Regional Anesthesia in Children

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Disclosures

BK Medical, Pajunk: Equipment support

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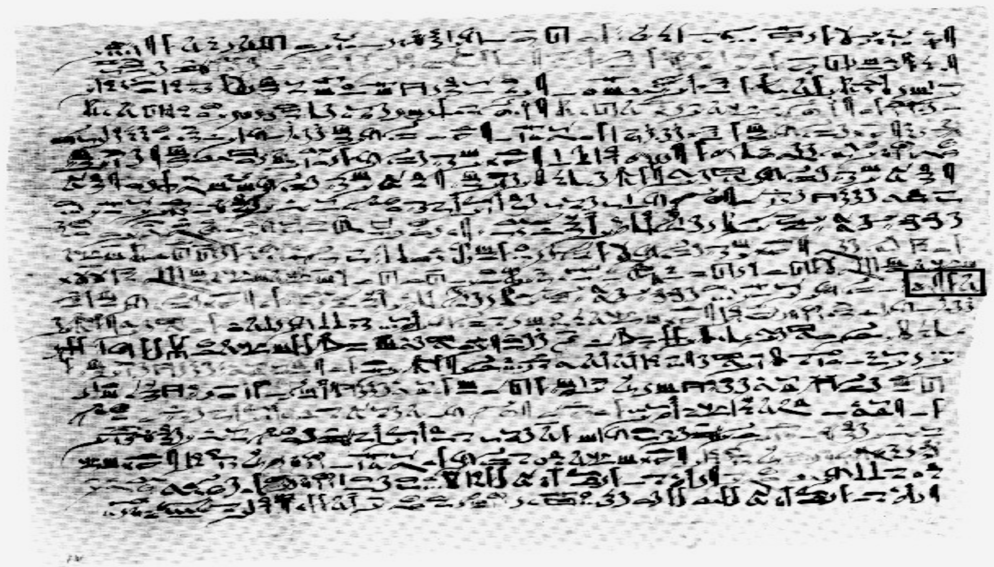
OKO (AAOS) Editorial Board



Overview

- Head and Neck blocks
- Ultrasound technology
- Equipment
- Nerve Block Techniques
- Education in regional anesthesia
- Future directions

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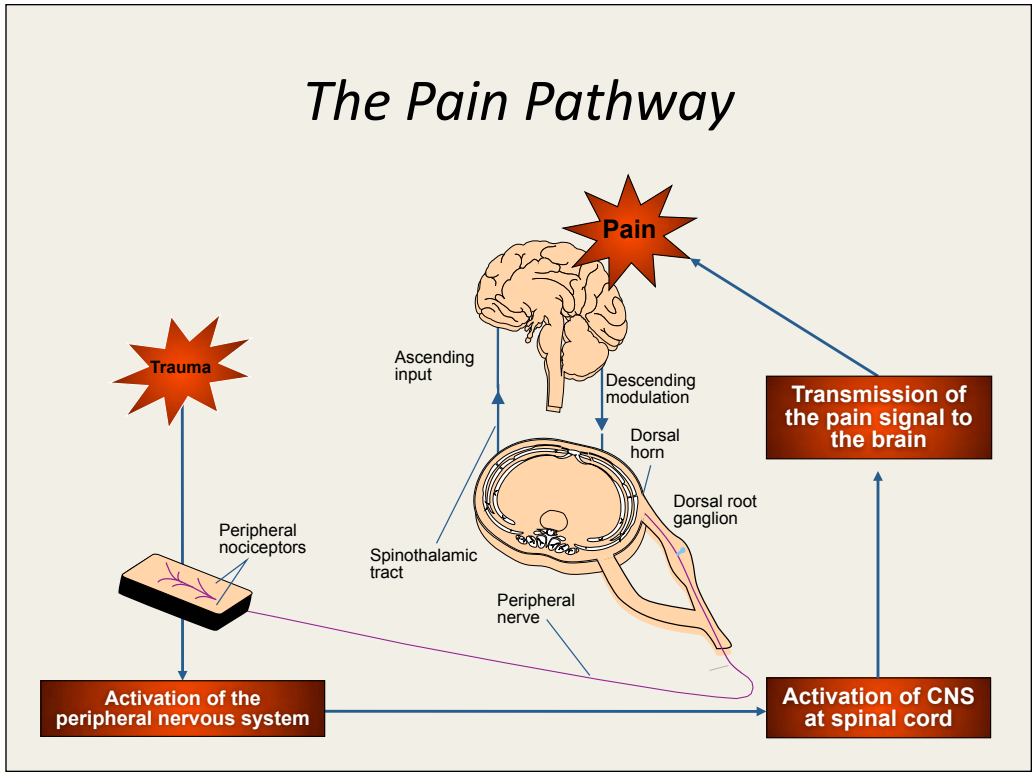

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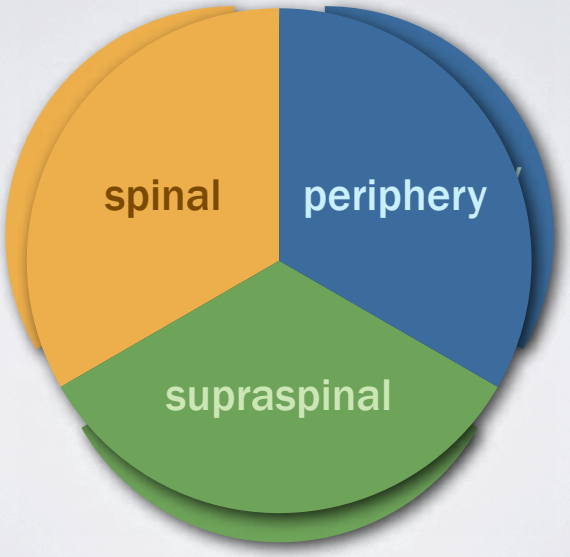
The pain response is a complex process that involves both the peripheral nervous system (PNS) and central nervous system (CNS).

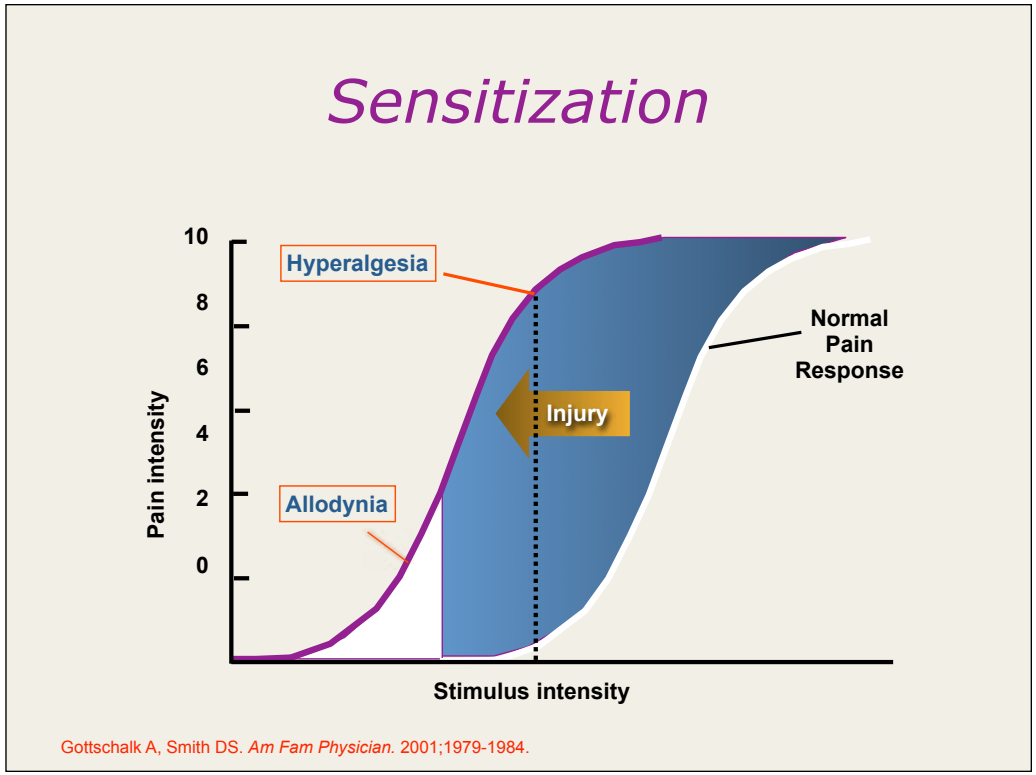
Tissue injury results in the activation of the PNS. Signals from the PNS travel into the CNS. They travel through the spinal cord before traveling to the brain, where pain perception occurs.

In addition, pain perception can be transmitted directly from the site of injury to the CNS via a humoral signal (probably via interleukin [IL]-6), which then induces cyclooxygenase (COX)-2 in the CNS.[1] This concept will be discussed in greater detail later in the presentation.

Samad TA, Moore KA, Sapirstein A, et al. Interleukin-1ß-mediated induction of Cox-2 in the CNS contributes to inflammatory pain hypersensitivity. *Nature.* 2001;410:471-475.

MECHANISM OF PAIN





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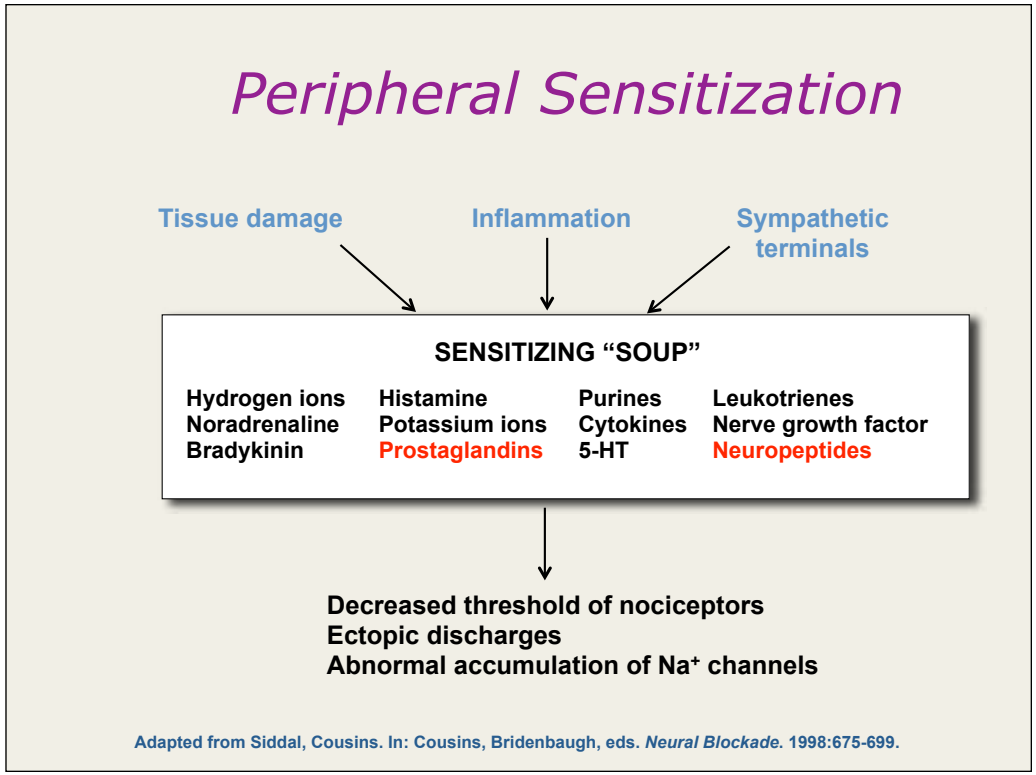
MAKE SURE THAT HYPERALENGIS AND ALLODAYSIAS PAIN FROM
NORMALLY PAINLESS STIMULI - DEFINE THESE FOR PAIN SPECIALIST
PUT THE NURON SLIDES BACK IN

Sensitization: In the normal pain response, pain intensity increases as the stimulus intensity increases[1]

Sensitization following injury causes the curve to shift to the left, resulting in hyperalgesia, in which noxious stimuli cause greater and more prolonged pain, as well as allodynia, in which pain results from normally painless stimuli. Sensitization is the manifestation of neuronal plasticity[1]

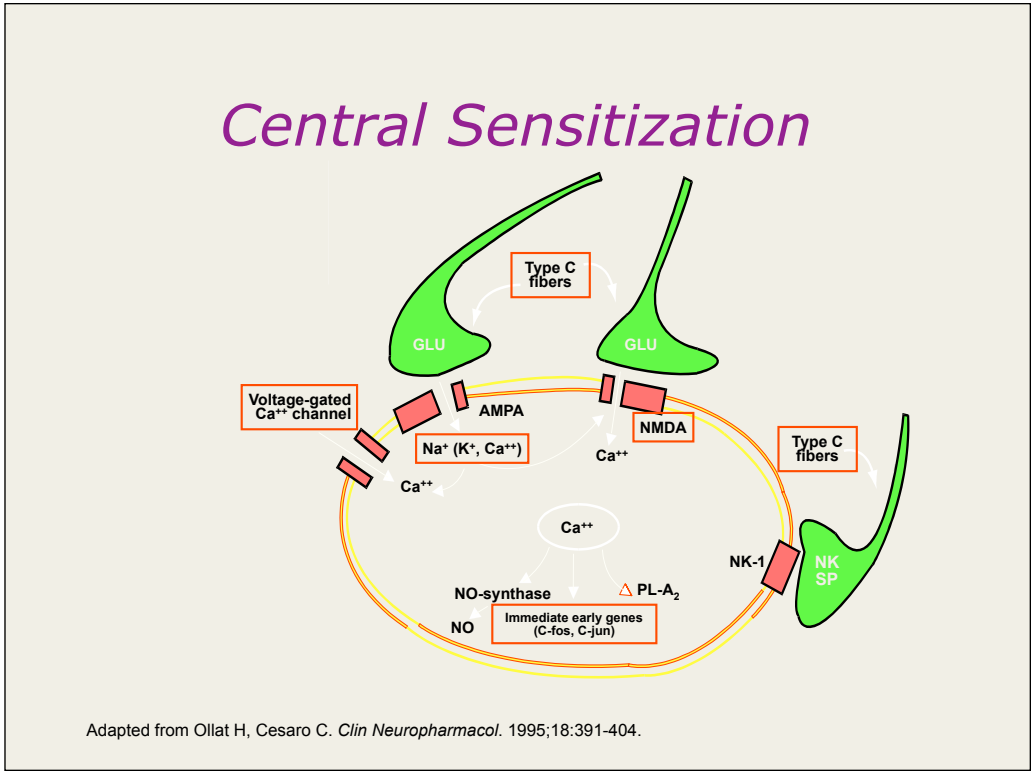
References:

Gottschalk A, Smith DS. New concepts in acute pain therapy: preemptive analgesia. *Am Fam Physician.* 2001;63:1979-1984.

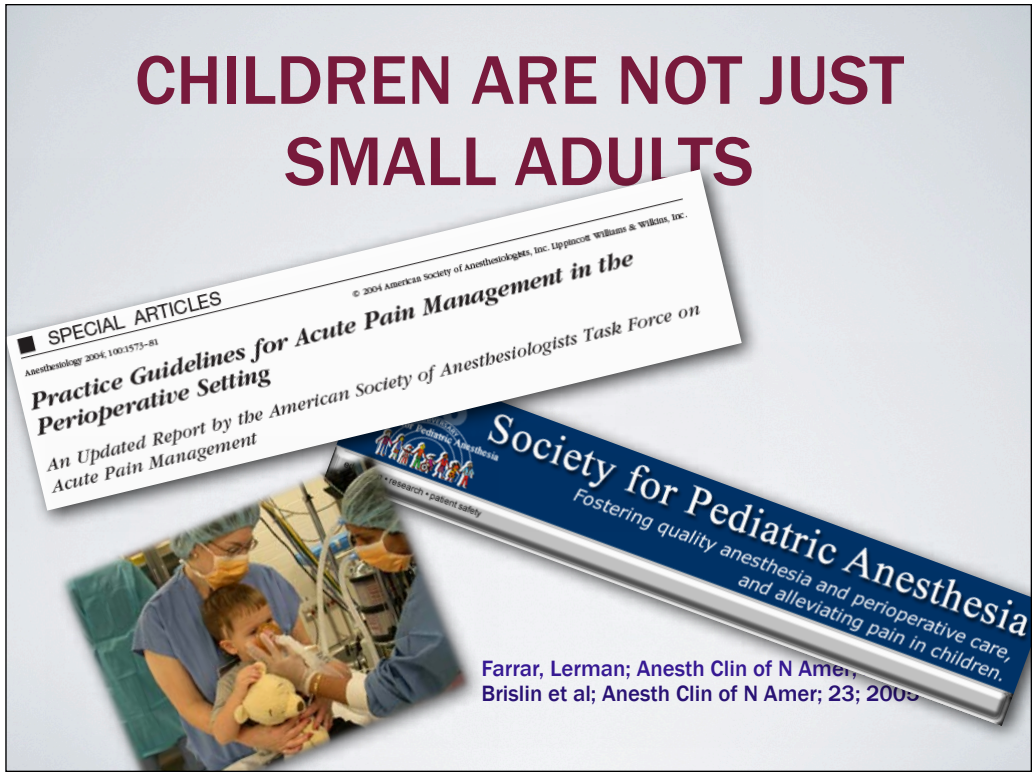


The mechanisms resulting in peripheral sensitization have been well-documented. Following a peripheral nerve injury, an inflammatory reaction occurs with the release of a variety of neurotransmitters, referred to as a *sensitizing "soup"*. These substances are released from damaged and inflammatory cells, including macrophages, mast cells, and lymphocytes. In addition, nociceptive stimulation causes a neurogenic inflammatory response with the release of substance P, neurokinin A, and calcitonin gene-related peptide from the nociceptive afferent fibers. This inflammatory reaction results in a decreased threshold of nociceptors. In addition, there is an abnormal expression and accumulation of sodium channels at the level of the injury, which partially accounts for the ectopic discharges following peripheral sensitization.

Since peripheral sensitization is partially due to an abnormal accumulation of sodium channels, one way to modulate pain related to peripheral sensitization is by using sodium channel modulators.



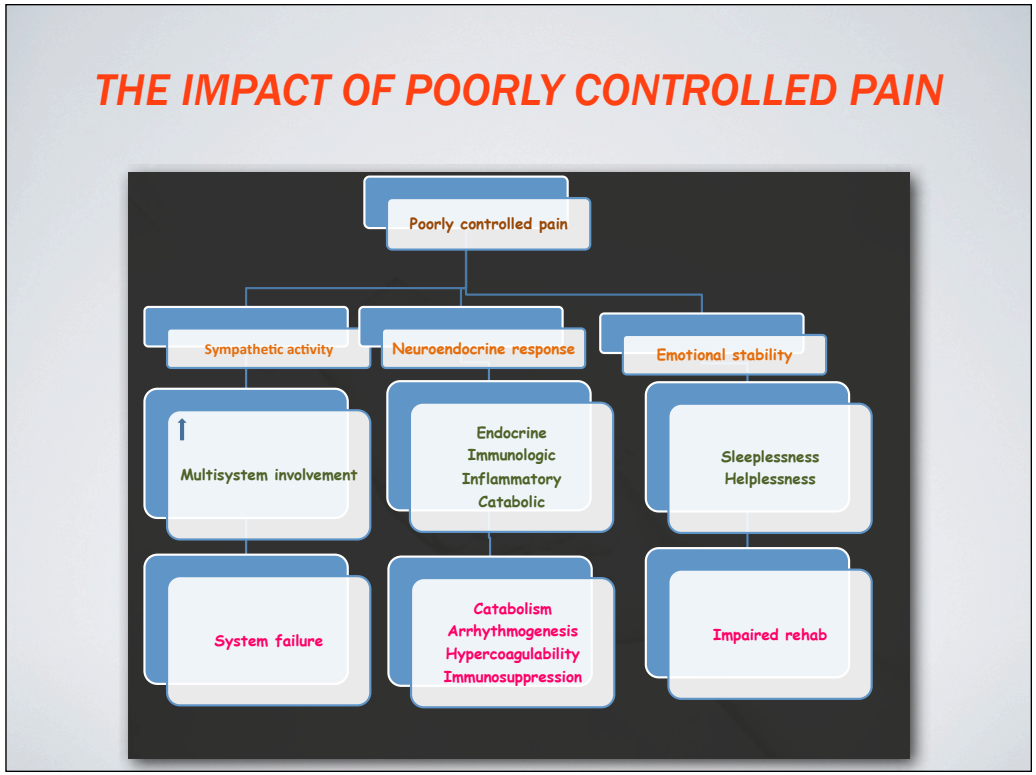
The process of central sensitization starts early in deafferentation. Following peripheral nerve injury, the peripheral nociceptor fibers release excitatory neurotransmitters, particularly glutamate and aspartate, both of which are excitatory in nature. These excitatory neurotransmitters activate a-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) and N-methyl-D-aspartate (NMDA) receptors, which cause calcium influx from voltage-gated Ca++ channels. Neurokinins and substance P interact with the NK-1 receptors, also leading to calcium entry. Activating these receptors removes the magnesium plug from the NMDA receptors, allowing more calcium entry into the cell. Calcium then acts as an important secondary messenger. It activates nitric oxide, leads to immediate early gene expression, and phosphorylates numerous receptors at the level of the dorsal horn, including the NMDA receptors, leading to a decreased threshold of the dorsal horn neurons and to ectopic discharges. This phenomenon is referred to as central sensitization. The pathophysiologic changes suggest that modulation of central sensitization can be accomplished by NMDA-blocking agents, NK-1 receptor blocking agents, or by calcium channel modulators.



When it comes to pain children are just like adults - they feel pain from intrauterine life to childhood. At 7 weeks gestational age, skin receptors and sensor nerves start to form and can be founder all over the fetus at the end of the third trimester along with inhibitory mechanisms. With other words, children are are not exempted from feeling pain.

Minimizing pain is in keeping with the physician's primary goal of relieving suffering. In addition, effective treatment of perioperative pain represents an important component of postoperative recovery as it serves to blunt autonomic, somatic and endocrine reflexes with a resultant potential for decrease in perioperative morbidity.

This knowledge applies to patients of all ages. While anesthesiologists have historically been leaders when it comes to treating pain, an interesting evolution has occurred by virtue of the creation of multidisciplinary pain services. In addition, the United States Congress formally recognized the last 10 years as the 'Decade of Pain Control and Research' with the intent to put an end to a miss-valued service



Chemical, mechanical, or thermal stimuli of sufficient quality or intensity to threaten or to disrupt vasculature integrity, typically lead to autonomic (changes in heart rate or blood pressure) or hormonal (adrenal and pituitary secretion) responses.

Noxious stimuli, such as surgical trauma and subsequent postoperative pain, result in a broad range of responses, which are endocrinologic, immunologic, and inflammatory in nature. This phenomenon is known collectively as the “neuroendocrine stress response to injury”. The stress response results in catabolism, arrhythmogenesis, hypercoagulability, immunosuppression, and emotional instability.

Do Neonates Feel Pain?

- Randomized controlled trial
- IV Fentanyl vs Pavulon/Oxygen
- Neuro-endocrine responses

Anand et al, NEJM, 1987

Pain Associated with Immunizations: Do Infants Remember?

- Randomized trial
- 3 groups of infants receiving immunizations with different pain backgrounds
- Infants who had received a circumcision with no pain meds had severe crying spells

Anna Taddio et al, JAMA, 1998

Local Anesthetic Solution Toxicity: Can This be Avoided?

- Use low and incremental doses
- Avoid large doses for central neuraxial infusions
- Have lipid emulsion available immediately
- 1.5mL/kg bolus followed by an infusion

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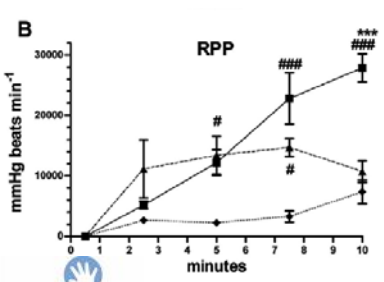
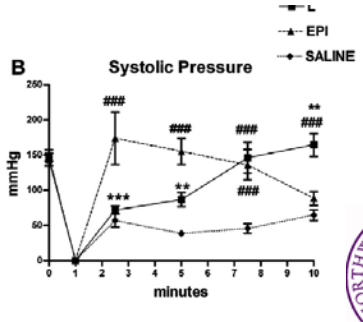
Anesthesiology 2008; 108:907–13

Resuscitation with Lipid versus *Epinephrine in a Rat Model of Bupivacaine Overdose*

Guy L. Weinberg, M.D., Guido Di Gregorio, M.D.,† Richard Ripper, C.V.T.,‡ Kemba Kelly, M.S.,‡ Malek Massad, M.D.,§ Lucas Edelman, B.S.,‖ David Schwartz, M.D.,# Nirali Shah, B.S.,‖ Sophie Zheng, B.S.,‖ Douglas L. Feinstein, Ph.D.***





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Successful Resuscitation After Ropivacaine and Lidocaine-Induced Ventricular Arrhythmia Following Posterior Lumbar Plexus Block in a Child

Hugues Ludot, MD*
Jean-Yves Tharin, MD*

We report the case of a 13-yr-old girl scheduled for knee surgery under general anesthesia and posterior lumbar plexus block. A ventricular arrhythmia developed 15 min after local anesthetic injection. A 20% lipid emulsion was successful in converting the ventricular arrhythmia to a sinus rhythm. This is consistent with previous reports suggesting that lipid emulsion is an effective emergency treatment availability of lipid rooms where local

Single dose 3 mL/kg of lipid emulsion

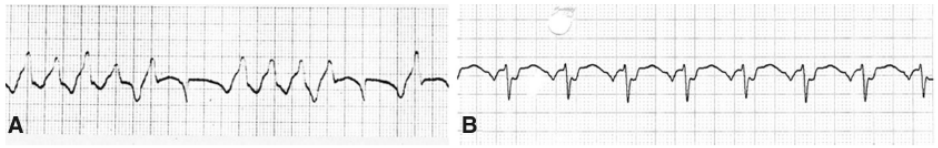

Figure 1. Electrocardiogram tracing after administration of a mixture of ropivacaine and lidocaine for lumbar plexus block. Trace A represents the ventricular arrhythmia occurring within 15 min after injection of local anesthetics. Trace B shows the effects of lipid emulsion on the arrhythmia approximately 2 min after IV injection of 3 mL/kg of Medialipid®.

Sedated & General Anesthesia: Should we avoid regional anesthesia?

Regional Anesthesia in Anesthetized or Heavily Sedated Patients

Christopher M. Bernards, M.D., Admir Hadzic, M.D., Ph.D.,
Santhanam Suresh, M.D., and Joseph M. Neal, M.D.

Regional Anesthesia and Pain Medicine, Vol 33, No 5 (September–October), 2008: pp 449–460

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Bernards, Hadzic, Suresh, Neal, RAPM, 2008

Table 2. Recommendations: Performing Regional Anesthesia in Anesthetized or Heavily Sedated Patients*

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The benefit of ensuring a cooperative and immobile infant or child may outweigh the risk of performing neuraxial regional anesthesia In pediatric patients undergoing general anesthesia or heavy sedation the overall risk of neuraxial anesthesia should be weighed against its expected benefit (Class II)

A
- Warning signs such as paresthesia or pain on injection of local anesthetic inconsistently herald needle contact with the spinal cord. Nevertheless, some patients do report warning signs of needle-to-neuraxis proximity. General anesthesia or heavy sedation removes any ability for the patient to recognize and report warning signs. This suggests that neuraxial regional anesthesia should be performed rarely in adult patients whose sensorium is compromised by general anesthesia or heavy sedation. (Class II)

Interscalene blocks should not be performed in anesthetized or heavily sedated adult or pediatric patient (Class-1)

should be weighed against its expected benefit. (Class II)

Interscalene blocks
- Case reports document spinal cord injury during the placement of interscalene blocks in patients under general anesthesia, which heightens concern associated with this practice. Interscalene blocks should not be performed in anesthetized or heavily sedated adult or pediatric patients. (Class I)

Recommendations may change with changing technology

injury, peripheral nerve blockade should not be routinely performed in most adults during general anesthesia or heavy sedation. However, the risk-to-benefit ratio of performing peripheral nerve blockade under these conditions may improve in select patient populations (e.g., dementia, developmental delay, or when unintended movement could compromise vital structures). (Class II)

Pediatric peripheral nerve blocks
- Regardless of wakefulness, infants and children may be unable to communicate symptoms of potential peripheral nerve injury. However, uncontrolled movement may increase the risk of injury. Therefore, the placement of peripheral nerve blocks in children undergoing general anesthesia or heavy sedation may be appropriate after duly considering individual risk-to-benefit ratio. (Class II)

refers to patients under general anesthesia. *Heavy sedation* is defined as the patient being sedated to the point of being ize and/or report any sensation that the physician would interpret as atypical during block placement.

Pediatric Regional Anesthesia Network

- Consortium of pediatric hospitals.
- Prospective data collection.
- Large amounts of data on utilization of blocks, complications etc.

PRAN
PEDIATRIC REGIONAL ANESTHESIA NETWORK

Pediatric Regional Anesthesia Network (PRAN): A Multi-Institutional Study of the Use and Incidence of Complications of Pediatric Regional Anesthesia

David M. Polaner, MD, FAAP,*† Andreas H. Taenzer, MD, MS, FAAP,†§ Benjamin J. Walker, MD,‖ Adrian Bosenberg, MB, ChB, FFA,‖ Elliot J. Krane, MD,¶# Santhanam Suresh, MD,**†† Christine Wolf, MBS,†† and Lynn D. Martin, MD, MBA, FAAP, FCCM‖§§

Asleep vs Sedated vs Awake: Regional Anesthetic Complications by Patient state at the time of of Blockade A Report from the Pediatric Regional Anesthesia Network (PRAN) 2011

Taenzer A , Bosenberg A, Krane E, Martin L, Polaner D, Suresh S & The investigators of the PRAN network

Table 1: Patient State by Block Type for Single Injections

Block Type	GA no NMB	GA with NMB	Sedated	Awake	Total
Neuraxial	6747 (82.9%)	1207 (14.6%)	119 (0.15%)	76 (0.1%)	8149
Upper Extremity	541 (69.6%)	65 (8.4%)	120 (15.4%)	51 (6.6%)	777
Lower Extremity	2889 (85.6%)	271 (8.0%)	164 (4.9%)	50 (1.5%)	3374
Other blocks	2772 (74.3%)	778 (20.9)	120 (3.2%)	60 (1.6%)	3730

Table 2: Patient State by Block Type for catheters

Block Type	GA no NMB	GA with NMB	Sedated	Awake	Total
Neuraxial	2034 (54.5%)	1315 (35.2%)	266 (7.1%)	117 (3.1%)	3732
Upper Extremity	38 (80.1%)	2 (4.2%)	6 (12.7%)	1 (2.1%)	47
Lower Extremity	634 (88.9%)	25 (3.5%)	48 (6.7%)	6 (0.8%)	713
Other blocks	22 (78.6%)	6 (21.4%)	0	0	28

Complications

Table 3: Incidence of complications

Patient status	Number of complications	Total blocks	Complication rate (%)
GA no NMB	1043	15677	6.6
GA with NMB	530	3669	14.4
Sedated	120	843	14.2
Awake	50	361	13.8

GA no NMB: 6.6%
GA with NMB: 14.4%
Awake: 13.8%

Table 4: Postopera placement

Complications	wake	Total
Neurologic	.33%)	36 (0.17%)
Positive test dose	.66%)	37 (0.18%)
Vascular puncture	.33%)	121 (0.59%)

PRAN
PEDIATRIC REGIONAL ANESTHESIA NETWORK

Taenzer et al, PRAN 2011

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Nerve Localization

- Nerve stimulation?
- US guidance
- Combination
- Safety?

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"I would have everie man write what he knowes and no more."—Montaigne

BRITISH JOURNAL OF ANAESTHESIA

Volume 94, Number 1, January 2005

Editorial I

Location, location, location! Ultrasound imaging in regional anaesthesia

Regional Anesthesia
Section Editor: Terese T. Horlocker

Medical Intelligence

CME Ultrasound-Guided Regional Anesthesia: Current Concepts and Future Trends

Peter Marhofer, MD*

ent W. S. Chan, MD, FRCPC†

The scope of ultrasound imaging guidance for regional anesthesia is growing rapidly. Preliminary data, although limited, suggest that ultrasound can improve block success rate and decrease complications. In this review, we describe the basic principles of ultrasound scanning and needling techniques for nerve blocks, highlight some of the data on clinical outcome, discuss specific limitations of ultrasound for regional anesthesia, and speculate on the future direction for physician training and competency assessment with this technology.
(Anesth Analg 2007;104:1265–9)

BJA Vol 94, Jan 2005

Pharmacodynamics: Can we reduce the dose of local anesthetic solution using Ultrasonography?

Ultrasonographic-Guided Ilioinguinal/Iliohypogastric Nerve Block in Pediatric Anesthesia: What is the Optimal Volume?

H. Willschke, MD*, A. Bösenberg, MBChB, FFA(SA)†, P. Marhofer, MD*, S. Johnston, MBChB, FCA(SA)†, S. Kettner, MD*, U. Eichenberger, MD§, O. Wanzel, MD†, and S. Kapral, MD*

0.075 mL/kg; 10 kg child = 0.75 mL

Bern, Switzerland

Table 2. Heart Rate (HR) in beats/min Before and After Skin Incision

0.25% levobupivacaine	HR before skin incision	HR after skin incision	Cumulative increase
0.2 mL/kg	96.50 (12.68)	95.40 (12.37)	1%
0.1 mL/kg	86.50(10.89)	86.20(13.28)	0.3%
0.05 mL/kg	90.10(19.15)	94.90(23.84)	5.3%
0.075 mL/kg	90.10(13.40)	89.90(16.91)	0.2%

Data are mean (SD).

ANESTH ANALG
2006;102:1680–4

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Regional Anesthesia For Postoperative Pain Management

- Central neuraxial
- Head & Neck Blocks
- Upper extremity
- Lower extremity
- Truncal

Head & Neck Blocks

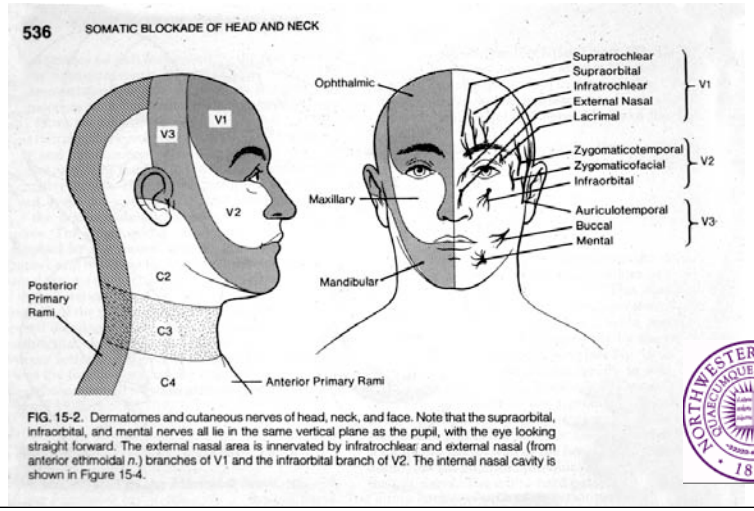

FIG. 15-2. Dermatomes and cutaneous nerves of head, neck, and face. Note that the supraorbital, infraorbital, and mental nerves all lie in the same vertical plane as the pupil, with the eye looking straight forward. The external nasal area is innervated by infratrochlear and external nasal (from anterior ethmoidal *n.*) branches of V1 and the infraorbital branch of V2. The internal nasal cavity is shown in Figure 15-4.

Regional Anesthesia in a Very Low–Birth-Weight Neonate for a Neurosurgical Procedure

Santhanam Suresh, M.D., F.A.A.P., and Gregory Bellig, M.D.

Regional Anesthesia and Pain Medicine, Vol 29, No 1 (January–February), 2004: pp 58–59

Pediatric Anesthesia 2008 doi:10.1111/j.1460-9592.2008.02565.x

Case report

Ommaya and McComb reservoir placement in infants: can this be done with regional anesthesia?

TETSU UEJIMA MD AND SANTHANAM SURESH MD

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1

Posterior Fossa Craniotomies

- Occipital nerve block
- Midline, medial to the pulsation of the occipital artery
- Can be used for occipital craniotomies as well for posterior VP shunt revisions

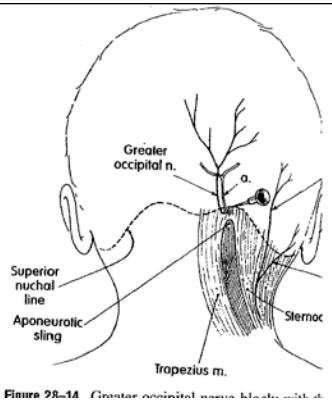
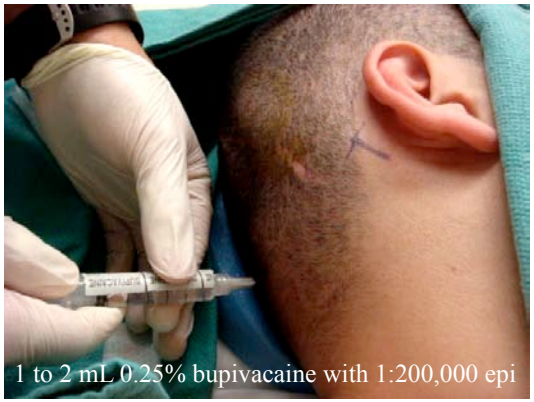


Figure 28–14 Greater occipital nerve block with t



Otolaryngology

- Endoscopic sinus surgery
- Tympanomastoid surgery
- Tympanoplasty
- Tonsillectomy
- Rhinoplasty

Tympanostomy

- Auricular branch of the Vagus nerve (N of Arnold)
- Provides analgesia for the external ear canal
- Easy to perform
- No side effects

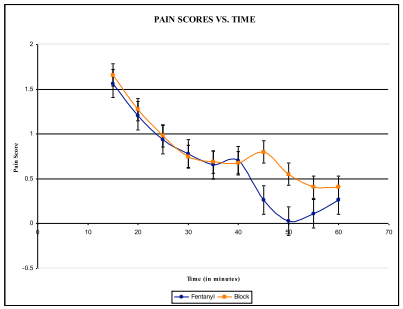
Dose: 0.2mL 0.25% bupivacaine with 1:200,000 epi

Pediatric Anesthesia 2008 doi:10.1111/j.1460-9592.2008.02789.x

Postoperative pain relief in infants undergoing myringotomy and tube placement: comparison of novel regional anesthetic block to intranasal fentanyl – a pilot analysis

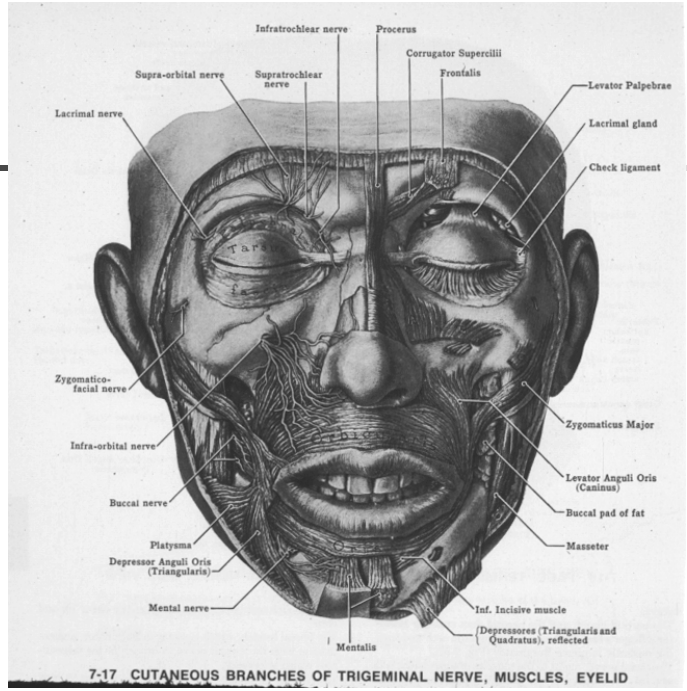
POLINA VORONOV MD FAAP*, MICHAEL J TOBIN MD FAAP†, KATHLEEN BILLINGS MD‡, CHARLES J. COTÉ MD FAAP§, ADITYA IYER M.ENG¶ AND SANTHANAM SURESH MD FAAP*

Pediatric Anesthesiology, Children's Memorial Hospital, Feinberg School of Medicine, Northwestern University, Chicago, IL, †The Shriner's Hospital, Oak Park, IL, ‡Division of Pediatric Otolaryngology, Children's Memorial Hospital, Feinberg School of Medicine, Northwestern University,Chicago, IL, §Pediatric Anesthesiology, Massachusetts General Hospital, Harverd Medical School, Boston, MA and ¶Children's Memorial Hospital, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA



Endoscopic Sinus Surgery

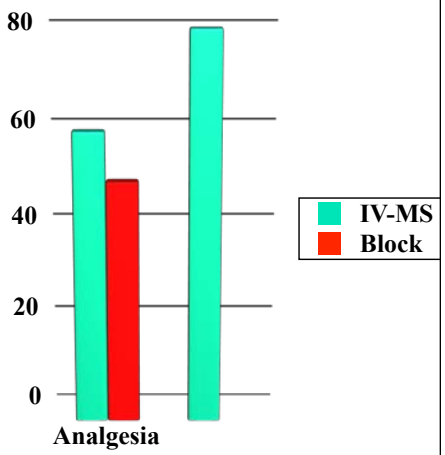
- Maxillary branch of the trigeminal nerve
- Supplies the upper lip, choana as well as the maxillary sinus
- Excellent pain relief
- Less additional analgesics and hence reduces morbidity



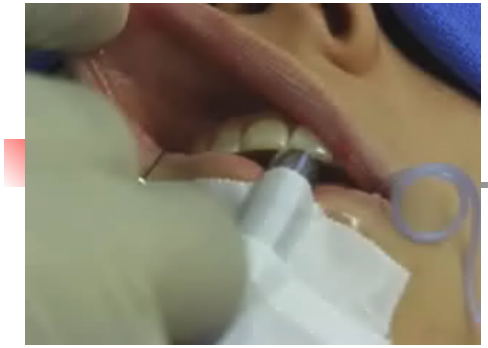
7-17 CUTANEOUS BRANCHES OF TRIGEMINAL NERVE, MUSCLES, EYELID

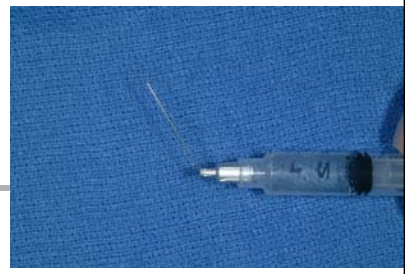
Postoperative Analgesia for FESS

- Analgesia between groups was equivalent (p=ns)
- PONV was increased in the IV-MS group (80%) vs the Block group (0%) (Fisher exact p=0.015)



Suresh,S et al Anesthesiology 2002; 96: A1292





Tympanomastoid Surgery

- Superficial Cervical Plexus (C3)
- Posterior border of the sternocleidomastoid at the level of the cricoid (C6)
- Superficial injection
- Decreased postoperative morbidity

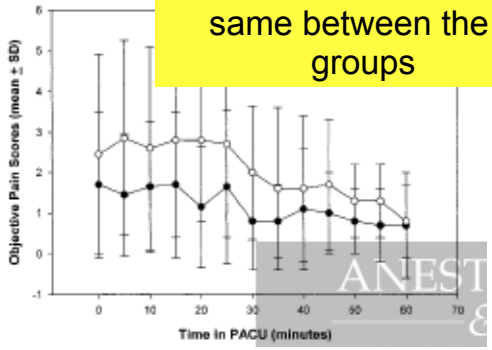
Postoperative Pain Relief in Children Undergoing Tympanomastoid Surgery: Is a Regional Block Better than Opioids?

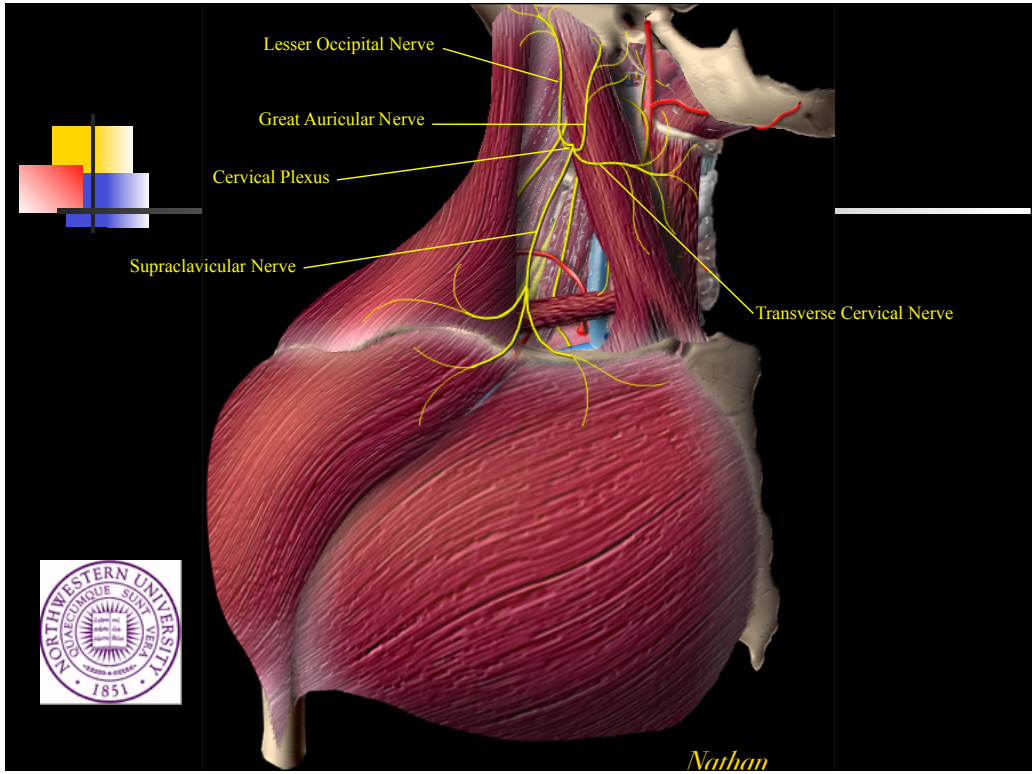
Santhanam Suresh, MD*, Sandra L. Barcelona, MD*, Nancy M. Young, MD†, Ilana Seligman, MD†, Corri L. Heffner, RN*, and Charles J. Coté, MD*

*Department of Pediatric Anesthesiology and †Division of Otolaryngology, Children's Memorial Hospital, Northwestern University Medical School, Chicago, Illinois

Anesth Analg 2002;94:859–62 859

Pain Scores were the same between the 2 groups




Lesser Occipital Nerve
Great Auricular Nerve
Cervical Plexus
Supraclavicular Nerve
Transverse Cervical Nerve
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Plastic Surgery

- Otoplasty
  - Great auricular nerve block
- Rhinoplasty
  - Infraorbital blocks
- Nevus removal
- Palate surgery
  - Greater palatine block
- Hand surgery
  - Median, radial and ulnar nerve block

Cleft Lips

- Infraorbital branch of the maxillary division of the trigeminal nerve
- Sucking ability is increased
- Decreases need for analgesics in the intra-operative period
- Excellent discharge criteria

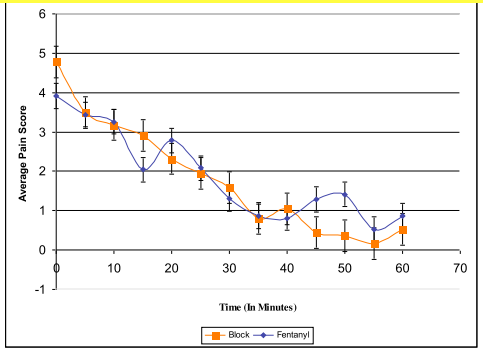
Pediatric Anesthesia 2008 doi:10.1111/j.1460-9592.2008.02721.x

Postoperative pain control for primary cleft lip repair in infants: is there an advantage in performing peripheral nerve blocks?

CARMEN SIMION MD*†, JULIA CORCORAN MD†‡, ADITYA IYER MENG* AND SANTHANAM SURESH MD FAAP*†

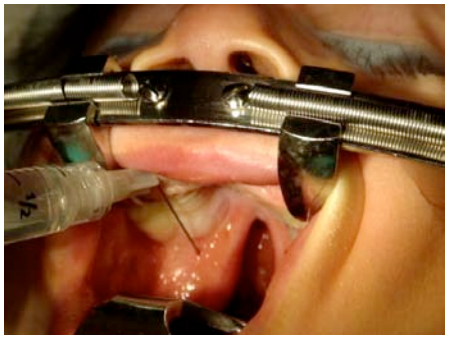
Children's Memorial Hospital, Chicago, IL, USA, †Northwestern University, Feinberg School of Medicine, Chicago, IL, USA and ‡Division of Plastic Surgery, Children's Memorial Hospital,

No difference in Pain Scores between block and fentanyl group



Cleft Palate Surgery

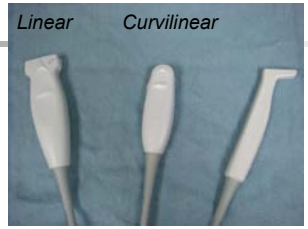
- Greater palatine nerve
- 0.5mL bupivacaine
- No need for postoperative analgesics



US Guidance for Regional Anesthesia

Knobology of your Ultrasound Machine

- Gain
  - Near Gain
  - Far Gain
- Depth
- Frequency of the probe
  - Higher frequency eg.13 mHz: Superficial scan
  - Lower frequency eg. 5 mHz: Deeper scan
- Data Entry
- Recording information/billing issues



Imaging & Preparation of the Probe

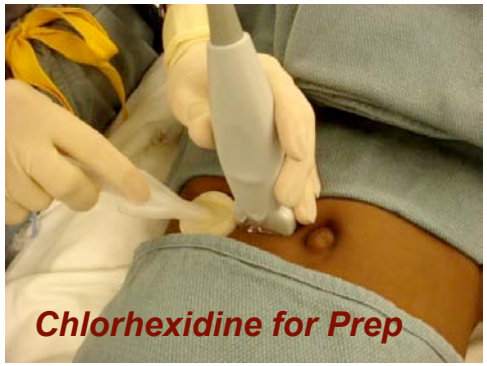
- Preparation of the probe
- Sterility of the probe
- In-plane vs. Out of plane
- Scanning to recognize needle trajectory.
- Tilting the probe.
- Hydro-dissection.
- Tissue dissection.
- Echogenic needles.

Probe preparation

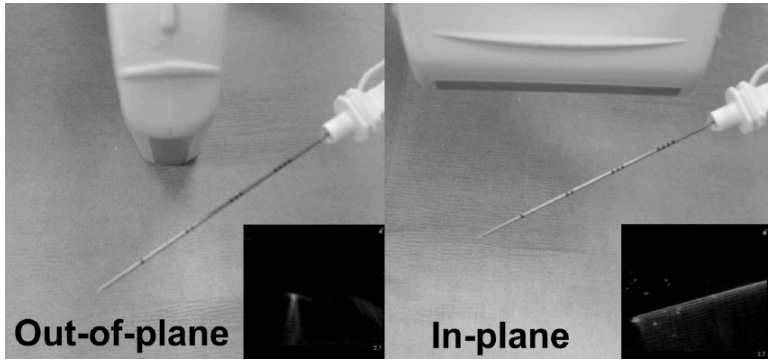
- Single shot blocks: Tegaderm/Opsite
- Catheters: Sterile sheath for all catheter placement with gown & glove
- Use Surgilube or K-Y jelly in individual packs in sterile pouches for gel, water can be used for spine imaging with good success


Tegaderm for Probe


Surgilube for gel


Chlorhexidine for Prep

In-plane vs. Out of Plane



Tsui BC, Suresh S, Anesthesiology 2010,112; 473-92

US Imaging=Pattern recognition

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ART of USGRA
A: Alignment
R: Rotation
T: Tilting

Slide the probe along the axis of the needle like a copying machine

Tilting the probe to get a better view

The ASRA Evidenced-based Medicine Assessment of Ultrasound-Guided Regional Anesthesia & Pain Medicine

Neal J, Brull R, Chan VW,et al

Regional Anesthesia & Pain Medicine, Volume 35, Number 2, Supplement 1, March -April 2010

Concluding Comments

- USGRA were superior to other conventional methods
- Statistical differences demonstrate that USGRA is superior in terms of
  - reduced onset time
  - improved intermediate measures of success.

Pediatric Blocks for everyone!

- Caudal blocks
- Brachial Plexus: Supraclavicular
- Femoral nerve block
- Sciatic Nerve block
- TAP block

Central Neuraxial Blocks

- Spinal
- Epidural
  - Caudal
  - Lumbar epidural
  - Thoracic epidural

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REVIEW ARTICLES

Anesthesiology 2010; 112:719–28

David S. Warner, M.D., Editor

Ultrasound Imaging for Regional Anesthesia in Infants, Children, and Adolescents

A Review of Current Literature and Its Application in the Practice of Neuraxial Blocks

Ban C. H. Tsui, M.D., F.R.C.P.C.,* Santhanam Suresh, M.D., F.A.A.P.†

Anesthesiology 2010; 112: 719-28

Caudal : Why US Guidance?

- Most common regional technique used in children.
- Sacral dimple? tethered cord
- Accurate spread of local anesthetic solution.
- Determine the spread cranially.

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British Journal of Anaesthesia **107** (2): 229–35 (2011)
Advance Access publication 3 June 2011 · doi:10.1093/bja/aer128

BJA

Ultrasound assessment of cranial spread during caudal blockade in children: the effect of different volumes of local anaesthetics

L. Brenner[1], P. Marhofer[1]*, S. C. Kettner[1], H. Willschke[1], A.-M. Machata[1], U. Al-Zoraigi[1], M. Lundblad[2] and P.-A. Lönnqvist[2]

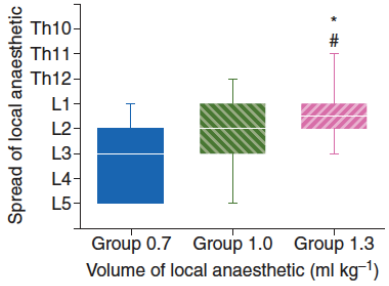
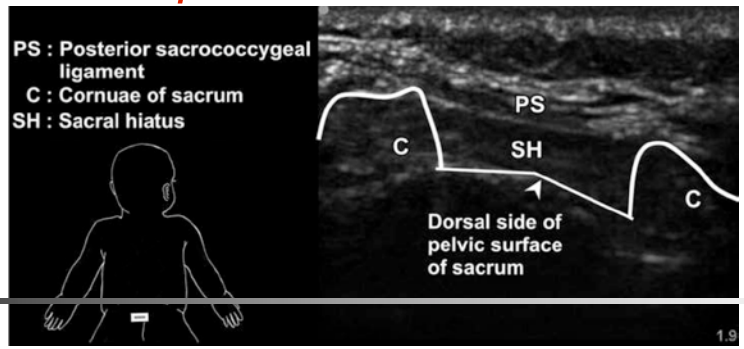


Fig 4 Cranial spread of local anaesthetic after caudal anaesthesia, representing the median, first, and third quartiles (boxes), and the range (whiskers). Asterisk denotes Group 1.3 *vs* Group 0.7, P=0.0002; hash represents Group1.3 *vs* Group 1.0, P=0.03.

Caudal Space: Transverse Scan



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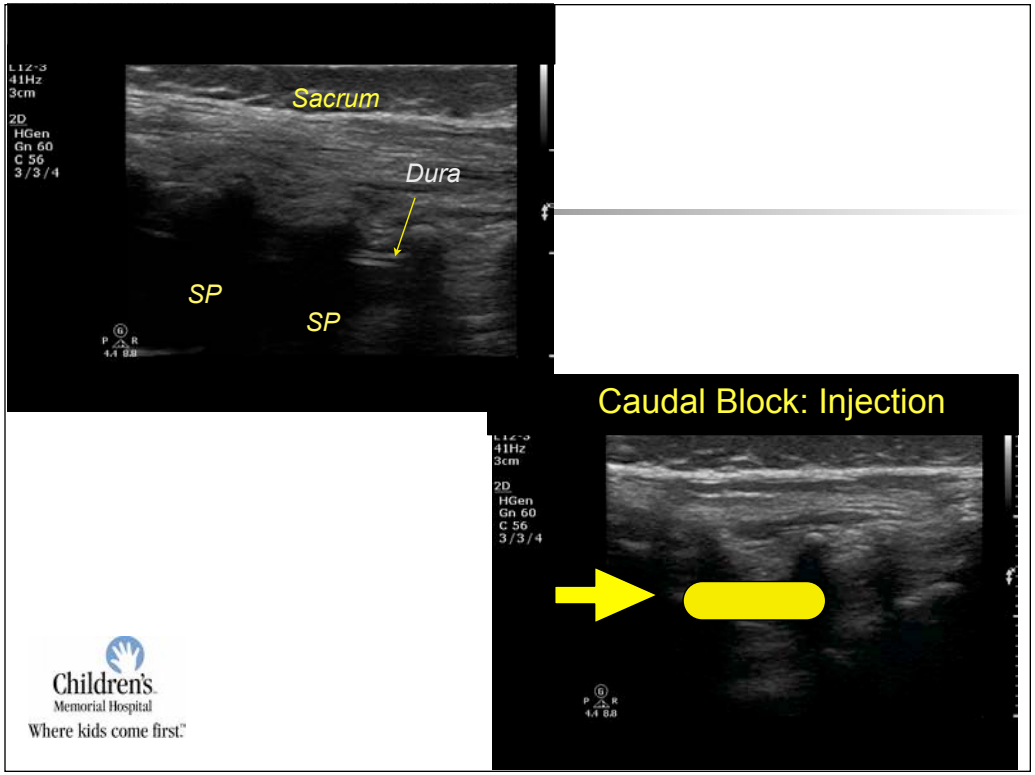
Tsui BC, Suresh S, Anesthesiology; 112: 473-92, Feb 2010



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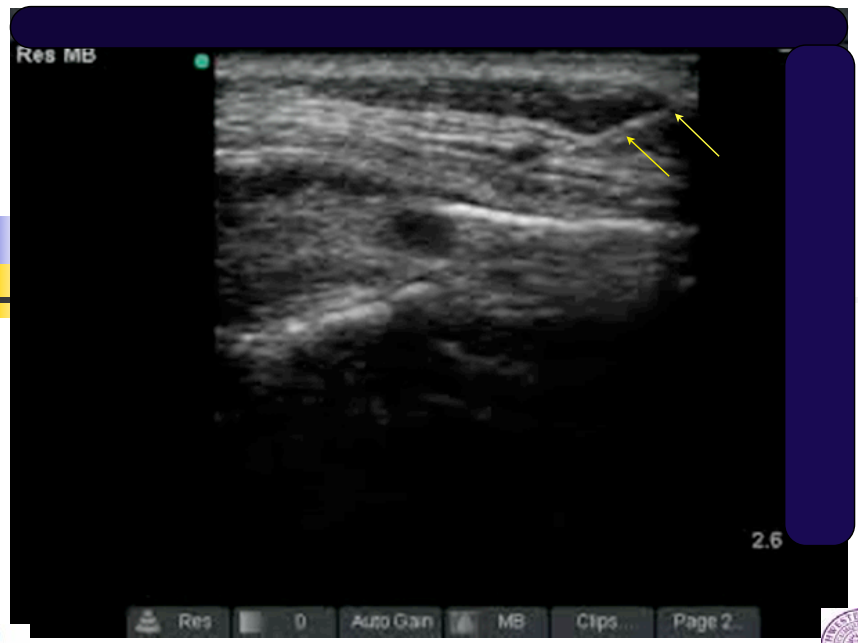

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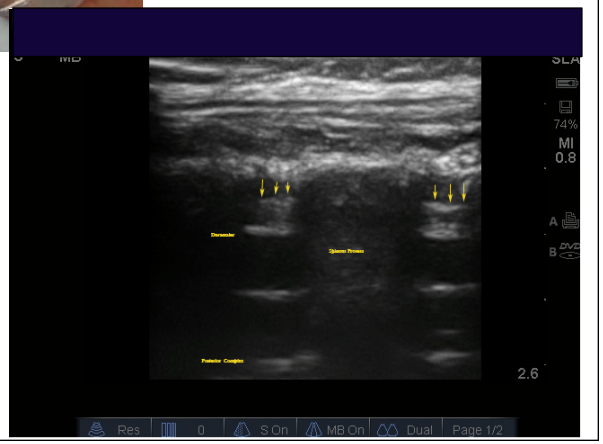
Paramedian Scan
Epidural Space



Use saline for loss of resistance

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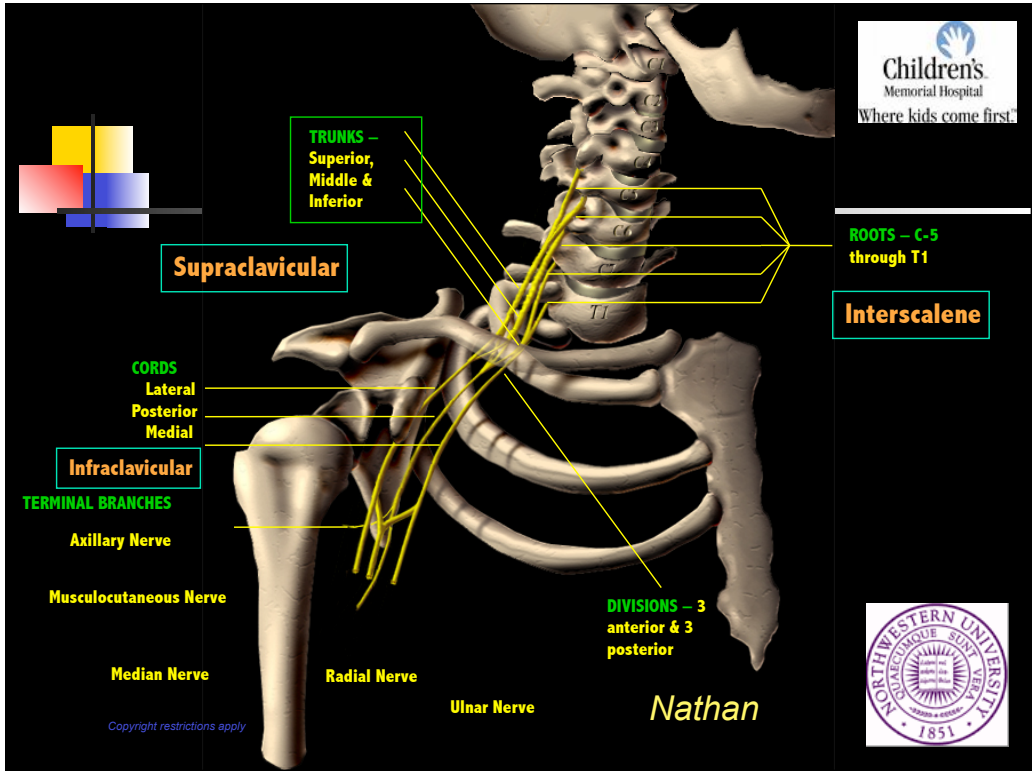
Upper Extremity Blocks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TRUNKS – Superior, Middle & Inferior
Supraclavicular
ROOTS – C-5 through T1
Interscalene
CORDS
Lateral
Posterior
Medial
Infraclavicular
TERMINAL BRANCHES
Axillary Nerve
Musculocutaneous Nerve
Median Nerve
Radial Nerve
Ulnar Nerve
DIVISIONS – 3 anterior & 3 posterior
Nathan
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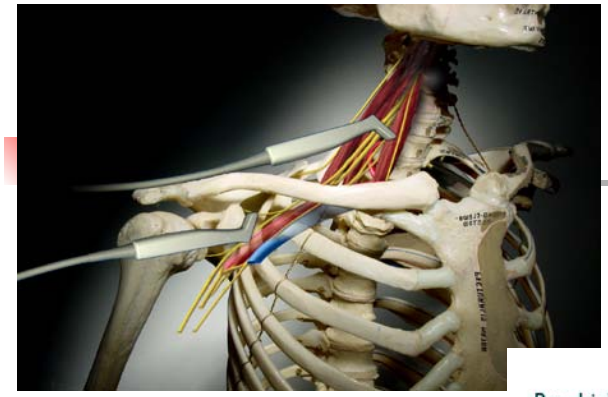
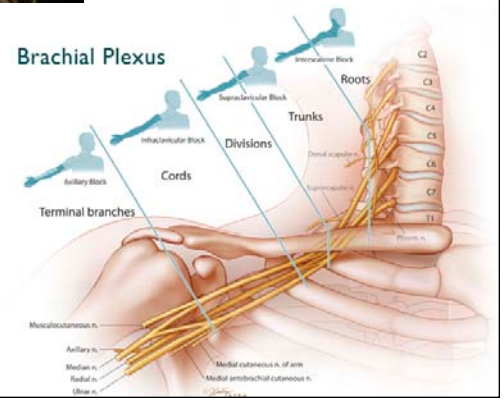
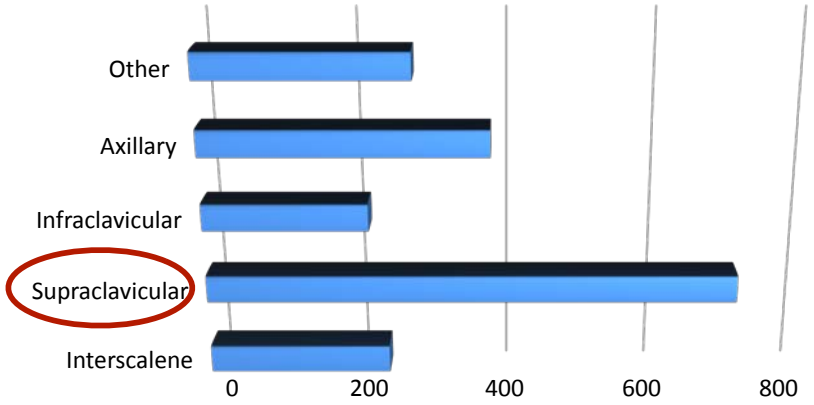




Nathan

Upper extremity blocks



PRAN
PEDIATRIC REGIONAL ANESTHESIA NETWORK

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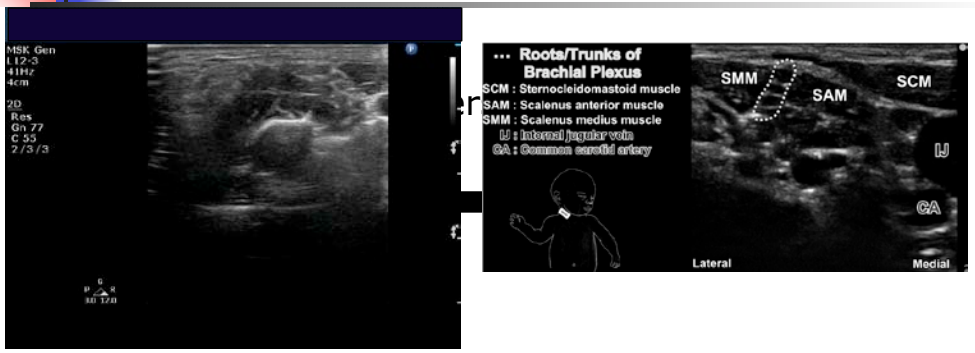
Interscalene



Tsui BC, Suresh S, Anesthesiology 2010,112; 473-92

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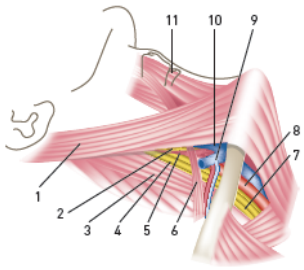
Supraclavicular block

- Useful for fracture reductions
- Performed in the emergency room with mild sedation
- Fast-tracking of patients postoperatively
- Easy to perform even in obese individuals



1 sternocleido-mastoid m.
2 phrenic n.
3 scalenus medius m.
4 brachial plexus (supraclavicular)
5 scalenus anterior m.
6 omohyoid m.
7 brachial plexus (infraclavicular)
8 subclavian a.
9 external jugular v.
10 internal jugular v.
11 cricoid cartilage

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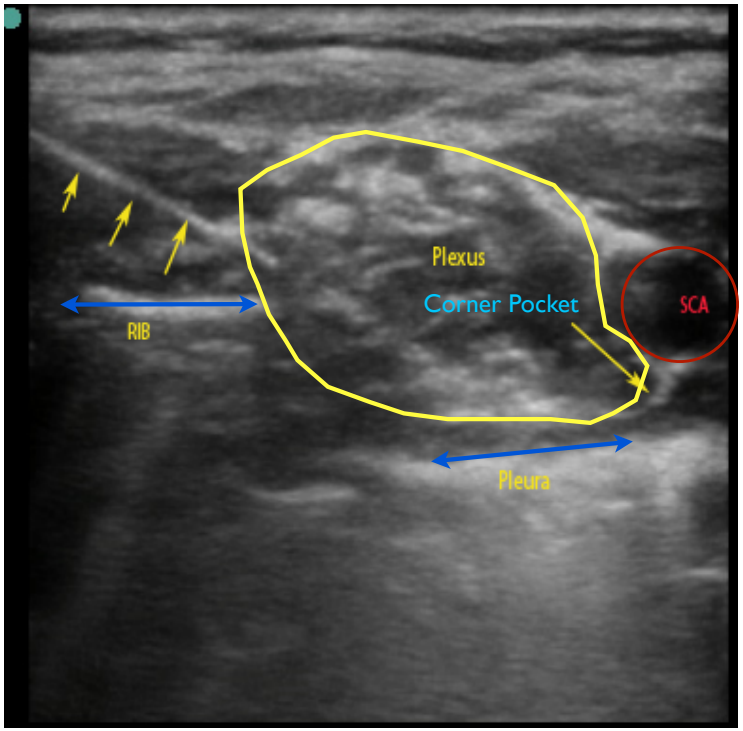
Eight Ball, Corner Pocket: The Optimal Needle Position for Ultrasound Guided Supraclavicular Block

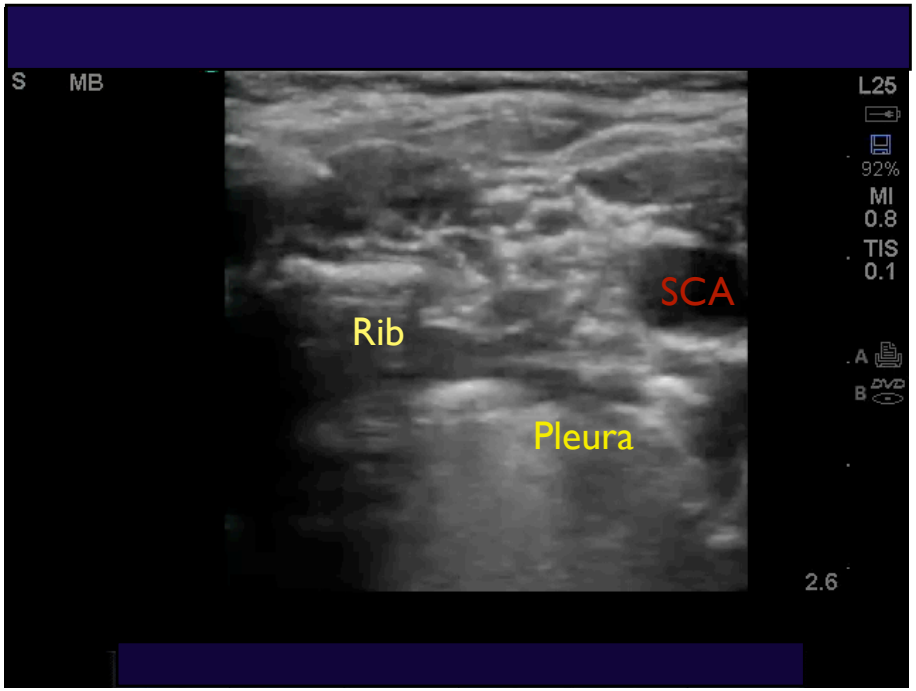
Soares LG, Brull R, Lai J, Chan VW

Toronto Western Hospital

Regional Anesthesia & Pain Medicine

Volume32, Issue 1, January 2007, Pages 94-95


Plexus
Corner Pocket
SCA
RIB
Pleura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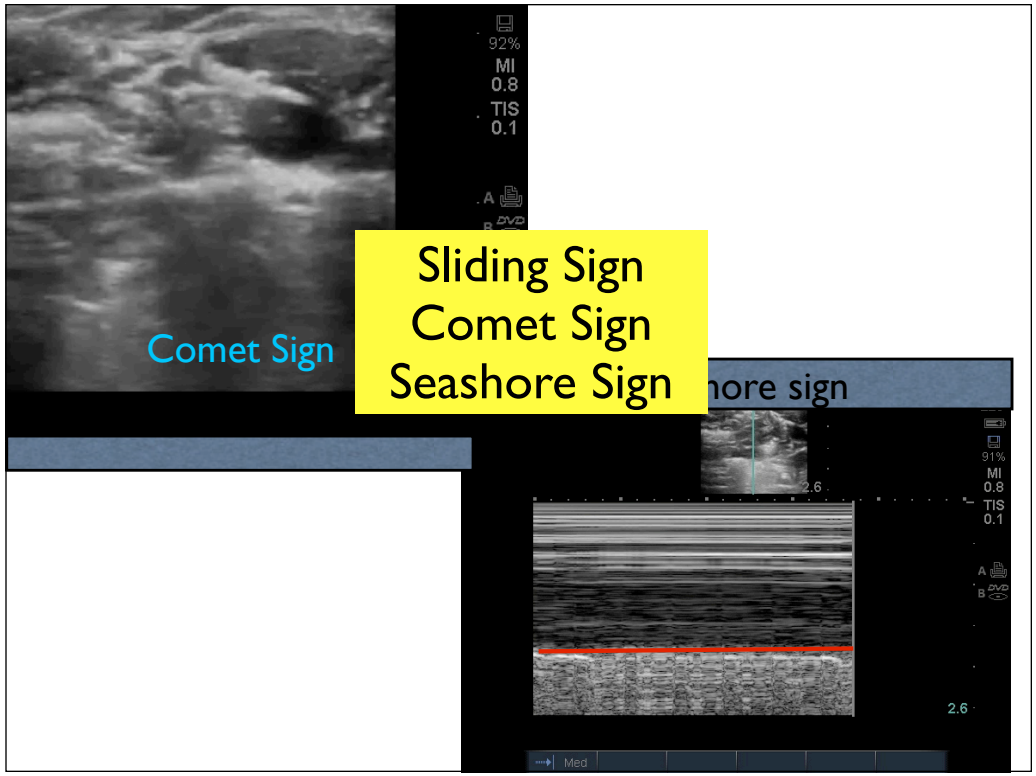
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hore sign
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0.1
2.6
2.6
Med

Performing Neural Checks for Pediatric Fractures After Surgery in the PACU (Post anesthesia

- ? Neural exam after fracture reduction.
- ? Vascular insufficiencies.
- ? Potential damage to the nerve when examined under anesthesia.
- Need to check Radial, Median and Ulnar nerve.

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Pediatric Anesthesia 2009; Dec; 19(12) 1238-40
Suresh S, Sarwark J, Bhalla T, Janicki J

***Radial Nerve**: Thumbs up*
***Median Nerve**: Thumb flexion*
***Ulnar nerve:** Scissoring of the fingers*

J-tip: Needleless lidocaine for skin analgesia

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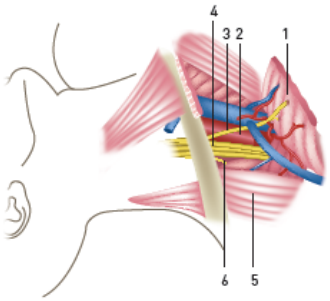
Infraclavicular approach

- Classic approach
- Paracorocoid approach



1 pectoralis major m.
2 subclavian a.
3 pectoral n.
4 brachial plexus (infraclavicular)
5 deltoid m.
6 suprascapular n.

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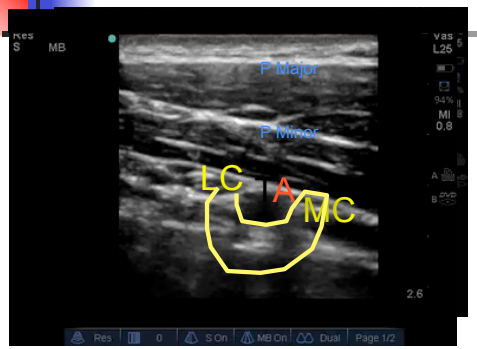
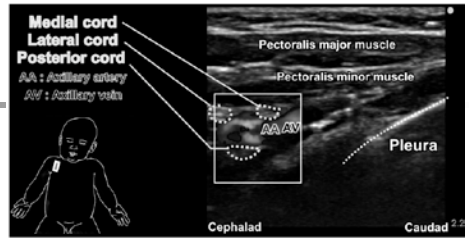
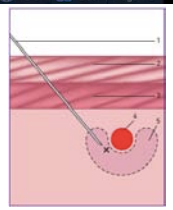
Infraclavicular







Tsui BC, Suresh S, Anesthesiology 2010,112; 473-92

Axillary Block

- Trans-arterial approach
- Nerve stimulation
- US Guided

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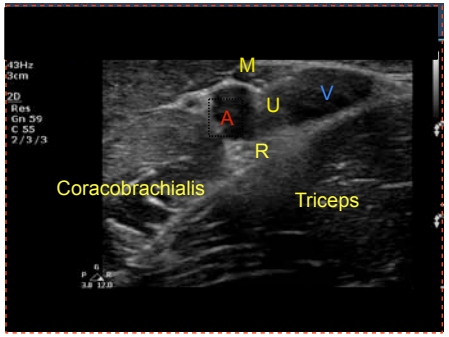
Brachial Plexus in the Axilla



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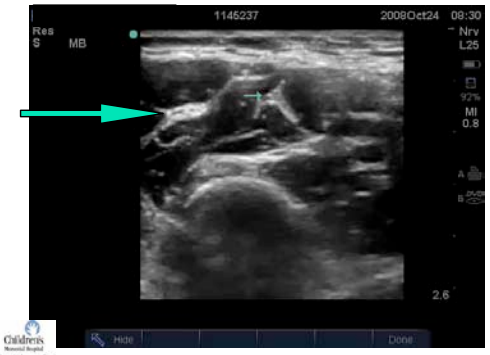
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Nrv
L25
92%
MI
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Done


1145237
2008Oct24 08:27
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S MB
Nrv
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MI
0.8
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Hide
Done

US Guided Lower extremity blocks

- Femoral nerve
- Lateral femoral cutaneous
- Saphenous nerve
- Sciatic nerve
  - Subgluteal
  - Midgluteal
  - Popliteal fossa

Femoral Nerve Block

- Most common pediatric nerve block
- Used for femoral fractures, hip pinning and for pin removal
- ? Use of nerve stimulator for the block
- Motor nerve, long duration of block

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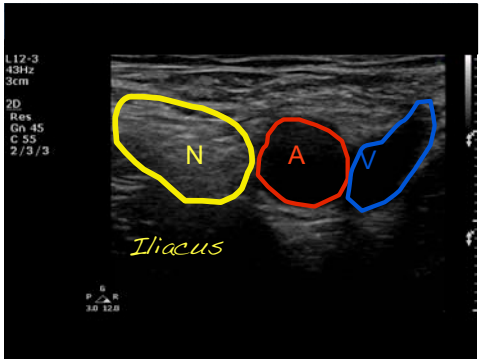
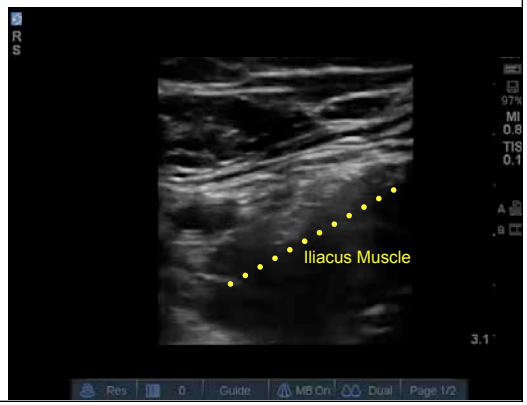
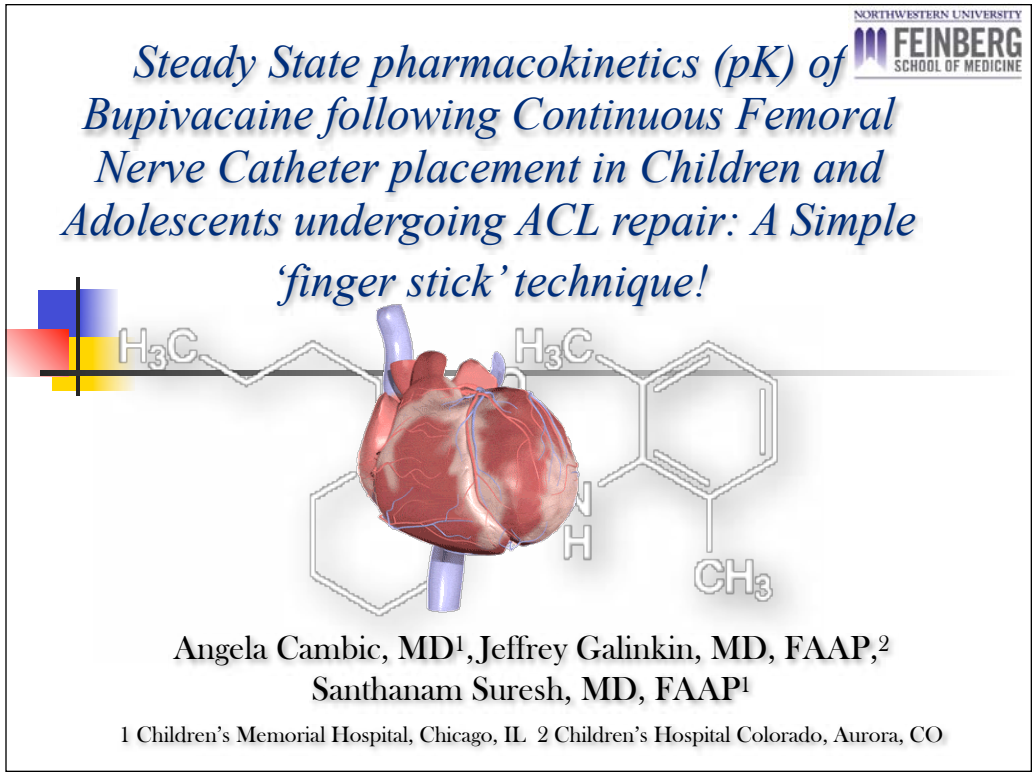


0.2mL/kg local anesthesia

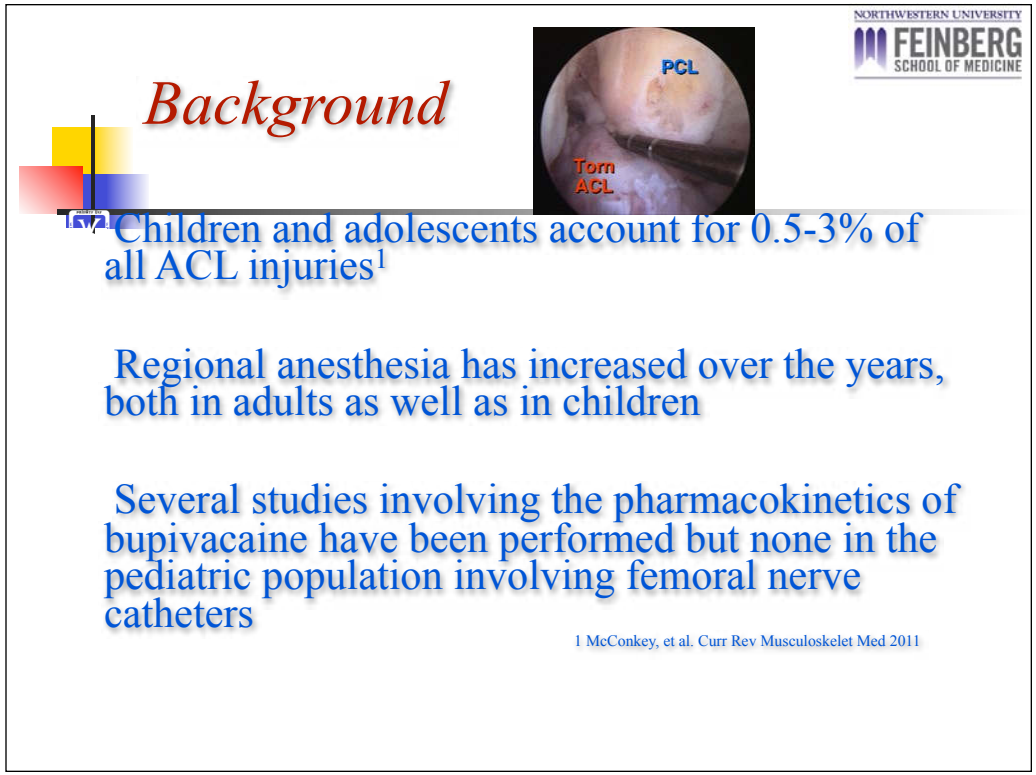


Peripheral Nerve Catheters

- ACL repair
  - Femoral Nerve catheter with single shot sciatic nerve block
- Osteotomies
  - Femoral nerve catheter



Background, methods, results and conclusions



Curr Rev Musculoskelet Med. 2011 Jun;4(2):37–44.
Pediatric anterior cruciate ligament reconstruction.
McConkey MO, Bonasia DE, Amendola A.

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Methods

IRB approval, parental consent and adolescent assent

- US Guided Single Femoral and Popliteal Nerve Blocks

Whole Blood Samples at various intervals

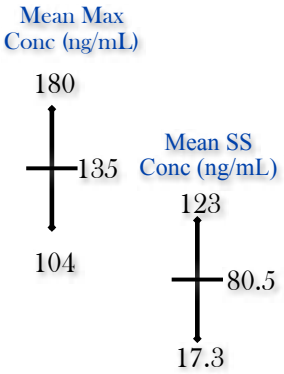
- While in house: baseline, 5, 15, 30, 60, 120, 240min
- At home, 24h and 48h with spot check

Analysis via LC-MS/MS System

- Mixed Reaction Mode

Results

Toxic Threshold 2100ng/mL



Conclusions

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This is the first study assaying steady state pharmacokinetics for continuous femoral nerve catheters in the pediatric population

The FNCs provided excellent analgesia with a continuous infusion of Bupivacaine 0.1%

The steady state levels of bupivacaine (80.5ng/ml) were found to be well below toxic levels (2100ng/ml)

Continuous bupivacaine infusion using femoral nerve catheters can be used safely in children in an outpatient setting

Knee Arthroscopy

- Femoral Nerve block
- Injection into the joint with bupivacaine+morphine
- Blockade of the infrapatellar branch of the saphenous nerve

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British Journal of Anaesthesia 97 (5): 710–14 (2006)
doi:10.1093/bja/ael241 Advance Access publication September 26, 2006

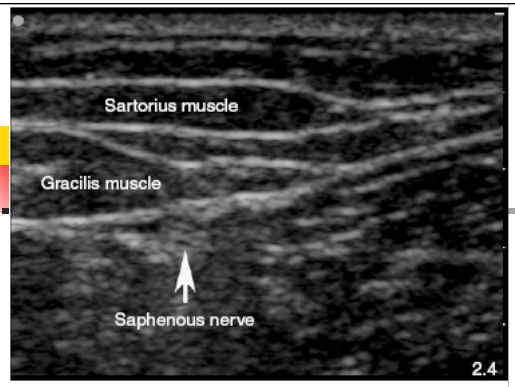
BJA

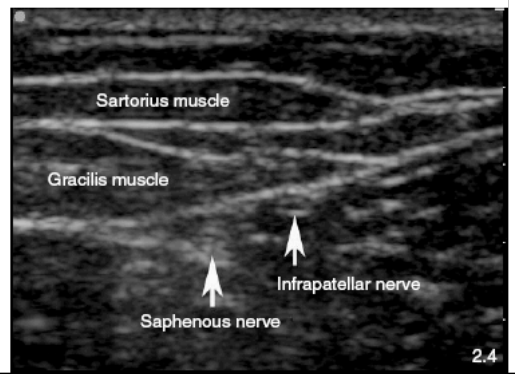
Ultrasound-guided infrapatellar nerve block in human volunteers: description of a novel technique†

M. Lundblad[1], S. Kapral[2], P. Marhofer[2] and P.-A. Lönnqvist[1]*

[1]Department of Paediatric Anaesthesia and Intensive Care, Astrid Lindgrens Children's Hospital, Karolinska University Hospital, Stockholm, Sweden. [2]Department of Anaesthesia and Intensive Care, AKH University Hospital, Vienna, Austria

**Corresponding author: Department of Paediatric Anaesthesia and Intensive Care, Astrid Lindgrens Children's Hospital, Karolinska University Hospital, SE-171 76 Stockholm, Sweden. E-mail: per-arne.lonnqvist@karolinska.se*





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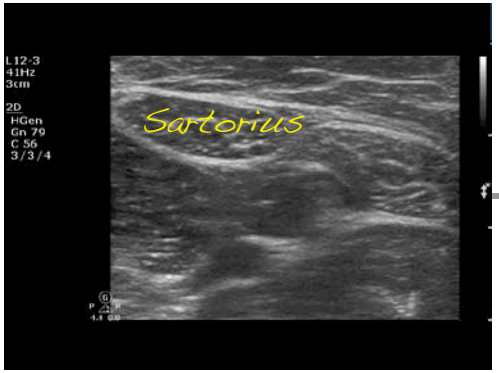

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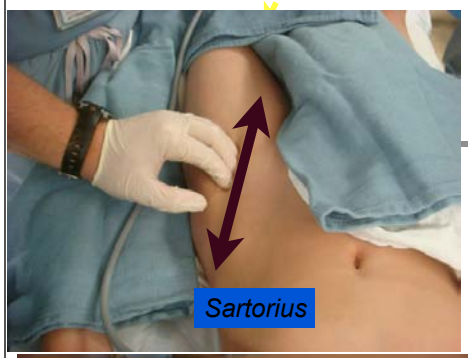
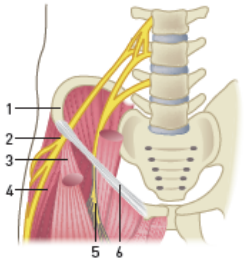
Total volume of local anesthetic solution: 2 to 3 mL

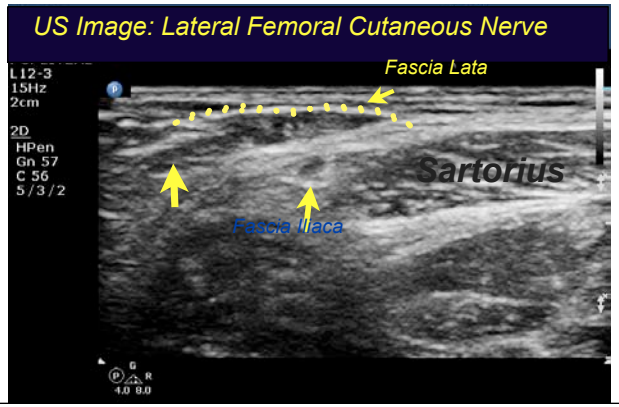
Lateral Femoral Cutaneous Nerve Block

- Graft for sling procedures of the eye.
- SCFE pinning.
- Pin and plate removal.





1 anterior superior iliac spine
2 lateral femoral cutaneous n.
3 sartorius m.
4 tensor fasciae latae m.
5 femoral n.
6 inguinal ligament


US Image: Lateral Femoral Cutaneous Nerve
L12-3
15Hz
2cm
2D
HPen
Gn 57
C 56
5/3/2
Fascia Lata
Sartorius
Fascia Iliaca

Sciatic Nerve Block

- Useful for procedures that involve foot and ankle surgery
- A lateral approach is easy and fast and can be used for procedures on the hip
- Useful for fascia lata grafts harvesting

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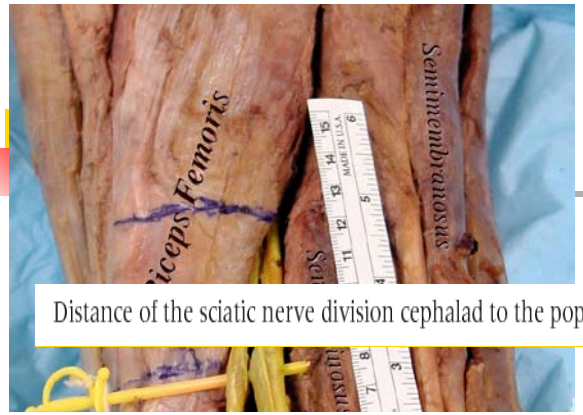
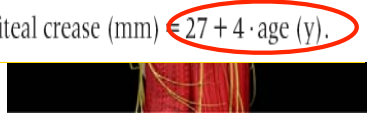
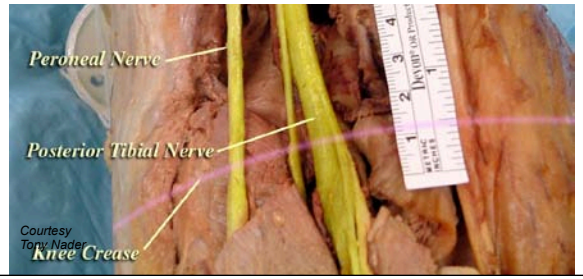


Distance of the sciatic nerve division cephalad to the popliteal crease (mm) = $27 + 4 \cdot \text{age (y)}$.



Regional Anesthesia and Pain Medicine, Vol 32, No 4 (July–August), 2007: pp 351–353

Suresh, Simion, Myers



Courtesy Tom Nater

Ultrasonographic Guidance for Sciatic and Femoral Nerve Blocks in Children

Oberndofer U, Marhofer P,
Bosenberg A, Willschke H et al

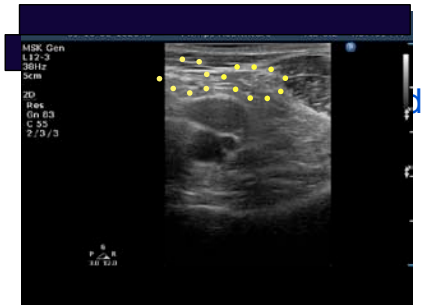
Br J Anaesth 2007; 98:797-801

The Sciatic Nerve and Knee Arthroplasty

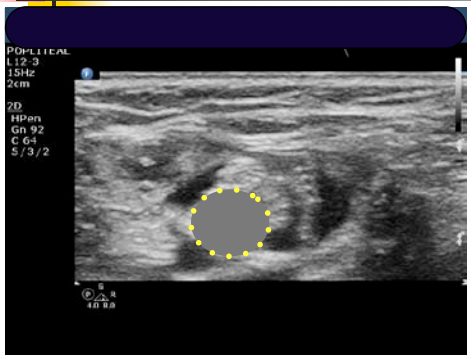
To Block, or Not to Block—That Is the Question

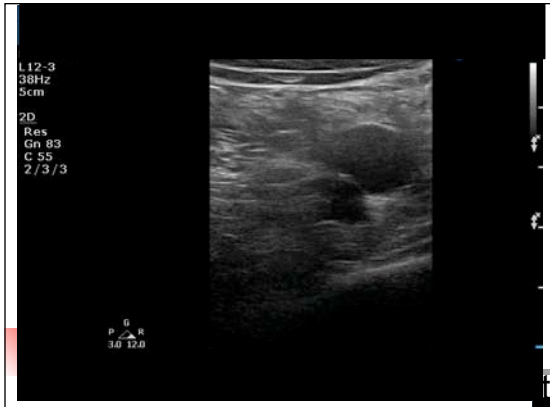
Brian M. Ilfeld, MD, MS and Sarah J. Madison, MD

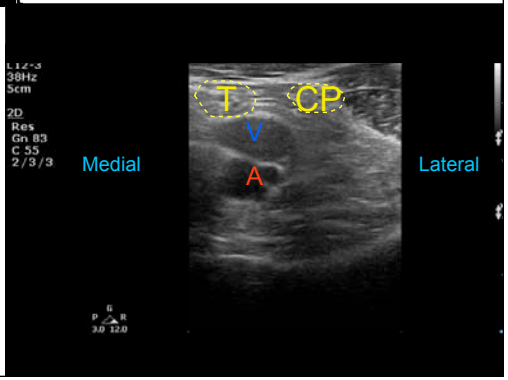
Regional Anesthesia and Pain Medicine • Volume 36, Number 5, September-October 2011



0.2mL/kg local anesthetic solution







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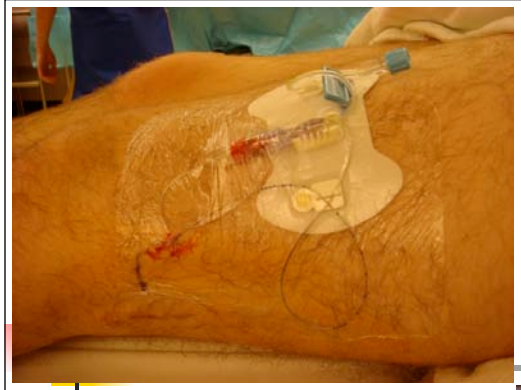

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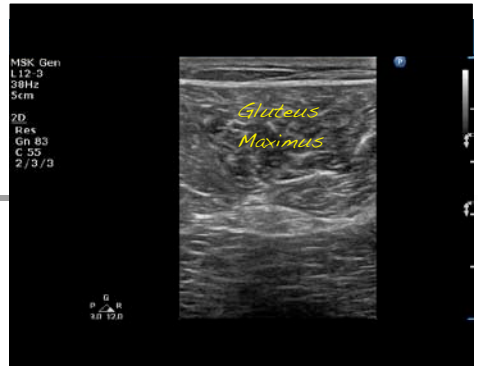
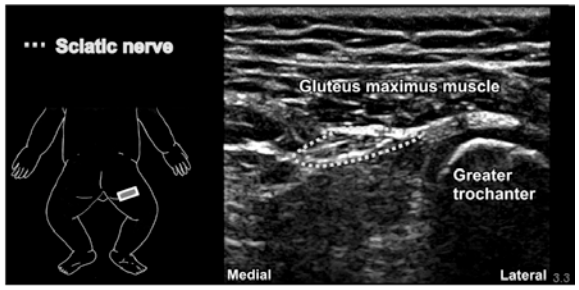
Home Discharge with disposable infusion pumps





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Tsui BC, Suresh S, Anesthesiology 2010,112; 473-92

Truncal Blocks

Ilioinguinal/iliohypogastric

Rectus sheath

Transversus abdominis plane (TAP) block

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Indications
Single incision laparoscopic surgery
Umbilical hernia repair

British Journal of Anaesthesia 97 (2): 244–9 (2006)
doi:10.1093/bja/ael143 Advance Access publication June 23, 2006

BJA

Ultrasonography-guided rectus sheath block in paediatric anaesthesia—a new approach to an old technique†

H. Willschke[1]*, A. Bösenberg[2], P. Marhofer[1], S. Johnston[2], S. C. Kettner[1], O. Wanzel[3] and S. Kapral[1]

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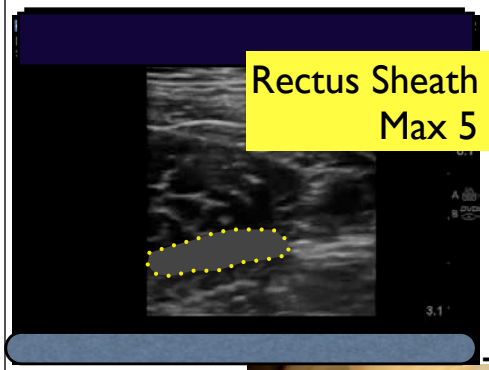
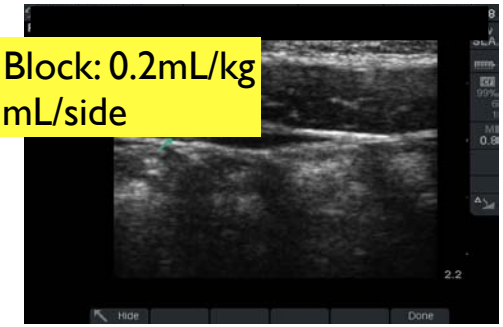
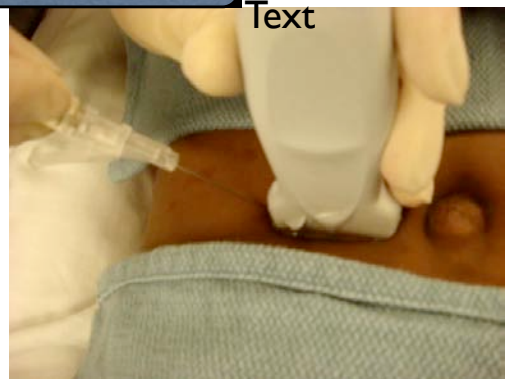


Rectus Sheath Block: 0.2mL/kg
Max 5 mL/side



Text



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Ilioinguinal & Iliohypogastric

- Inguinal hernia repair.
- Iliac crest bone graft.
- Patients who are not suitable for caudal blocks.
- Patients with coagulation abnormalities.

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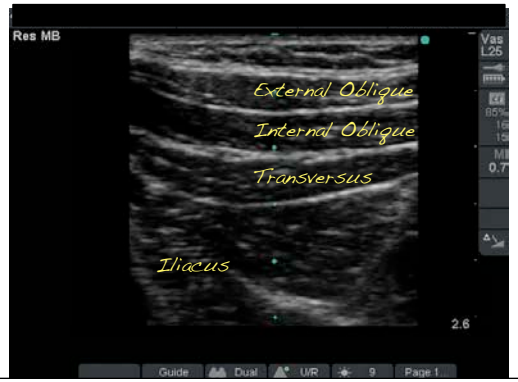
Performing Blocks we never used to do routinely

Colonic Puncture:

these blocks can lead to colonic or small bowel puncture, or pelvic hematoma if US guidance is not used.

Ilioinguinal block Complication

Ilioinguinal Nerve Block
0.1mL/kg local anesthetic solution.



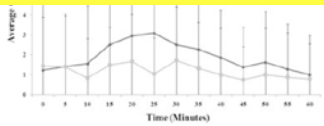
Pediatric Anesthesia
Pediatric Anesthesia 2009 19: 892–898 doi:10.1111/j.1460-9592.2009.03092.x

Unilateral groin surgery in children: will the addition of an ultrasound-guided ilioinguinal nerve block enhance the duration of analgesia of a single-shot caudal block?

NARASIMHAN JAGANNATHAN MD*, LISA SOHN MD*, AMOD SAWARDEKAR MD*, ANDREW AMBROSY BS*, JENNIFER HAGERTY DO†, ANTHONY CHIN MD‡, KATHLEEN BARSNESS MD‡ AND SANTHANAM SURESH MD*

*Department of Pediatric Anesthesiology †The Division of Pediatric Urology and ‡Pediatric Surgery, Children's Memorial Hospital, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

Additional US Guided Ilioinguinal Block improved pain control postoperatively for Inguinal hernia Surgery



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Postoperative Pain Control in Children Undergoing Laparoscopic Appendectomy: Comparison of US Guided Peripheral Nerve Blocks to Local Anesthetic Infiltration Analgesia

Sohn L, Voronov P, Sawardekar A,
Jagannathan N, Suresh S

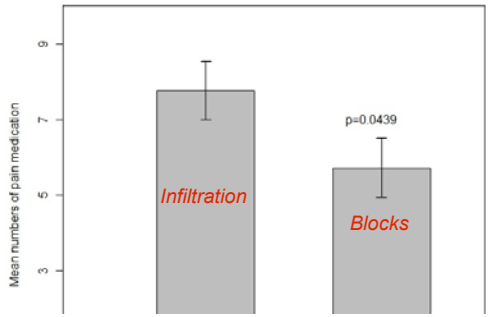
Children's Memorial Hospital, Northwestern University

Chicago, IL

ASA 2010 Abstract

US guided blocks vs Local Infiltration

- Pain scores were reduced in the US guided blocks group
- Rescue medications were decreased in the US guided block group



Sohn et al, ASA 2010

The Analgesic Efficacy of Transversus Abdominis Plane Block After Abdominal Surgery: A Prospective Randomized Controlled Trial

John G. McDonnell, MB, FCARCSI*†

Brian O'Donnell, MB, FCARCSI†

Gerard Curley, MB*

Anne Heffernan, MB, FCARCSI†

Camillus Power, MD, FCARCSI†

John G. Laffey, MD, MA, FCARCSI*‡

BACKGROUND: The transversus abdominis plane (TAP) block is a novel approach for blocking the abdominal wall neural afferents via the bilateral lumbar triangles of Petit. We evaluated its analgesic efficacy in patients during the first 24 postoperative hours after abdominal surgery, in a randomized, controlled, double-blind clinical trial.

METHODS: Thirty-two adults undergoing large bowel resection via a midline abdominal incision were randomized to receive standard care, including patient-controlled morphine analgesia and regular nonsteroidal antiinflammatory drugs and acetaminophen ($n = 16$), or to undergo TAP block ($n = 16$) in addition to standard care ($n = 16$). After induction of anesthesia, 20 mL of 0.375% levobupivacaine was deposited into the transversus abdominis neuro-fascial plane via the bilateral lumbar triangles of Petit. Each patient was assessed by a blinded investigator in the postanesthesia care unit and at 2, 4, 6, and 24 h postoperatively.

RESULTS: The TAP block reduced visual analog scale pain scores (TAP versus control, mean ± SD) on emergence (1 ± 1.4 vs 6.6 ± 2.8, $P < 0.05$), and at all postoperative time points, including at 24 h (1.7 ± 1.7 vs 3.1 ± 1.5, $P < 0.05$). Morphine requirements in the first 24 postoperative hours were also reduced (21.9 ± 8.9 mg vs 80.4 ± 19.2 mg, $P < 0.05$). There were no complications attributable to the TAP block. All TAP patients reported high levels of satisfaction with their postoperative analgesic regimen.

CONCLUSIONS: The TAP block provided highly effective postoperative analgesia in the first 24 postoperative hours after major abdominal surgery.

(Anesth Analg 2007;104:193–7)

Pediatric Anesthesia 2009 **19**: 296–299 doi:10.1111/j.1460-9592.2009.02958.x

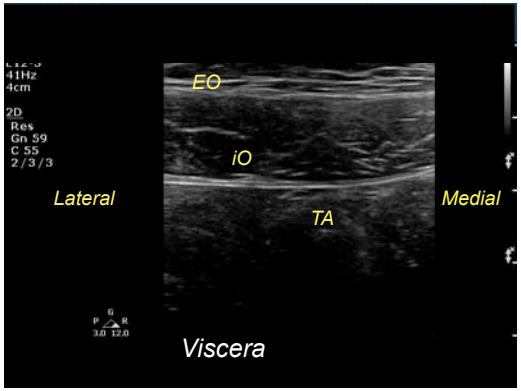
Review article

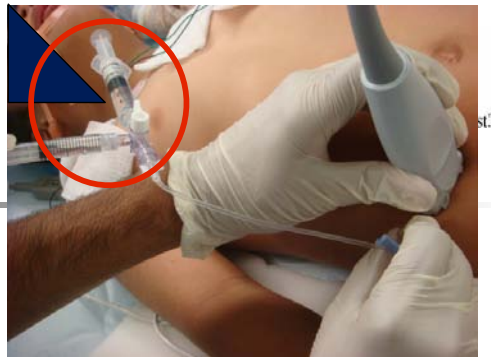
Ultrasound guided transversus abdominis plane block in infants, children and adolescents: a simple procedural guidance for their performance

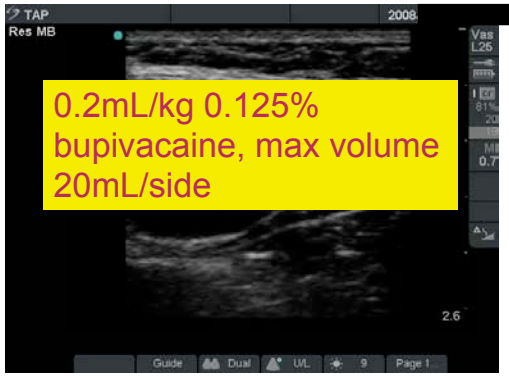
SANTHANAM SURESH MD FAAP* AND VINCENT W.S. CHAN MD FRCPC†

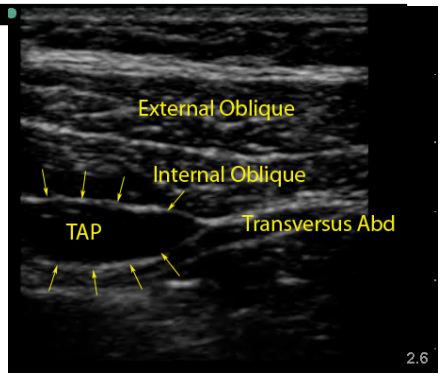
*Children's Memorial Hospital, Northwestern University, Feinberg School of Medicine, Chicago, IL, USA and †Department of Anesthesia, University of Toronto, Toronto, ON, Canada

US scanning of abdominal wall
Scanning medial to lateral






TAP
Res MB
2008
Vas
L25
0.2mL/kg 0.125% bupivacaine, max volume 20mL/side
2.6
Guide
Dual
UVL
9
Page 1

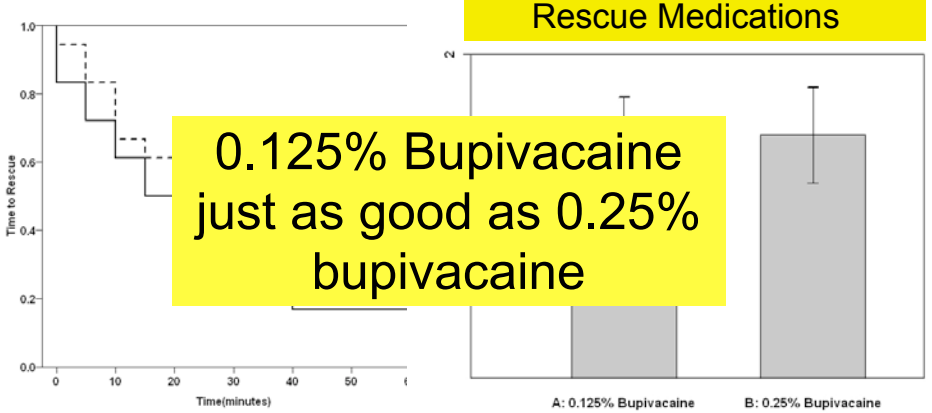

External Oblique
Internal Oblique
TAP
Transversus Abd
2.6

Concentration & Volume of Local Anesthetic Solution for TAP Blocks

- Total volume used 1mL/kg divided between the two sides.
- Concentration of local anesthetic solution: 0.125% bupivacaine.
- Subcostal for upper abdominal surgery
- Above the iliac crest for lower abdominal surgery.

Pharmacodynamics of Bupivacaine for TAP block in Children

Rescue Medications



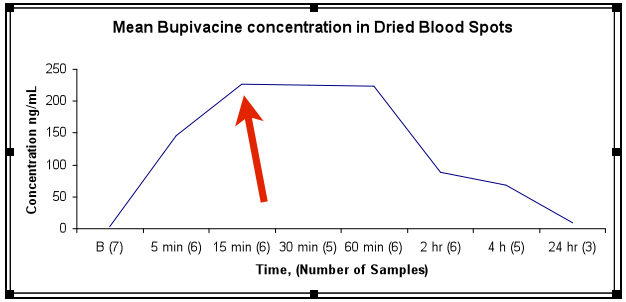
0.125% Bupivacaine just as good as 0.25% bupivacaine

Taylor L, Suresh et al
FAER MSARP Submission, ASA 2010

Single -Dose Pharmacokinetics of Bupivacaine following TAP Block in Neonates

Cambic A, Birmingham PK, Hall SC, Galinkin J, Suresh S

Abstract: ASA 2011, A830



Pediatric Anesthesia

Pediatric Anesthesia 2010 **20**: 951–954 doi:10.1111/j.1460-9592.2010.03414.x

Case Report

Children with spinal dysraphism: transversus abdominis plane (TAP) catheters to the rescue!

LAUREN J. TAYLOR BA, PATRICK BIRMINGHAM MD, ELIZABETH YERKES MD AND SANTHANAM SURESH MD

Department of Pediatric Anesthesiology and Division of Pediatric Urology, Children's Memorial Hospital, Northwestern University's Feinberg School of Medicine, Chicago, IL, USA

Section Editor: Allison Ross

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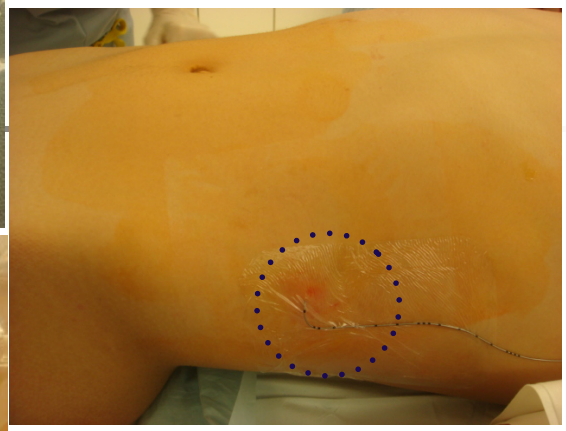

TAP Catheters

Advanced Blocks

- Paravertebral blocks.
- Lumbar plexus blocks.
- US aided epidural analgesia.
- Pudendal nerve block
- Obturator nerve block.
- .

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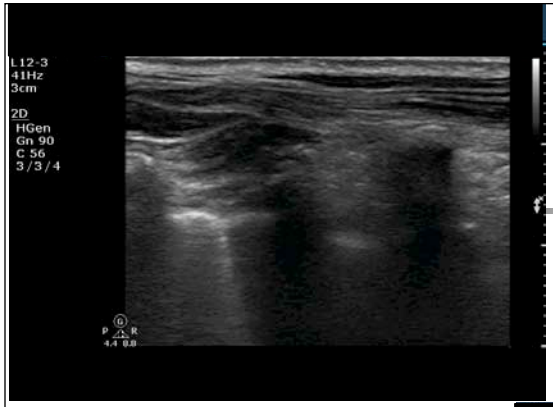

Paramedian Scan Thoracic Paravertebral Space

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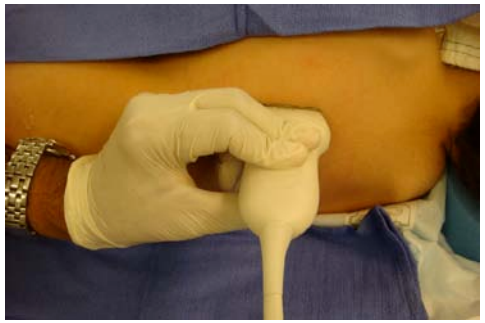
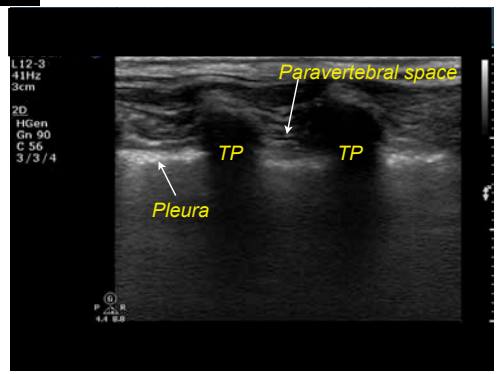
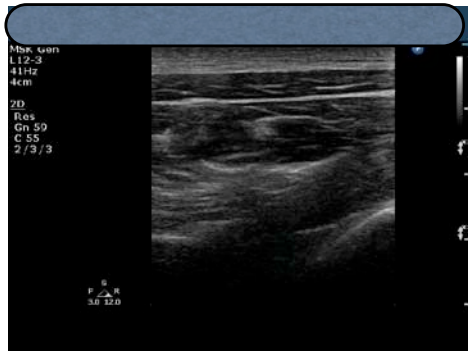
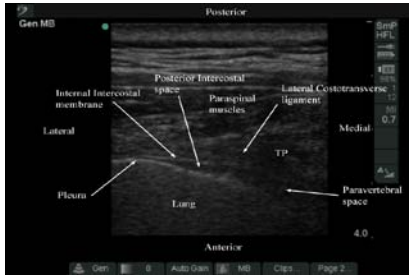
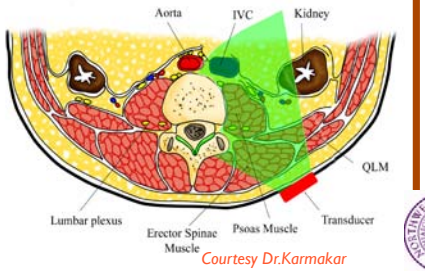




Paravertebral Space
Paramedian Transverse Oblique Scan







Courtesy Dr.Karmakar

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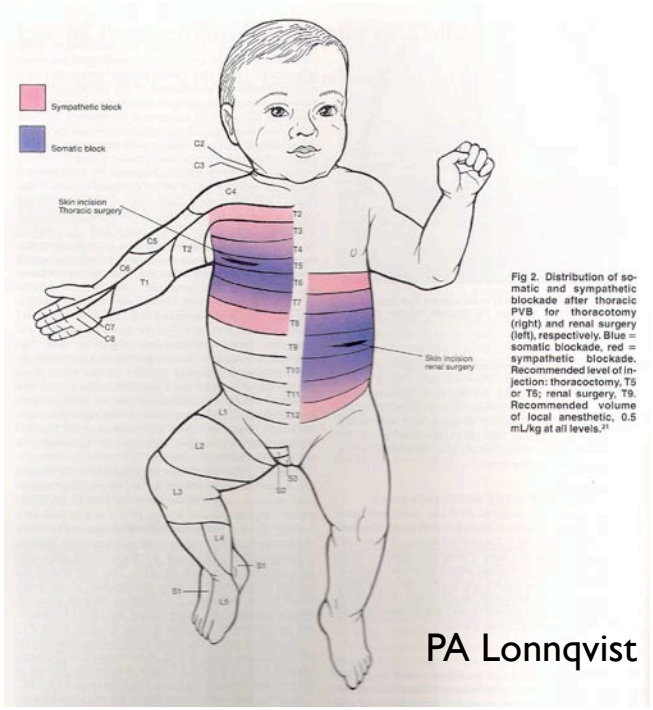


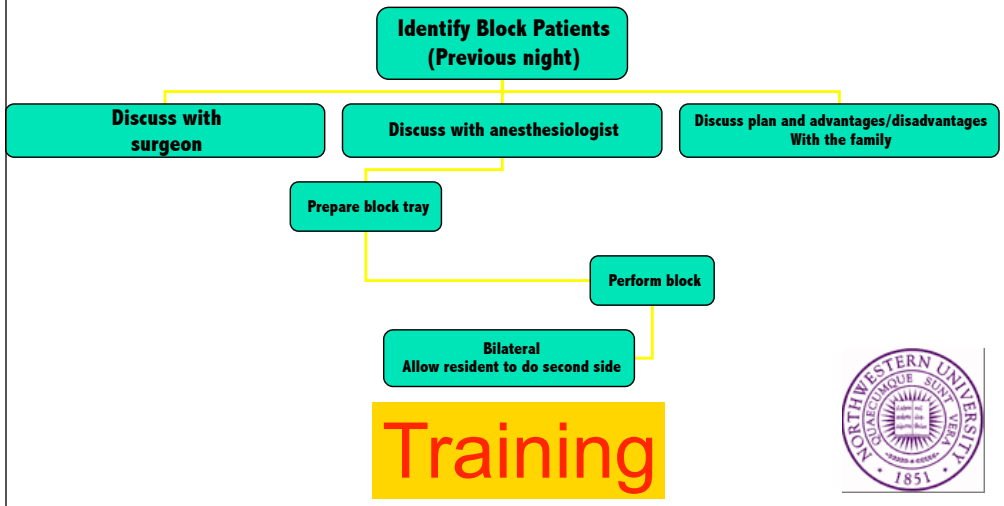
Fig 2. Distribution of somatic and sympathetic blockade after thoracic PVB for thoracotomy (right) and renal surgery (left), respectively. Blue = somatic blockade, red = sympathetic blockade. Recommended level of injection: thoracoctomy, T5 or T5; renal surgery, T9. Recommended volume of local anesthetic, 0.5 mL/kg at all levels.[21]

PA Lonnqvist

Peripheral Nerve block catheters

- Femoral catheters
- Infraclavicular/Interscaene catheters
- Ilioinguinal catheters
- TAP catheters

Pediatric Peripheral Nerve Block Rotation



Training

Billing for Blocks: ASA Relative Value Guide

Block	Type	CPT	Unit
Brachial plexus	Single injection	64415	8
Axillary	Single injection	64417	8
Sciatic	Single injection	64445	7
Femoral	Single injection	64447	7
Brachial plexus	Catheter	64416	13
Sciatic	Catheter	64446	12
Femoral	Catheter	64448	12

Use the 59 modifier for postoperative pain

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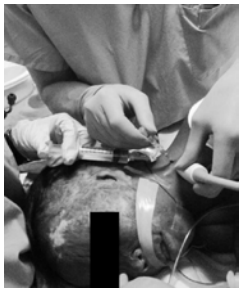
Pediatric Anesthesia 2008 doi:10.1111/j.1460-9592.2008.02633.x

Feasibility of ultrasound-guided peripheral nerve block catheters for pain control on pediatric medical missions in developing countries

EDWARD R. MARIANO MD*, BRIAN M. ILFELD MD MS*, GLORIA S. CHENG MD*, HECTOR F. NICODEMUS MD† AND SANTHANAM SURESH MD FAAP‡§

*Department of Anesthesia, University of California, San Diego Medical Center, San Diego, CA, †Holy Cross Hospital, Silver Spring, MD, ‡Department of Anesthesiology and Pediatrics, Northwestern University, Feinberg School of Medicine and §Department of Anesthesia, Children's Memorial Hospital, Chicago, IL, USA



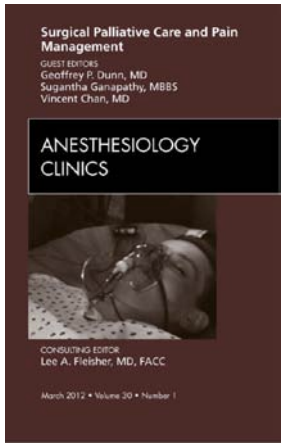
Exciting New Developments in Pediatric Regional Anesthesia

- Improved analgesia with greater accuracy
- Decreased dosing with better pharmacodynamic models
- Potential for longer acting regional blocks
- Improved care by use of regional anesthesia catheters

Pediatric Pain Management

Santhanam Suresh, MD*, Patrick K. Birmingham, MD, Ryan J. Kozlowski, BS

Anesthesiology Clin 30 (2012) 101–117



Will Nerve Stimulation become a Relic?


ssuresh@luriechildrens.org