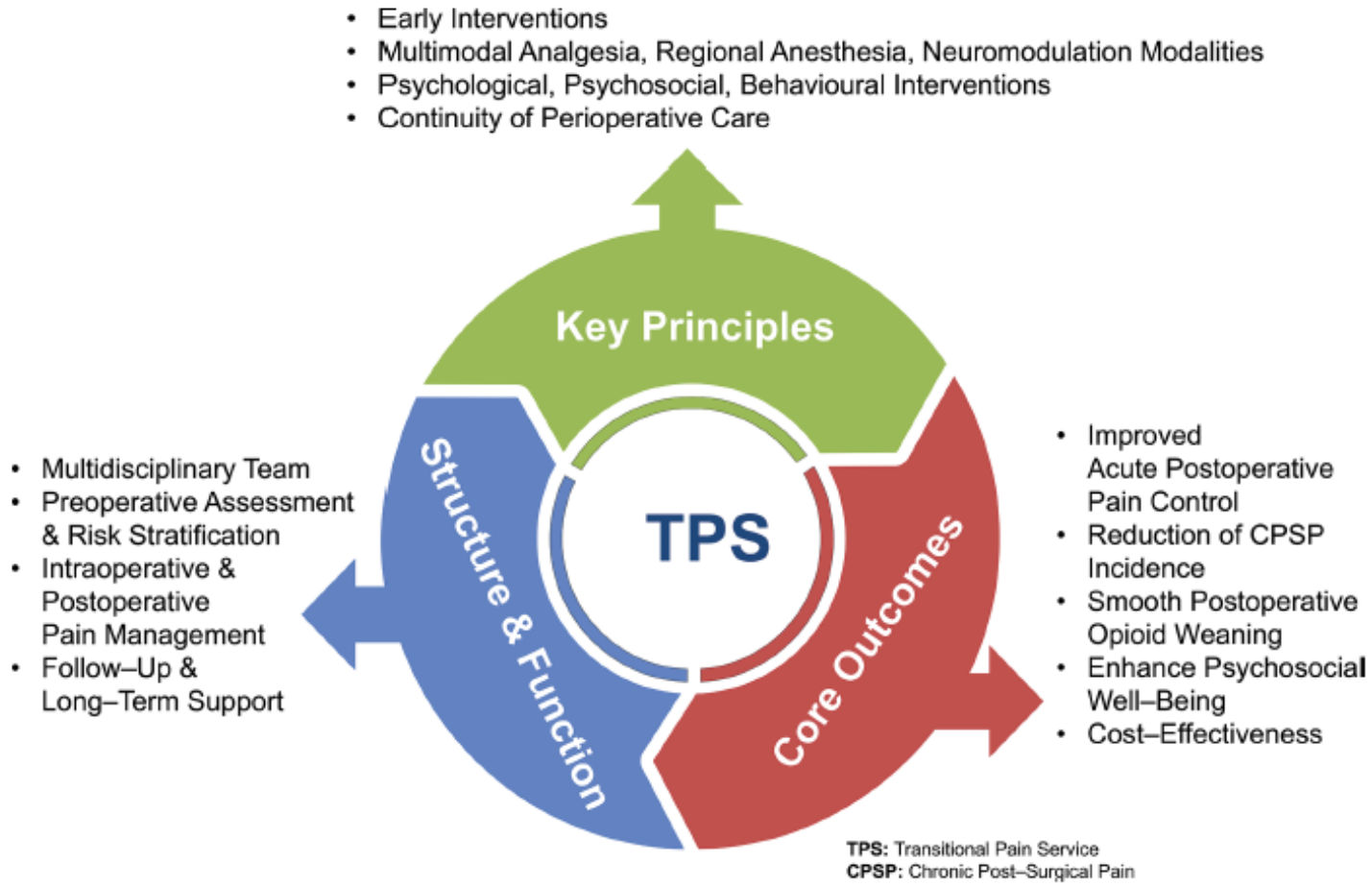
European TPS Framework



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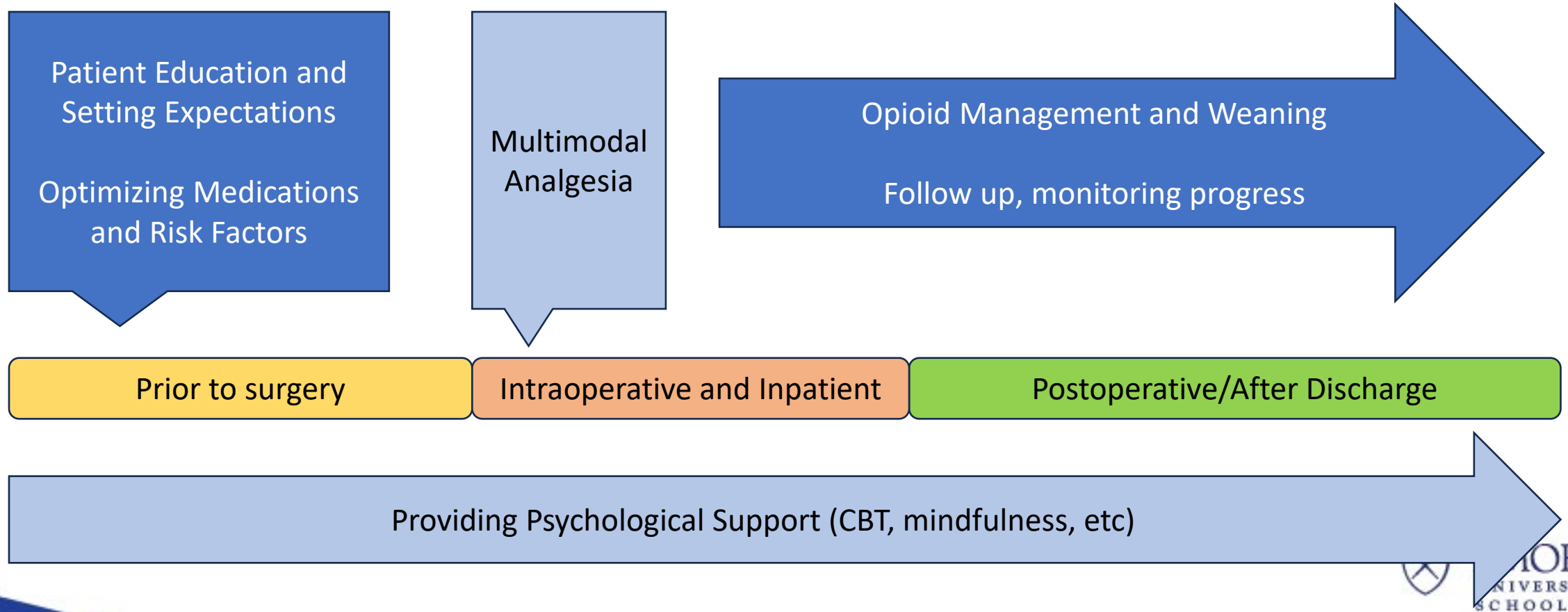
Phases of the Transitional Pain Service



TPS - Preoperative

Assessment of risk based on factors related to CPSP and PPOU	• History of chronic pain, substance use, psychiatric diagnoses
Patient education	• Setting of expectations (duration of stay, expected degree of pain) • Potential issues related to surgery • Expected course (ICU? Discharge to rehab or home) • Plans to follow up with relevant providers
Psychological Preparations	• Discuss concerns and anxiety about the surgery or related matters • Cognitive behavior therapy, mindfulness, etc.
Development of pain management plan	• Changes to existing pain medication regimen leading up to surgery • Discussing regional anesthesia, intraoperative medications, and inpatient pain plan

Preoperative Opioid Screening

- Does the patient have a history of opioid use disorder?
- Are they allergic to certain analgesic medications?
- Preoperative management of chronic pain medications
  - Long-acting opioids (oxycodone ER)
  - Methadone for pain or for opioid use disorder
  - Buprenorphine for pain or opioid use disorder

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Preoperative Opioid Planning

Buprenorphine management

- Butrans and Belbuca – continue as usual
- Continue buprenorphine ≤ 16mg daily throughout perioperative period, regardless of surgical pain level
- Pure mu-opioid agonists can still be used effectively
- Shared decision making between patient, acute pain service, addiction medicine, as well as involvement of outpatient prescriber

Methadone management

- Usually continued, often in divided doses to optimize analgesic effect
- Expect a higher opioid requirement

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TPS – Intraoperative and Inpatient

Regional anesthesia techniques	• Depending on surgical type, risk of infection, presence of coagulopathy
Intraoperative adjuncts:	• IV ketamine • IV methadone

TPS – Regional Anesthetic Options

- Thoracic Epidurals –thoracic and abdominal
- Lumbar Epidurals –pelvic and lower extremity
- Erector Spinae blocks and catheters – thoracic and abdominal
- Transverse Abdominus Plane blocks – abdominal

- Cervical plexus – neck, carotid surgery
- Pterygopalatine fossa block – facial, jaw surgery
- Brachial plexus blocks (supraclavicular, interscalene, axillary) – upper extremity
- Sciatic and femoral nerve blocks – lower extremity
- IPACK, PENG, ankle block – lower extremity orthopedic surgery

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TPS – Inpatient Management

Daily assessment on acute pain needs

Monitoring of opioid usage, response to medications, and side effects

Titrating patient-controlled analgesia settings

Monitoring and troubleshooting of indwelling epidural or nerve block catheters

Coordination between surgeon, hospital medicine, PT, and social work for discharge planning

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TPS – Post-Discharge

- Regular follow up to monitor progress
- Availability of mental health providers for CBT sessions
  - Dealing with stress during recovery, PT, sense of loss, physical limitations
- Evaluation of weaning plan and making adjustments as needed
- Treatment of secondary postoperative pain
- Engage in palliative care discussions when needed
- Coordination with patient's outpatient provider (PCP, chronic pain) for long-term planning after completion of TPS

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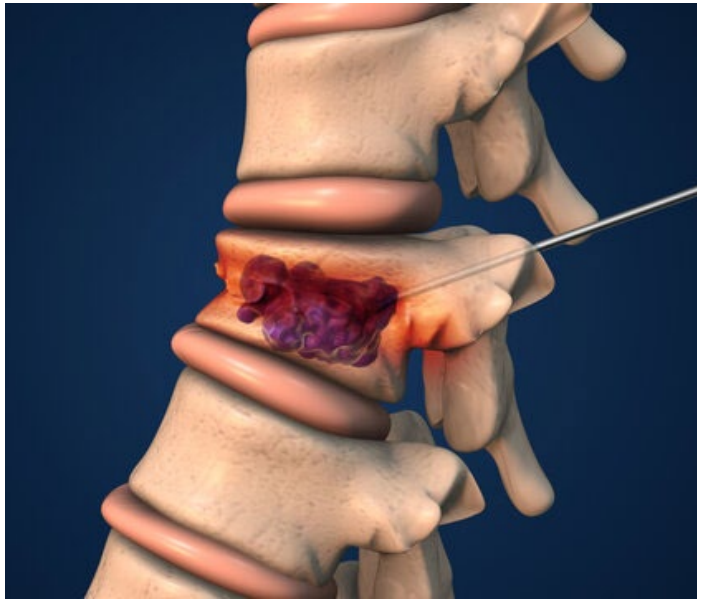
TPS – Post-Discharge

There are also additional tools from the chronic pain management field that can be useful

- Trigger point injections
- Referral for acupuncture therapy
- Fluoroscopy and ultrasound guided procedures such as joint injections and nerve blocks
- Advanced procedures when appropriate
  - Nerve neurolysis
  - Vertebral augmentation
  - Intrathecal pain pumps
  - Spinal cord stimulation or peripheral nerve stimulation



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Research Outcomes

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Toronto General Hospital TPS

- Established in 2014, one of the earliest examples
- Wide assortment of surgical procedures included
- Staff included anesthesiologist w/ acute and chronic pain training, clinical psychologists, acute pain APPs, physical therapists with acupuncture training, palliative care specialist, exercise physiologist, and patient care coordinators/admin staff.
- Separate services from the Acute Pain Service, follows patient while admitted
- Patient is seen 2-3 weeks following discharge in TPS clinic, and continued to be assessed every 2-3 weeks with goal of transition back to PCP with 6 months.

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Telehealth TPS – Feasibility Trial

- Preoperative screening visit at preoperative assessment clinic
- Initial Therapy Session – within 7 days of discharge
  - HIPAA compliant audio-visual telemedicine, provided by licensed therapists
- Opioid naïve patients:
  - Sessions were 1 hour long, weekly for up to 4 weeks
  - 90-day follow up visit
- Opioid exposed patients:
  - 1-hour sessions weekly for up to 26 weeks, with follow up at 30, 90, and 180 days if patient stopped attending therapy sessions
- Outcomes: High engagement, tapering to zero MMEs was achievable for most patients, improvement of pain and behavioral scores, and no ER or rehospitalization occurred

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(Hussain 2023)

TPS is associated with reduction of opioid use

- Postoperative opioid MME reduced by 65% in opioid naïve and 44% in non-naïve patients at 6 months
  - Clark 2018 at Toronto General Hospital, total of 112 naïve and 139 non-naïve patients
- Same study showed complete discontinuation of opioids in 45% of opioid naïve and 26% of non-naïve patients
- Initiation of TPS at a VA Medical center resulted in:
  - Decrease in # of opioid tablets at discharge pre = 80, post = 45
  - Fewer patients on opioids at 90 days: pre = 27.3%, post = 13.4%
  - More chronic opioid users who weaned down on their pre-surgery medications: pre = 45.3%, post = 67.5%

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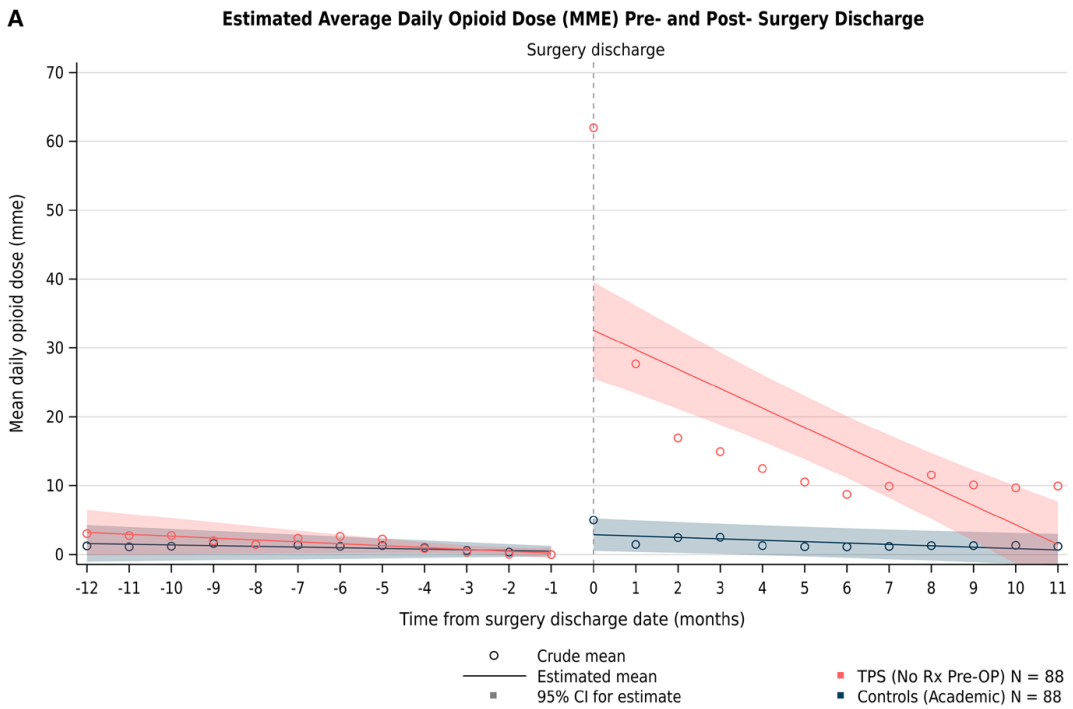
Even if opioid usage was not lower, TPS was associated with a more rapid decrease in post-surgery MME

- Clark et al 2024 retrospective cohort study
  - Studied 209 TPS patients matched to 209 patients at other facilities
  - Opioid use 1 month preop vs. 1 month postop
    - TPS group 9.6 MME to 46.5 MME*
    - Control group 7.0 MME to 12.7 MME
  - Reduction in MMEs per month was significantly quicker in TPS group
    - TPS reduction 3.53 MME/month compared to 1.05 MME per month
- It does speak to variability in treatment practices



Across multiple studies, TPS is associated with improved opioid usage, with some caveats

- Clark et al 2025 reviewed several studies and found that TPS patients compared to the control group is associated with:
  - Fewer opioid tablets prescribed at discharge
  - Improved opioid weaning results
  - Lower incidence of new chronic opioid use
  - Lower consumption of opioids at later time periods
- However, the effect size is small and overall clinical significance is unclear

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Patients found value in the services offered by TPS

- Manoharan 2024 evaluated patient experiences following initiation of a TPS at Johns Hopkins
- Interviews conducted with 26 patients for an average of 33 months following initial TPS program initiation
- Findings showed that patients:
  - Valued pain expectation setting, along with individualized care and physician interactions
  - Felt treatment of depression, anxiety and other mental health issues were important to recovery
  - Successful in continuing to wean opioids and saw improved functioning after the program

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The addition of TPS did not seem to increase the healthcare costs on a per patient basis

- Yoo 2023 study to estimate effect of TPS on cost of care following orthopedic surgery
- Total of 4954 patients included, stratified by non-opioid and chronic opioid patients. Placed into TPS intervention vs. control group
- TPS in the non-opioid group associated with an increase in number of outpatient visits, no change in outpatient costs, and a decrease in inpatient costs.
- TPS in the chronic opioid group showed no impact in usage of outpatient, inpatient, or pharmacy services. No changes in cost.
- Overall, use of a TPS did not add to overall cost of services

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Implementation Needs

- Inter-department collaboration
- Allocation of provider clinical effort
- Provider and staff buy-in
- Standardized patient enrollment criteria
- Coordination as patient moves through phases of care
- Institutional support and alignment of goals

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Barriers and Challenges

- Cost
  - Dedicated personnel to coordinate visits prior to and after surgery
  - Provider availability for the transitional pain clinic separate from standard outpatient chronic pain
- Lack of standardized protocols
  - Variability in practices between providers and certainly between institutions
  - Lack of the “Perfect Pain Plan”
- Lack of high-quality evidence in support of the value added

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Getting Started at Your Institution

- Reach out to your anesthesia, pain management and surgical leadership to discuss interest and need for this service
- Advocate leadership on the benefits of TPS
- Support ongoing research for TPS outcomes
- Consider collaborating on a pilot program for a subset of patients and measure the outcome

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Emory – A Pilot for Transitional Pain Service

- Patients: limited to Midtown Neurosurgery patients
- Providers: select group of Emory Pain Center faculty and APPs
- Ideal Workflow:
  - Preop (if possible): Clinic visit with pain provider to discuss goals, manage expectations, and review multimodal pain plan
  - Perioperative: involvement of the acute pain service for regional anesthesia options and inpatient management
  - Surgery team to manage medications up to 3 months
  - Follow-up visit with TPS at 3 months postop to adjust medications, consider chronic pain interventions, develop an opioid weaning plan
  - Continue for one year with regular follow ups

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Beyond The OR:

Pediatric Anesthesia in New Frontiers

Renee Tolly MD, MHA

Children's Healthcare of Atlanta

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Learning Objectives

1. Identify the most common pediatric NORA locations and the unique challenges each environment poses.
2. Review current safety standards, monitoring requirements, and staffing models for pediatric NORA.
3. Apply strategies for adapting anesthetic plans to limited resources, physical constraints, and procedure-specific demands.
4. Discuss innovations and future directions in pediatric NORA

Why Pediatric NORA matters

- ~23% of Peds anesthesia occurs outside the OR
- Higher risk of respiratory events compared with OR cases
- Driven by imaging, interventional procedures, and outpatient growth

Common Pediatric NORA Locations

- MRI, CT, Nuclear Medicine
- Inventional Radiology and Cath Lab
- Endoscopy and Radiation Oncology
- Emergency Department
- Ophthalmology and Dental Suites

Radiological Scans and Nuclear Medicine Scans

- Remain completely motionless
- Developmental Delayed Patients
- Venous access necessary to administer contrast agents or radiotracers
- Rigorous Screening for patient and family
- Sedation is most often achieved using a propofol infusion with maintenance of spontaneous ventilation and a natural airway
- Breath Holding
- Resuscitation Zone should be located as close as possible
- Nuclear Medicine – timing of ~45 minutes prior to image acquisition

Interventional Radiology

- Expanding area
- Procedures:
  - Vascular access
  - Placing or adjusting Gtubes or GJTubes
  - Needle biopsies
  - Draining fluid collections
  - Lumbar Punctures
  - Treating vascular anomalies
  - Neuro-interventional procedures
- Big range of level of anesthesia
- Fluoroscopy equipment can obstruct access to patient, IV lines and monitoring devices
- PACU - Reduce agitation and support patient immobility without affecting respiration – Dexmedetomidine may be beneficial

Radiation Oncology Procedure Room

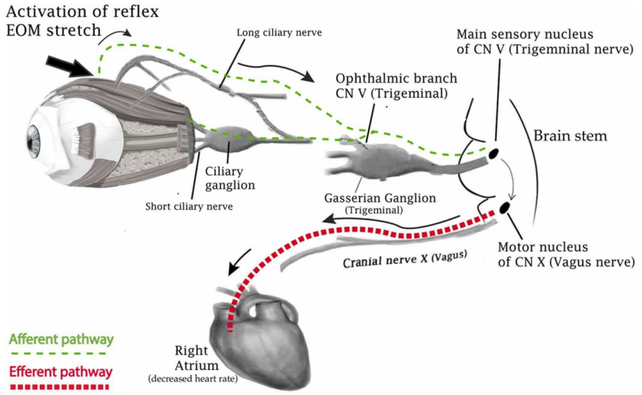
- Medically complex patients and repeated anesthetics
- Patient is not directly observable during radiation delivery
- Simulation session is conducted first to map the tumor and design devices
- Same airway device used during sim must be used in all treatments
- Standard monitoring is conducted remotely
- Continuous visual observation and careful titration of sedation depth

Emergency Room

- Most commonly assists with sedation for fractures of long bones and/or joint dislocations
- Multiple sedating options:
  - Bier Block
  - Inhaled Nitrous Oxide
  - Deep sedation (MC Ketamine/midazolam combination)
- Special healthcare needs patients
- Anticipated Difficult Airways
- Small Procedures:
  - Laceration Repairs
  - NG Tube placements
  - Drainage of small abscesses

Ophthalmology Suite

- Physical Space is often limited
- Although brief procedures, can potentially be intensely stimulating
- Minimizing Coughing or bucking during emergence → Increase IOP
- Ketamine and Succinylcholine → Increase IOP
- Propofol and Volatile Anesthetics → Decrease IOP
- IOP measurements before instrumentation of airway to ensure accuracy
- Strabismus Surgeries → Increase PONV
- Regional Blocks, peribulbar or retrobulbar, are options for analgesia



- Oculocardiac Reflex
  - Pediatric pts are particularly vulnerable to hemodynamic instability during bradycardia due to their reduced cardiac compliance

Endoscopy Suite

- Most Common Category of Off -Site Interventions
  - EGD most frequently performed
- Pediatrics require deeper levels of sedation
- High risk for aspiration in Achalasia Cardia or significant GERD
- ERCPs required deep sedation or general anesthesia
  - Higher risk with intraop complications (duodenal perforation)
  - Prone positioning require GA as increased risk of desaturation and other airway complications
- Majority of complications are from inadequate oxygenation and ventilation with a LMA

Dental Suite

- Expandingdue to limited access to OR time
- American Academy of Pediatric Dentistry has articulated specific populations for Deep Sedation or GA:
  - Situational Anxiety
  - Dental Anxieties or phobias
  - Uncooperative behavior for their age
  - Immature Cognitive Functioning
  - Pre-communicative or Noncommunicative abilities
  - Disabilities
  - Extensive dental interventions in special needs children
  - Other Medical conditions that necessitate deep sedation or GA
- Nasal intubation > oral intubation
  - Epistaxis, infection, or nasal trauma
  - Bleeding Disorders

Challenges to Safe Pediatric NORA

Emergency Readiness	Delayed access to help
Communication	Limited Interdepartmental Planning
Environment	Limited Space, Lighting, power, access
Equipment	Incompatible or outdated monitors
Staffing	Variable pediatric experience
Transport	Transport may compromise safety
Patient Selection	High risk patients may be inappropriate

Checklist for Pediatric Off -Site Setup

- ❑ Oxygen Supply & Secondary Source
- ❑ Ventilation Equipment (Positive Pressure & Back up Ambu bag)
- ❑ Suction (Yankuer & Soft Catheter)
- ❑ Gas Scavenging
- ❑ Power Supply
- ❑ Monitoring & Safety Alarms
- ❑ Lighting
- ❑ Access
- ❑ Supplies (The Broselow Approach)
  - ❑ Airway
  - ❑ Laryngoscopes
  - ❑ IV Access
- ❑ Emergency Preparedness
- ❑ Support
- ❑ Post-Anesthesia Care

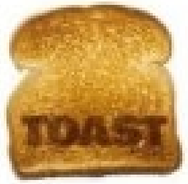
Pediatric Physiology: Key Differences

- Immature hepatic and renal systems alters drug metabolism and clearance
- Airway Considerations:
  - Larger heads, shorter necks
  - Larger tongues, more cephalad and anterior larynx
  - Shorter and narrower trachea
  - Cricoid cartilage is the narrowest part of the airway
- Higher oxygen consumption and lower reserves
- Increased Risk of Airway Reactivity
- Post-anesthesia Apnea Risk
- Cardiac output dependent on heart rate
- Parasympathetic Predominance
- Prone to hypothermia d/t a higher surface area to body mass ratio and limited thermoregulatory capacity

Pre-Anesthetic Evaluation and Patient Assessment

- ❑ Procedure Requirements
- ❑ Developmental Status
- ❑ Aspiration Risk & NPO Status
- ❑ Airway Assessment
- ❑ Respiratory Status
- ❑ Systemic Comorbidities
- ❑ Vascular Access

ASA Fasting Guidelines (2023)

Hours Pre-Op	Allowable Food or Beverage
>8	**Heavy foods** (fried/fatty) and meats
6	**Light meal** (e.g., toast + clear liquid) **Cow's milk** (in moderation) **Infant formula** 
4	**Breast milk**
2	Non-alcoholic **clear liquids** (e.g., water, fruit juice without pulp, nutritional drinks, clear tea, black coffee) 
0-2	**NPO**

Common Complications / Considerations:

- Respiratory Complications: Laryngospasm (20.7 per 10,000 cases), Bronchospasm
- Vomiting and Aspiration during sedation
- Obstructive Sleep Apnea
- Malignant Hyperthermia
- Former Premature Infants and Retinopathy of Prematurity
- Anaphylaxis
- Neurodiverse Patients

Innovations and Future Directions

- Audiovisual Distraction: In-bore video systems and VR Goggles
- "Feed and Wrap" Protocols with vacuum-immobilization mattresses
- High-Flow Nasal Cannula during deep sedation
- Minimalist Sedation with Remimazolam
- EEG-guided depth of sedation monitoring
- Digital Crisis Support: Tools like PEDI Crisis App

Questions?

Claiming CMEs for Winter Forum

Once the ASA enrolls registrants for the 2026 Winter Forum, you can expect to receive an email from the ASA with instructions on how to claim your credits. Please note that you will not be able to claim your credits until the ASA has completed your enrollment. This process may take one to two weeks following our meeting.

If you can't remember your password or no longer have access to the email associated with your account, please contact

ASA Member Services at (630) 912-2552 or email info@asahq.org or jpmeetings@asahq.org.

Please avoid creating a duplicate account, as this will significantly delay the processing of your credits.