

# Regional Anesthesia for Extremity Surgery

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# Disclosures

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No financial disclosures or conflicts of interest

# Objectives

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- Discuss in brief the pharmacology of local anesthetics
- Discuss the anatomy of the brachial plexus
- Discuss the anatomy of the lumbar plexus
- Discuss the anatomy of the sacral plexus
- Discuss cutaneous sensory innervation of the arm
- Discuss distal cutaneous sensory innervation of the leg
- Discuss the different types of peripheral nerve blocks
- Discuss area of expected analgesia/anesthesia with each block

# Local Anesthetic Pharmacology

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Local anesthetics can be broadly classified into several groups

	<b>Analgesic Concentration</b>	<b>Anesthetic Concentration</b>
Long Acting	Bupivacaine 0.25% Ropivacaine 0.2%	Bupivacaine 0.5% Ropivacaine 0.5%
Intermediate Acting	Lidocaine 1% Mepivacaine 1%	Lidocaine 2% Mepivacaine 1.5%

# Local Anesthetic Pharmacology

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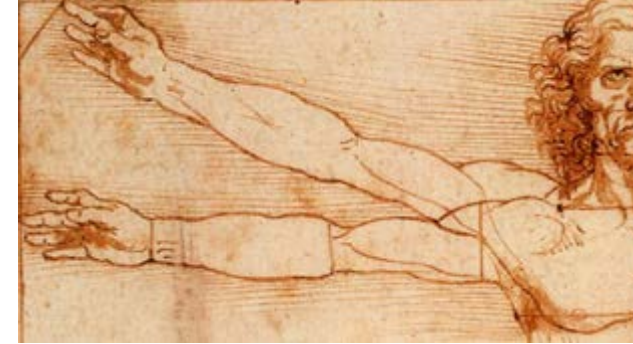
Drug (plain)	Onset	Duration of Action
Bupivacaine	20-30 mins	6 – 12 hrs
Ropivacaine	20-30 mins	6 – 12 hrs
Lidocaine	10-20 mins	2 – 4 hrs
Mepivacaine	10-20 mins	2 – 4 hrs

# Local Anesthetic Pharmacology

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- Adjuvants to local anesthetics
  - Vasoconstrictors: Epinephrine
    - Decreases vascular uptake
    - Improves depth and duration of anesthesia
    - Serves as an intravascular marker
  - Clonidine
    - May prolong duration of block
    - Has both vasoconstrictor and direct peripheral nerve effect
    - More pronounced increase in duration with intermediate acting local anesthetics
  - Dexamethasone
    - Improves analgesic duration.
  - Buprenorphine
    - Improves analgesic duration.
    - Possibly mediated via peripheral opioid receptors and possible intrinsic local-anesthetic-like ability to block voltage gated Na<sup>+</sup> channels
    - Also has antihyperalgesic effects

# Upper Extremity Surgery



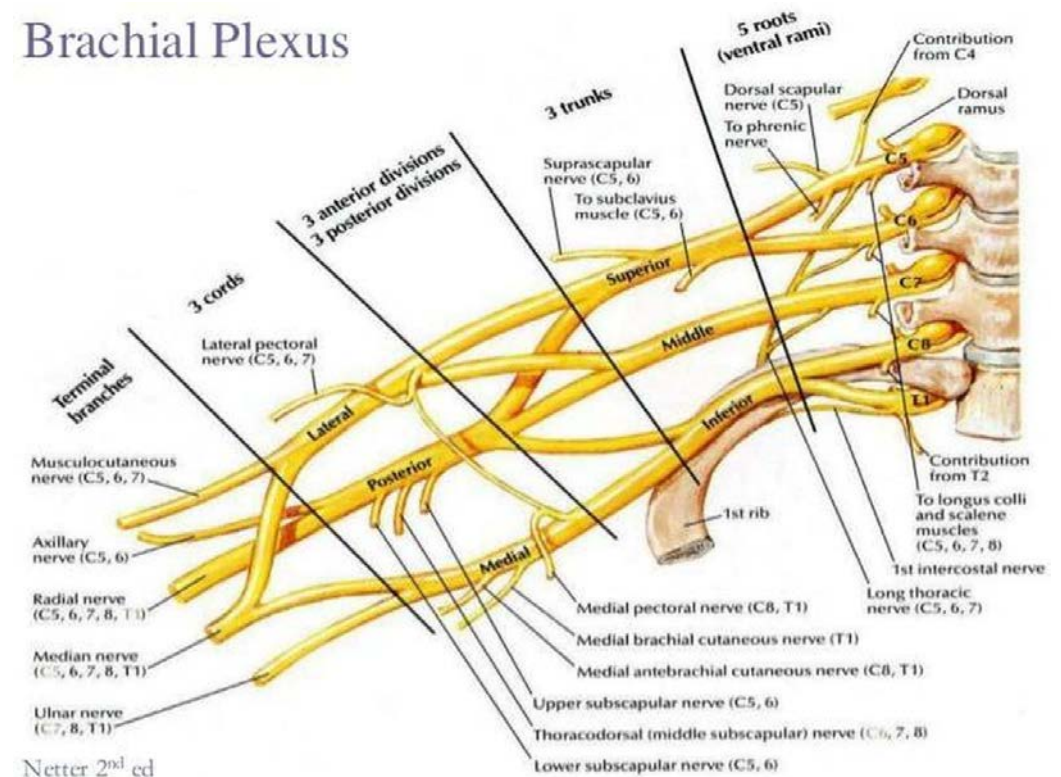
What is the location of the surgery

What skin, muscle, and bony components will be involved

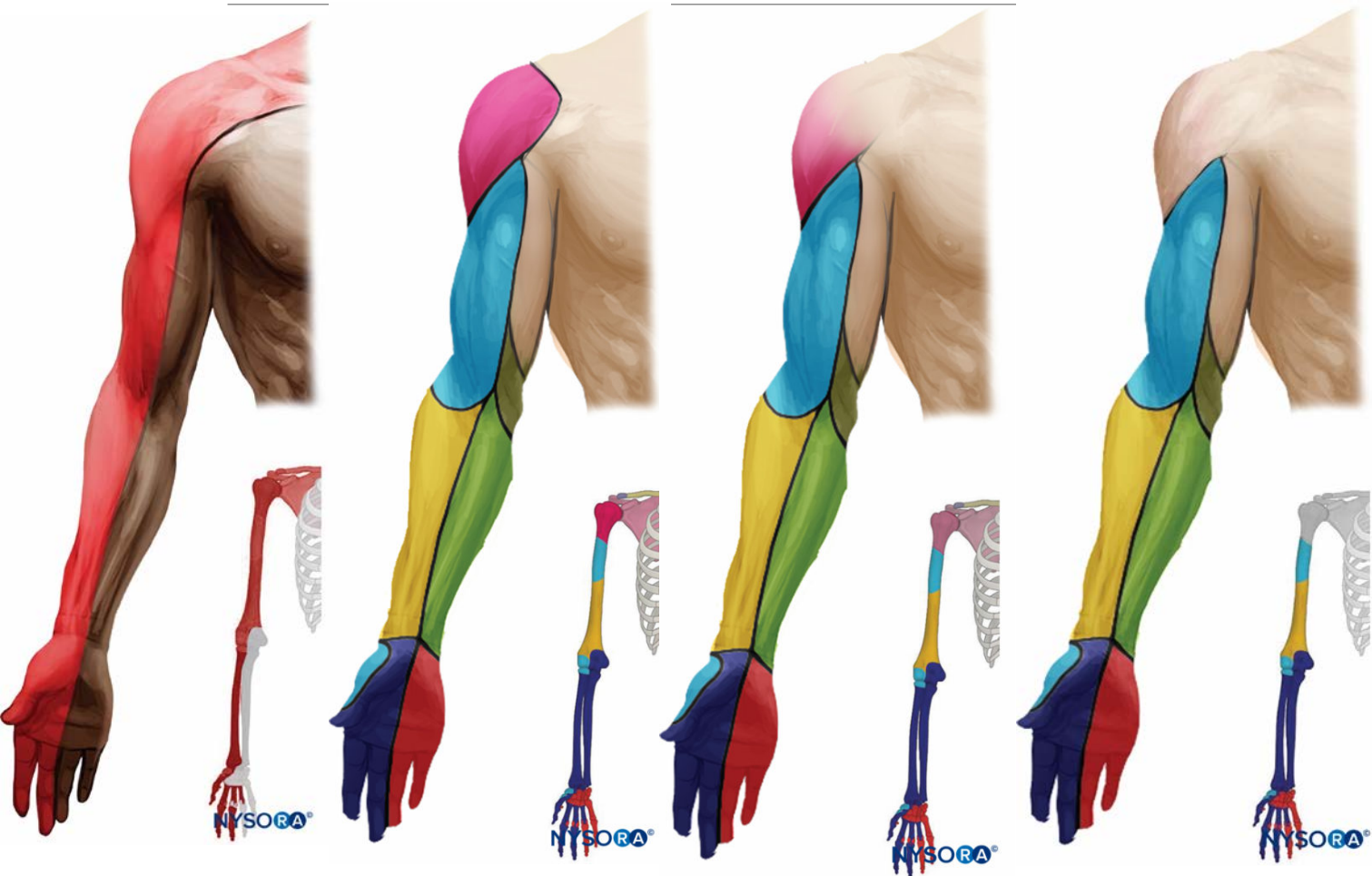
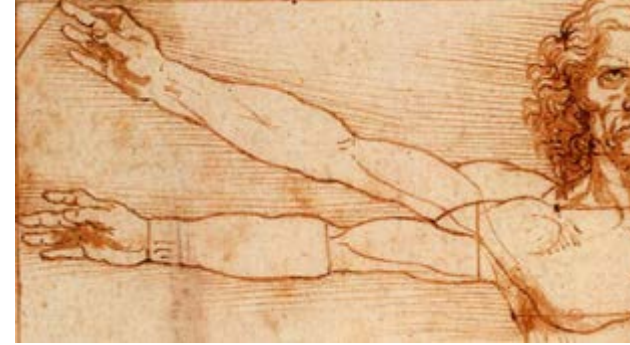
Which nerves are involved when answering the above questions

Does my patient have any medical issues that would preclude “standard” blocks

Brachial Plexus



# “-Tomes”



Interscalene

Supraclavicular

Infraclavicular

Axillary

## Sensory innervation of the human shoulder joint: the three bridges to break

Pierre Laumonerie<sup>1</sup>, Yoann Dalmas<sup>2</sup>, Meagan E Tibbo<sup>3</sup>, Suzanne Robert<sup>2</sup>, Marie Faruch<sup>4</sup>, Patrick Chaynes<sup>5</sup>, Nicolas Bonneville<sup>2</sup>, Pierre Mansat<sup>2</sup>

Affiliations + expand  
PMID: 32712453 DOI: 10.1016/j.jse.2020.07.017

### Abstract

**Background:** Painful shoulders create a substantial socioeconomic burden and significant diagnostic challenge for shoulder surgeons. Consensus with respect to the anatomic location of sensory nerve branches is lacking. The aim of this literature review was to establish consensus with respect to the anatomic features of the articular branches (ABs) (1) innervating the shoulder joint and (2) the distribution of sensory receptors about its capsule and bursae.

**Materials and methods:** Four electronic databases were queried, between January 1945 and June 2019. Thirty original articles providing a detailed description of the distribution of sensory receptors about the shoulder joint capsule (13) and its ABs (22) were reviewed.

**Results:** The suprascapular, lateral pectoral, axillary, and lower subscapular nerves were found to provide ABs to the shoulder joint. The highest density of nociceptors was found in the subacromial bursa. The highest density of mechanoreceptors was identified within the insertion of the glenohumeral ligaments. The most frequently identified innervation pattern comprised 3 nerve bridges (consisting of ABs from suprascapular, axillary, and lateral pectoral nerves) connecting the trigger and the identified pain generator areas rich in nociceptors.

**Conclusion:** Current literature supports the presence of a common sensory innervation pattern for the human shoulder joint. Anatomic studies have demonstrated that the most common parent nerves supplying ABs to the shoulder joint are the suprascapular, lateral pectoral, and axillary nerves. Further studies are needed to assess both the safety and efficacy of selective denervation of the painful shoulders, while limiting the loss of proprioceptive function.

**Keywords:** Anatomy; denervation; joint innervation; nerve; pain; review; shoulder joint.



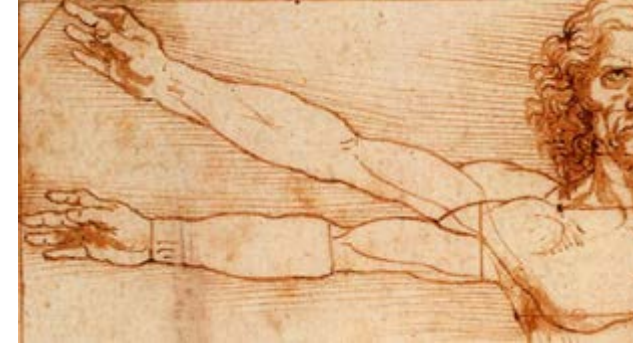
# Shoulder Surgery: ISB

Indications: Rotator cuff repair, shoulder arthroscopy, total shoulder arthroplasty. Also applicable for proximal humerus operations

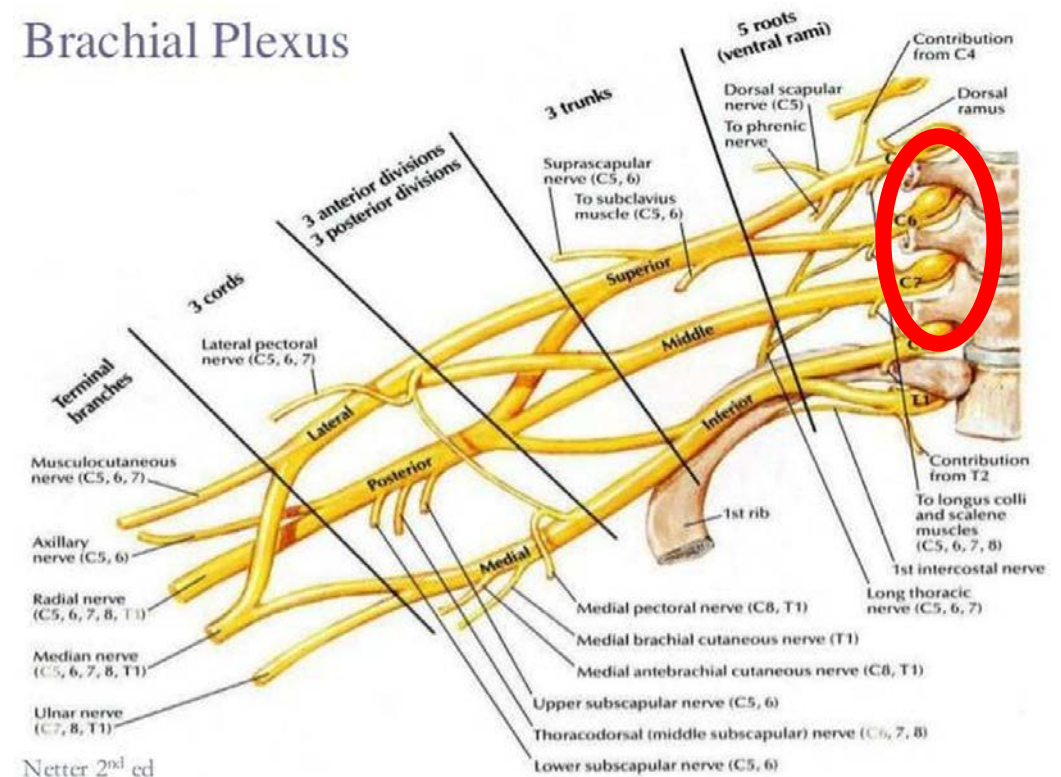
Contraindications: severe pulmonary cripple, contralateral phrenic nerve or RLN palsy, patient refusal, infection over site of block placement

Considerations: 100% blockade of phrenic nerve, ptosis/Horner's syndrome, hoarseness (RLN)

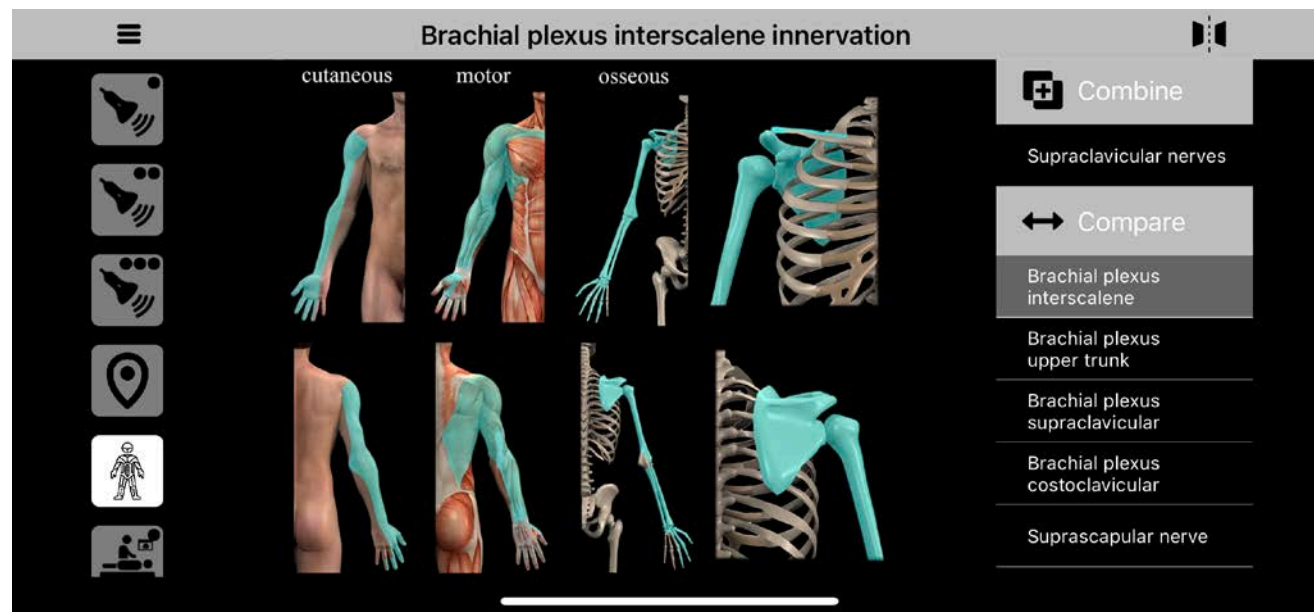
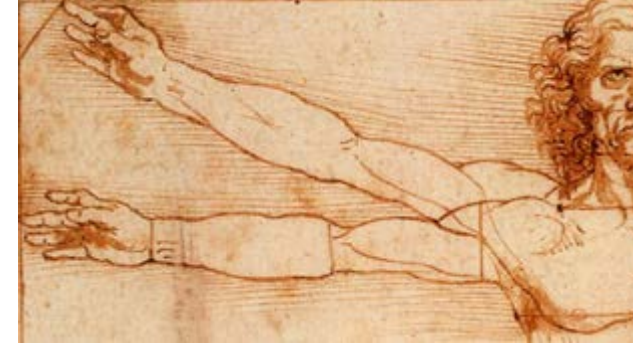
Complications: dyspnea, vessel puncture, IV injection, intrathecal/epidural injection, motor weakness



Brachial Plexus

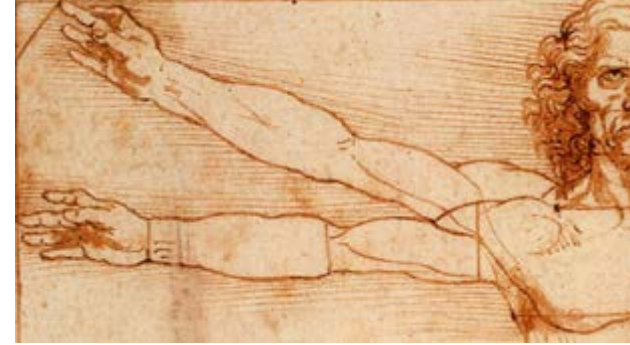


# Shoulder Surgery: ISB



- Anatomic studies have demonstrated that the most common parent nerves supplying articular branches to the shoulder joint are the suprascapular (C5, 6), lateral pectoral (C5, 6, 7), and axillary (C5, 6) nerves, all of which are covered in an interscalene block.
- Coverage can be accomplished with single shot or catheter placement

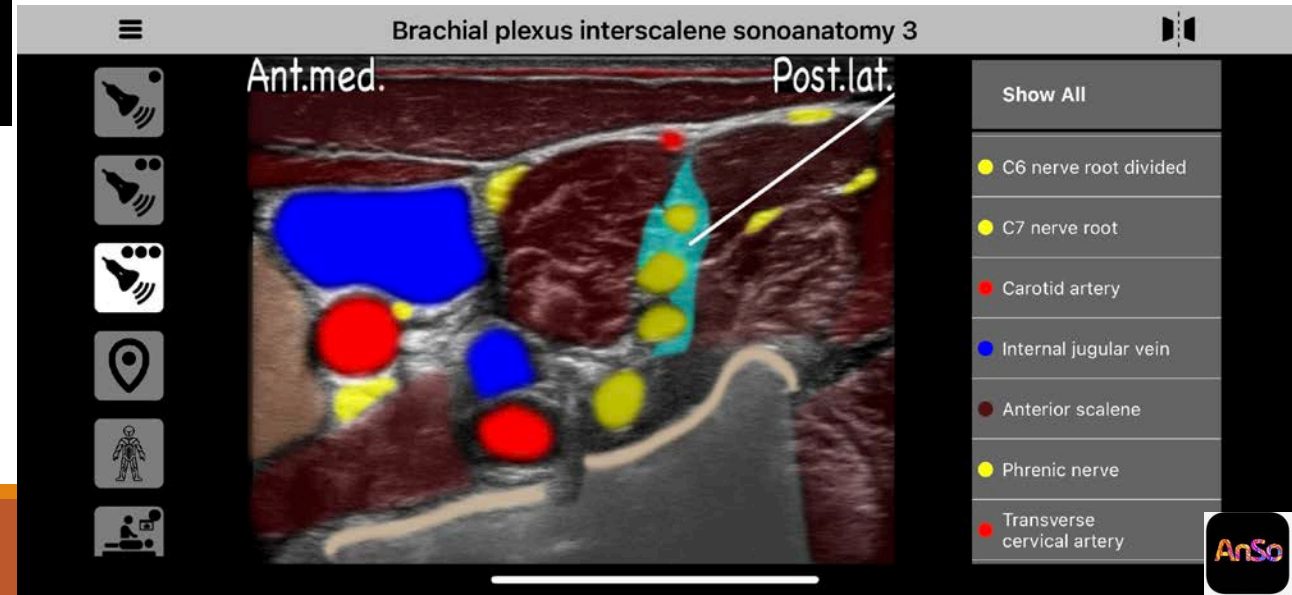
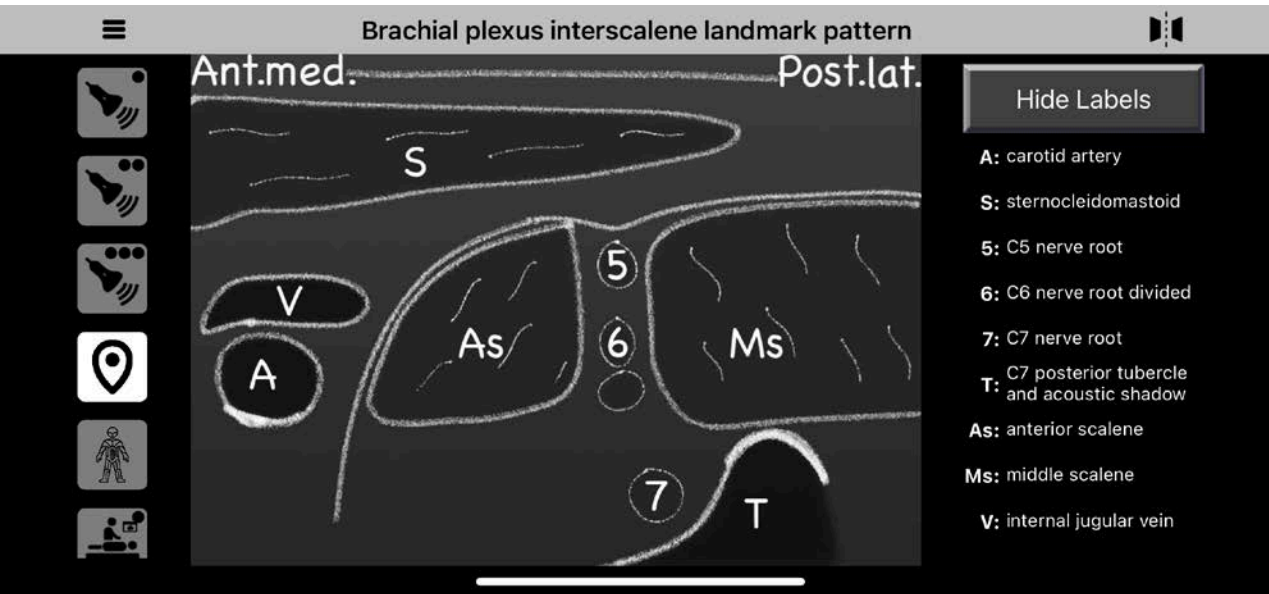
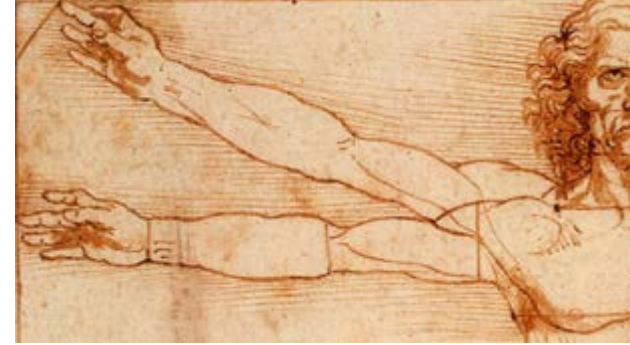
# Shoulder Surgery: ISB



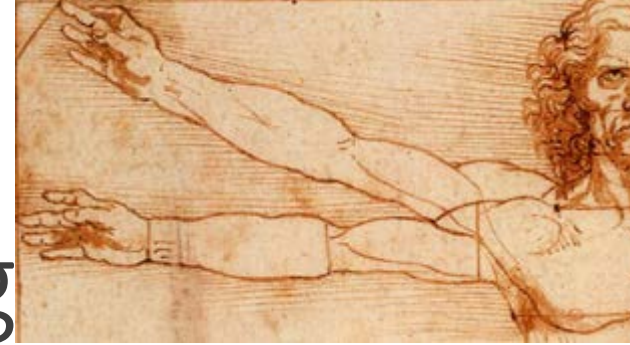
Brachial plexus interscalene ergonomics 2

The video player interface includes a menu icon (three horizontal lines) on the top left, a volume icon (two vertical bars) on the top right, and a vertical toolbar on the left side with the following icons from top to bottom: a hand with a signal wave, a location pin, a human figure with a skeletal overlay, two identical icons of a person with a skeletal overlay, and a list icon.

# Shoulder Surgery: ISB



# Shoulder Surgery: Phrenic Sparing



Suprascapular nerve anterior innervation

cutaneous motor osseous

Combine

Axillary nerve

Supraclavicular BP

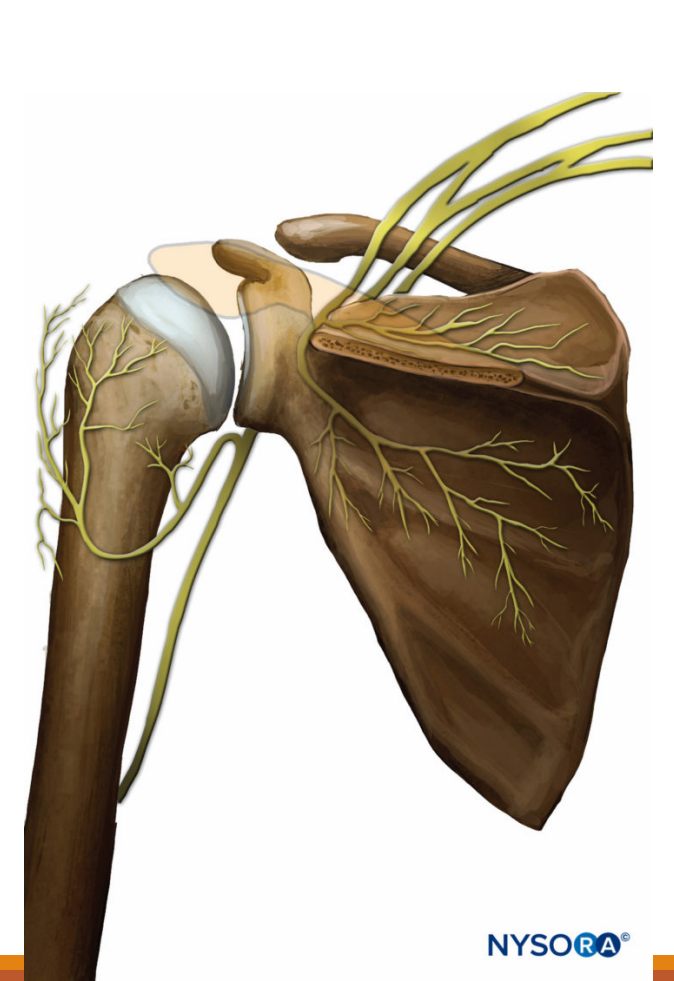
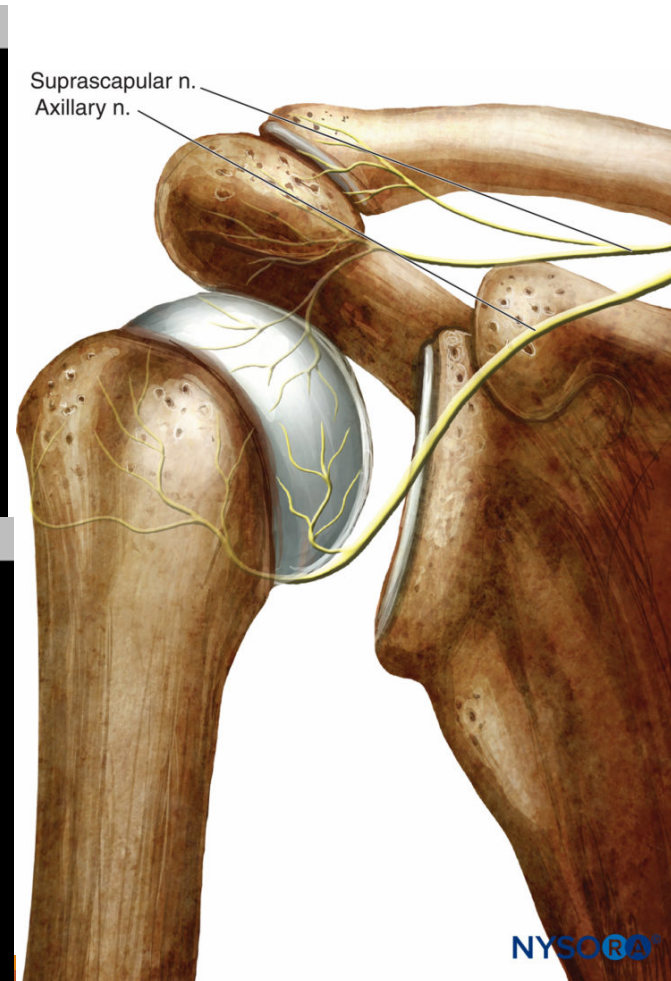
Compare

Suprascapular nerve

Brachial plexus interscalene

Brachial plexus costoclavicular

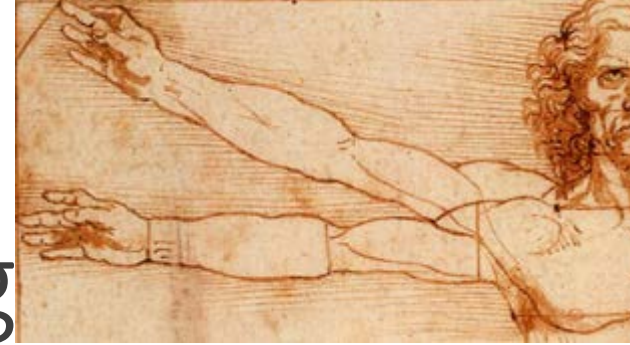
Brachial plexus infraclavicular

An anatomical software interface titled "Suprascapular nerve anterior innervation". It features a grid of eight small images showing different views of the shoulder and upper arm, categorized into "cutaneous", "motor", and "osseous". To the right of the grid is a control panel with buttons for "Combine", "Compare", and a list of anatomical structures: "Axillary nerve", "Supraclavicular BP", "Suprascapular nerve", "Brachial plexus interscalene", "Brachial plexus costoclavicular", and "Brachial plexus infraclavicular".

Suprascapular nerve anterior ergonomics

A photograph of a patient lying on a table, with a medical professional performing an ultrasound on their shoulder. The patient is wearing a blue surgical cap and a blue gown. The medical professional is wearing blue gloves and is using a handheld ultrasound device. A monitor in the background displays the ultrasound image.

# Shoulder Surgery: Phrenic Sparing



Suprascapular nerve anterior landmark pattern

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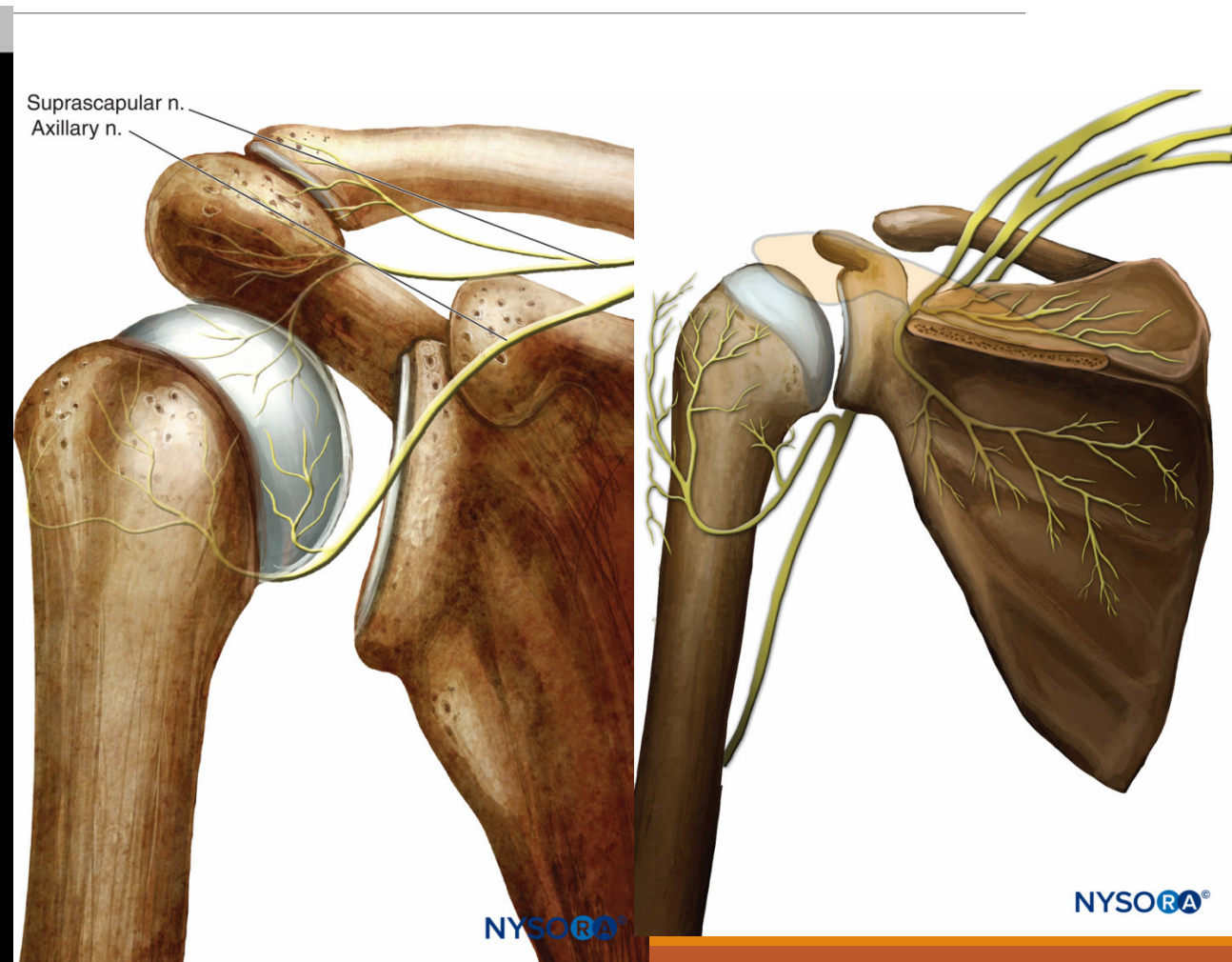
Hide Labels

- N: suprascapular nerve
- O: omohyoid
- A: subclavian artery
- BP: brachial plexus
- R: ribs and acoustic shadow
- P: pleura and lung artefact
- Sm: middle scalene
- S: serratus anterior

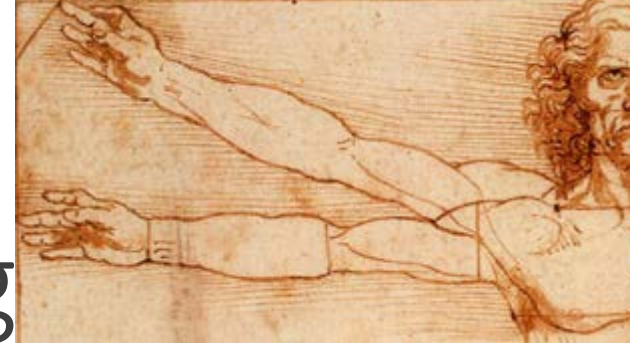
Show All

- Needle path
- LA
- Suprascapular nerve
- Subclavian artery
- Brachial plexus
- Omohyoid
- First rib cortex

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# Shoulder Surgery: Phrenic Sparing



Suprascapular nerve posterior innervation

cutaneous motor osseous

Combine

Axillary nerve

Compare

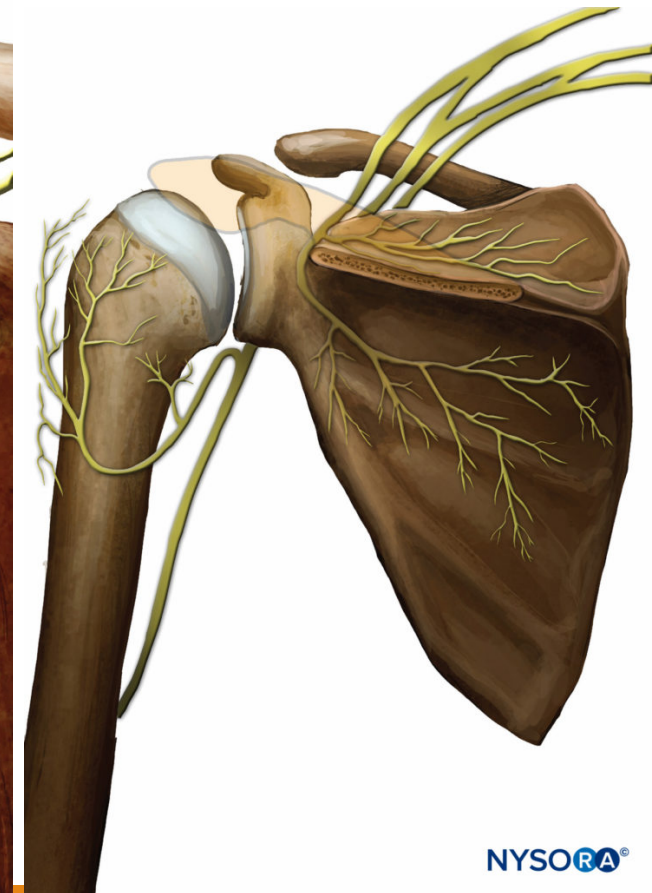
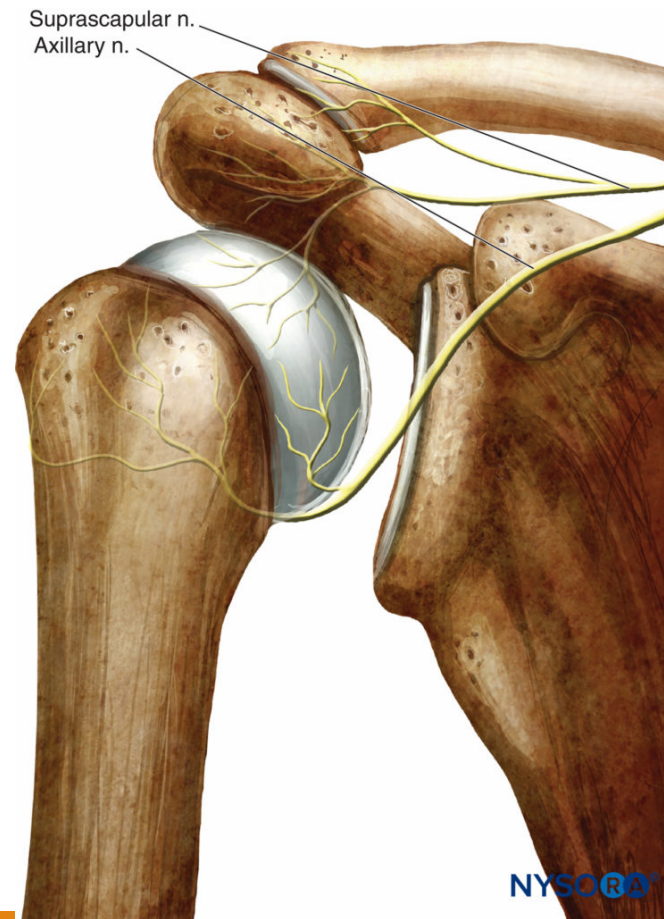
Suprascapular nerve

Brachial plexus interscalene

Brachial plexus supraclavicular

Brachial plexus costoclavicular

Brachial plexus infraclavicular

A screenshot of a medical software interface. The top section is titled "Suprascapular nerve posterior innervation" and features three columns of anatomical images labeled "cutaneous", "motor", and "osseous". To the right of these images are several interactive buttons: "Combine", "Axillary nerve", "Compare", "Suprascapular nerve", "Brachial plexus interscalene", "Brachial plexus supraclavicular", "Brachial plexus costoclavicular", and "Brachial plexus infraclavicular". The interface includes a sidebar with icons for navigation and a volume control icon.

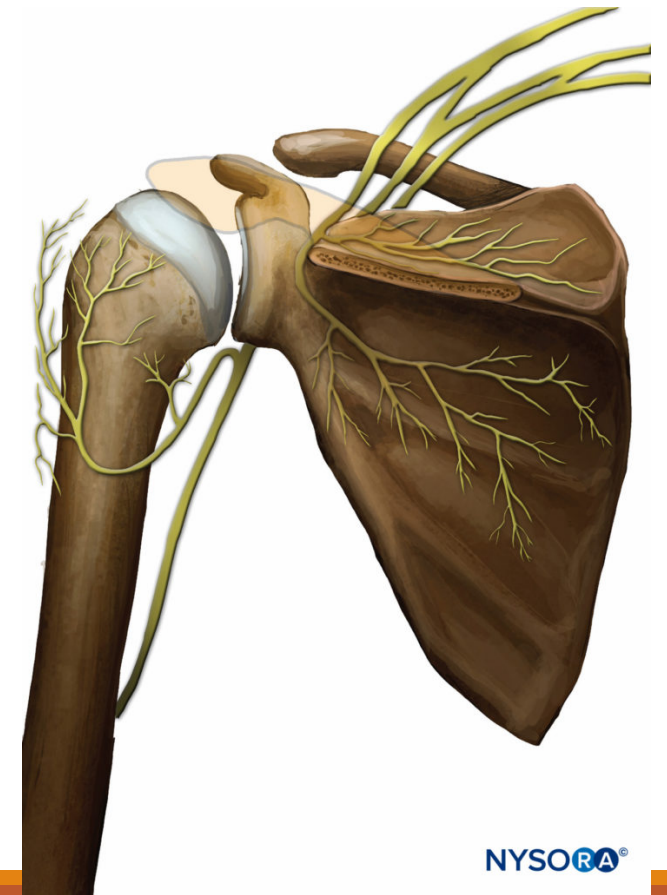
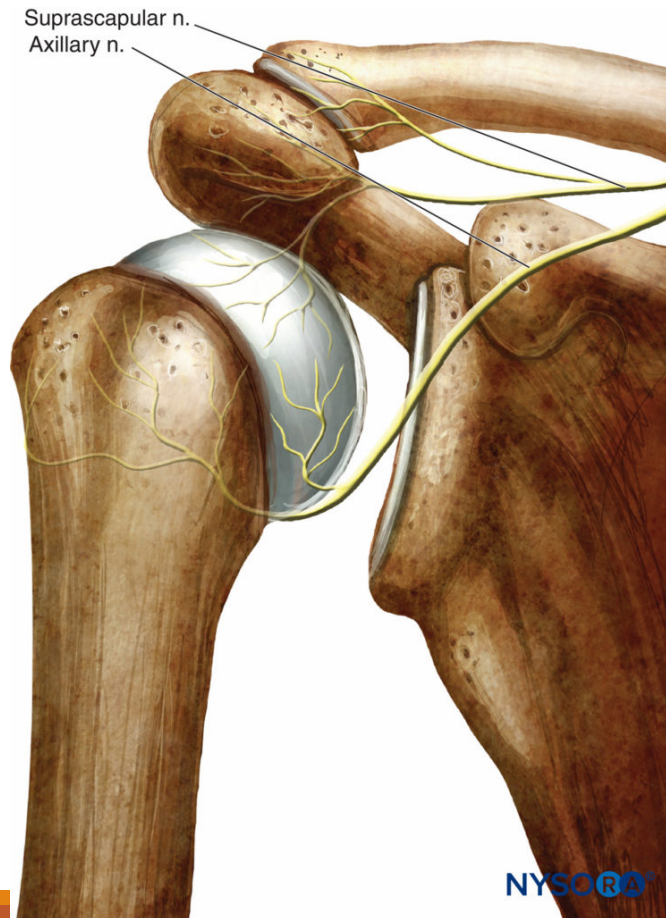
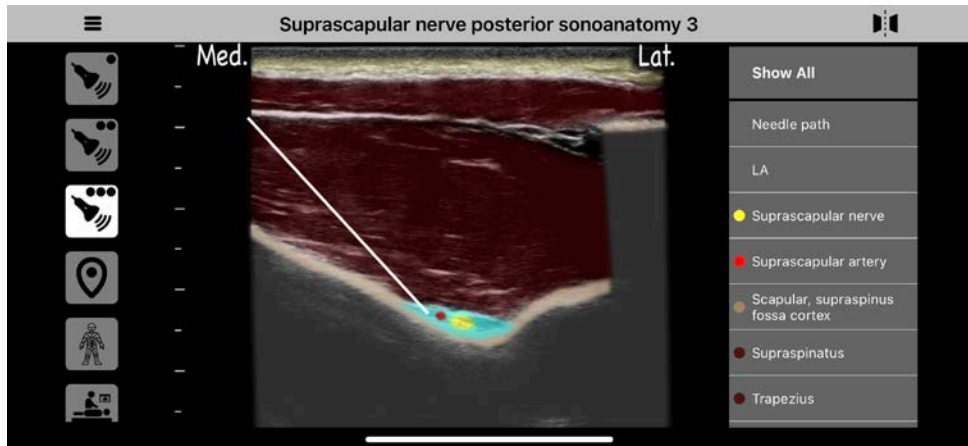
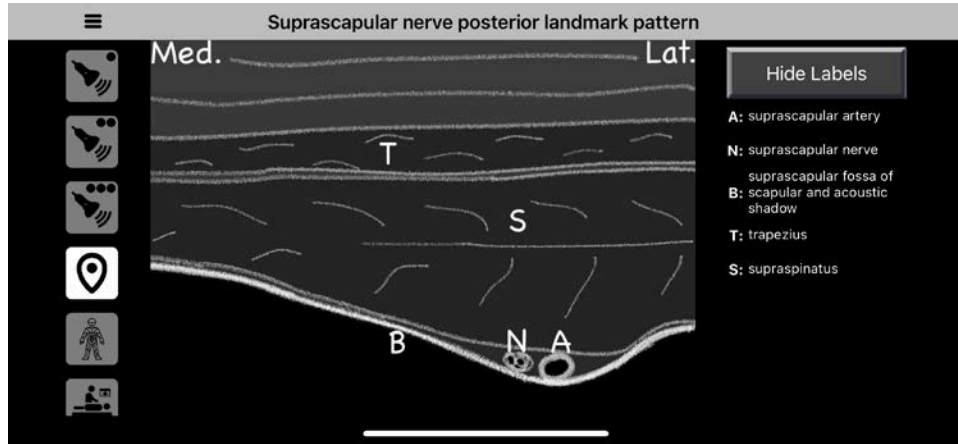
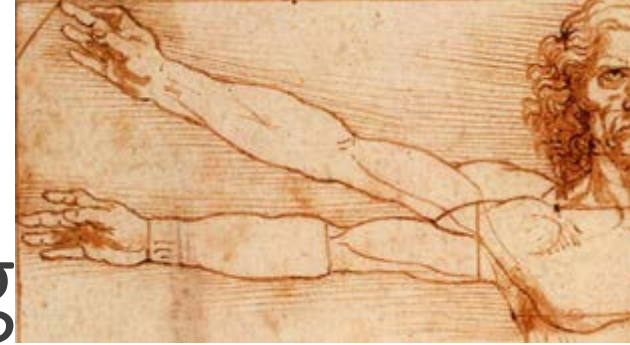
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Suprascapular nerve posterior ergonomics

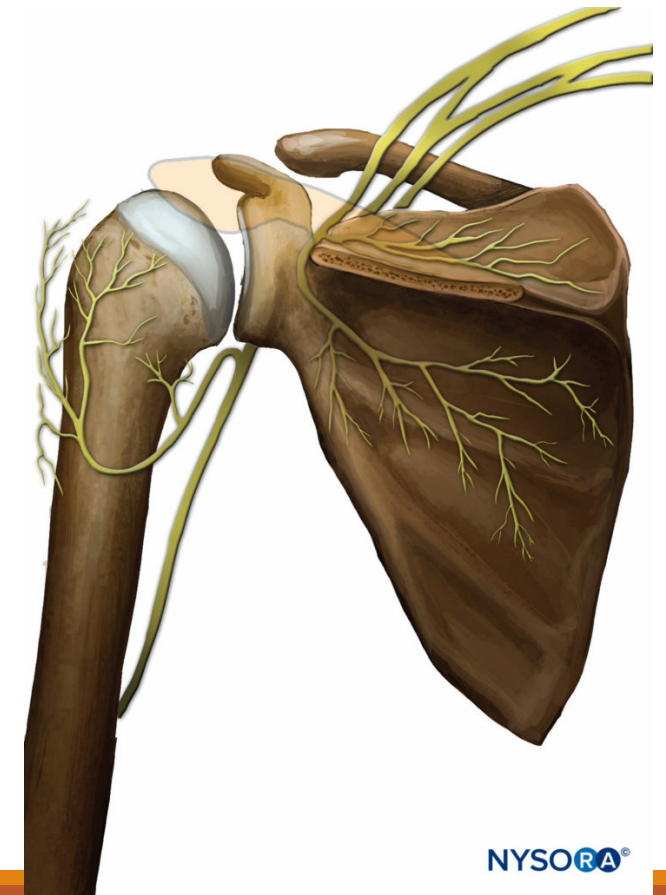
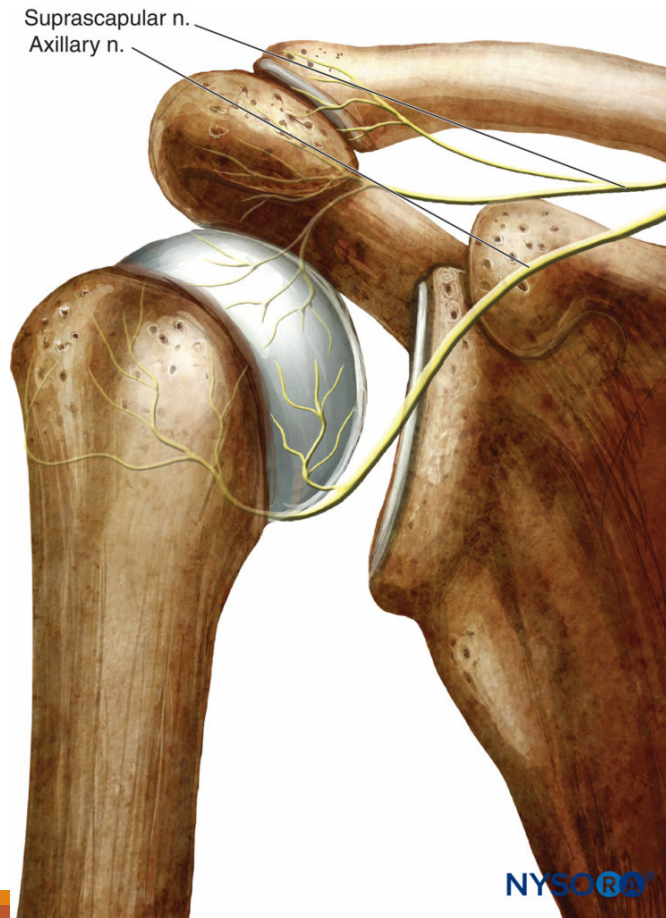
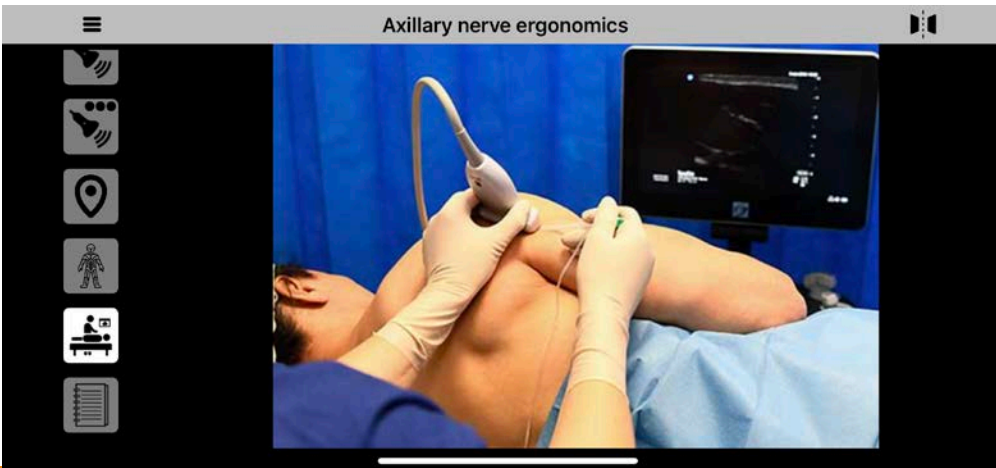
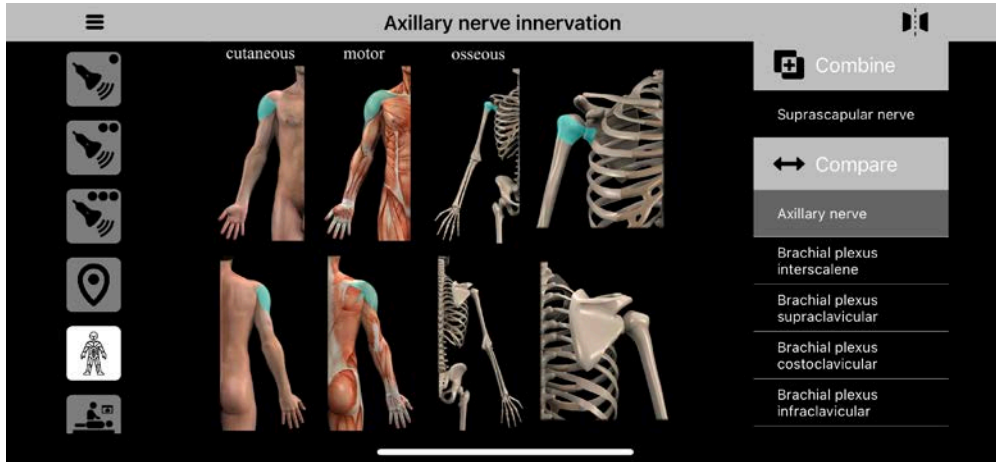
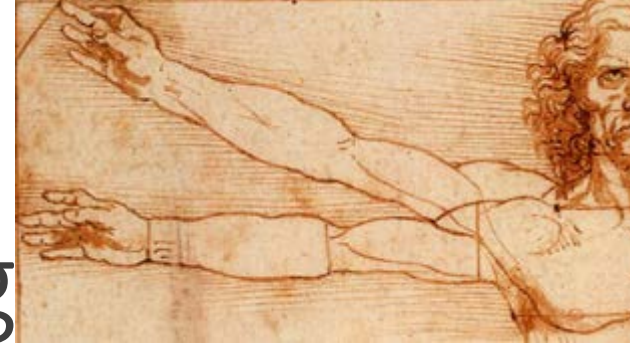
A screenshot of a medical software interface. The top section is titled "Suprascapular nerve posterior ergonomics" and features a video player showing a shoulder surgery. The video player includes a sidebar with icons for navigation and a volume control icon.

# Shoulder Surgery: Phrenic Sparing

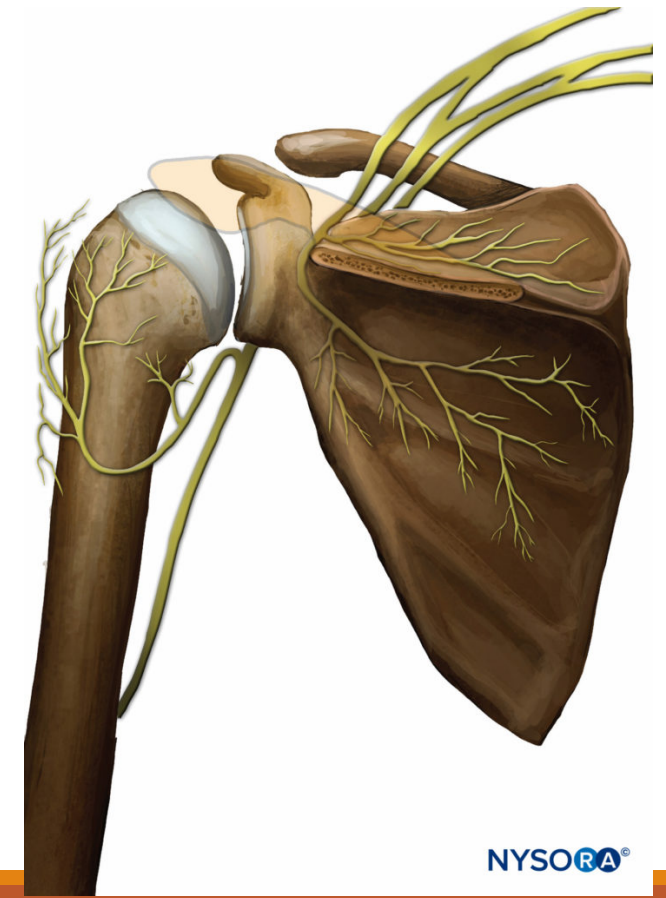
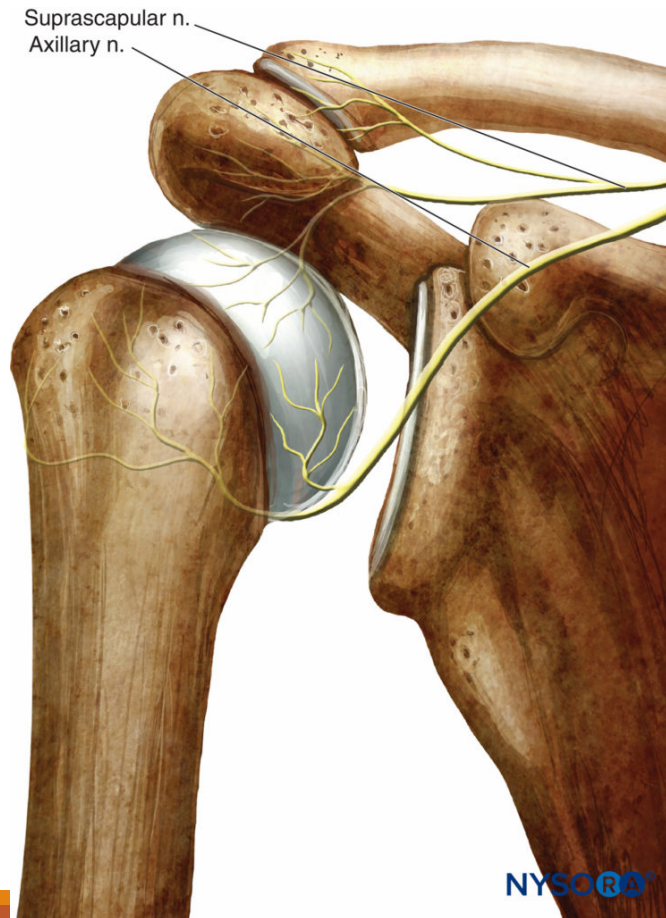
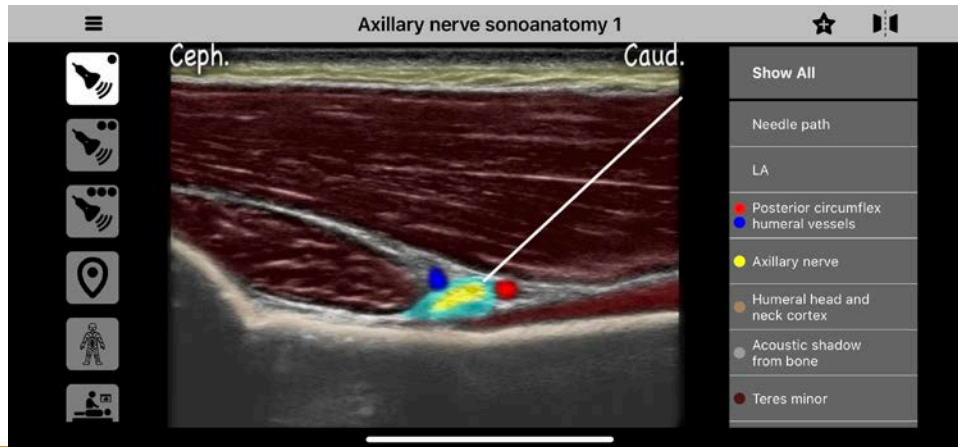
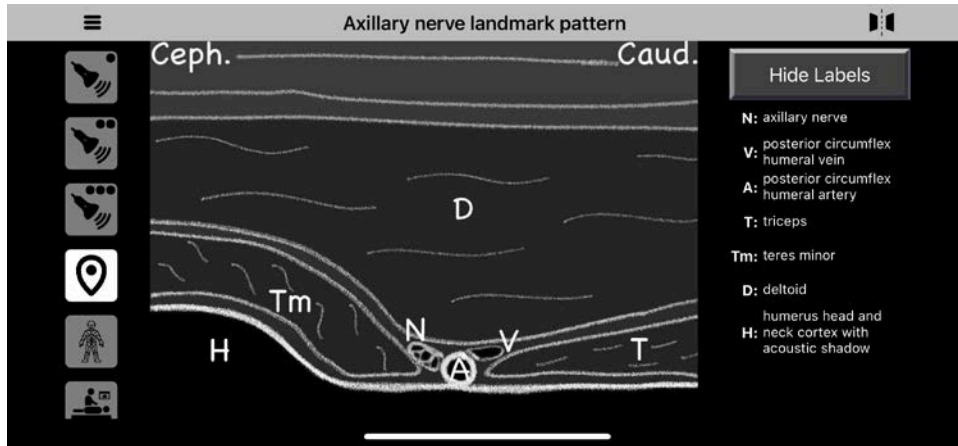
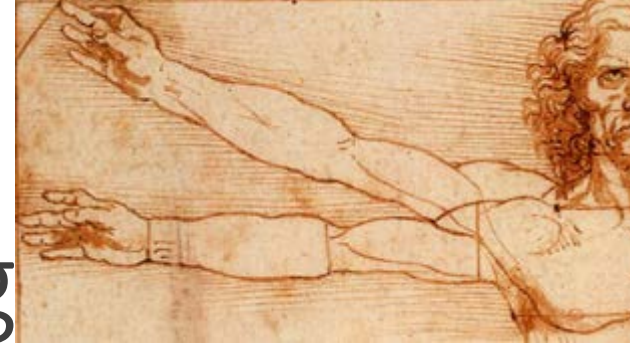




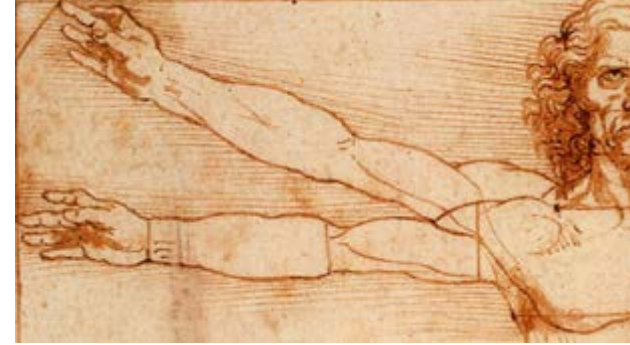
# Shoulder Surgery: Phrenic Sparing



# Shoulder Surgery: Phrenic Sparing

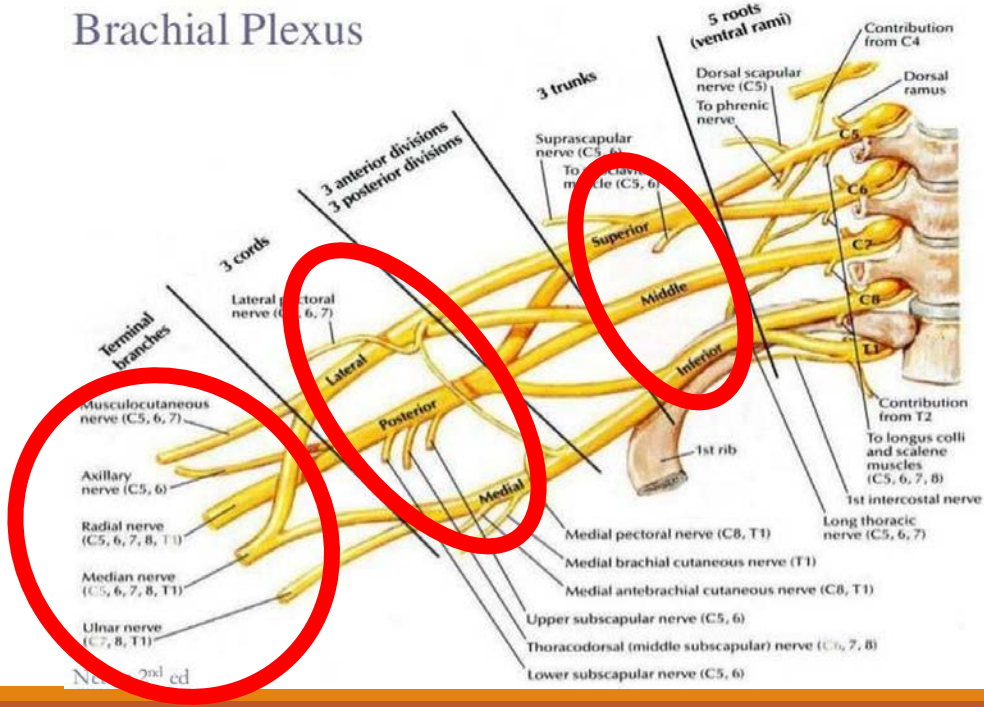


# Elbow and below



Any BPB distal to the interscalene block can be performed for surgical or analgesic coverage for joint surgery elbow and below

## Brachial Plexus



Interscalene



Supraclavicular

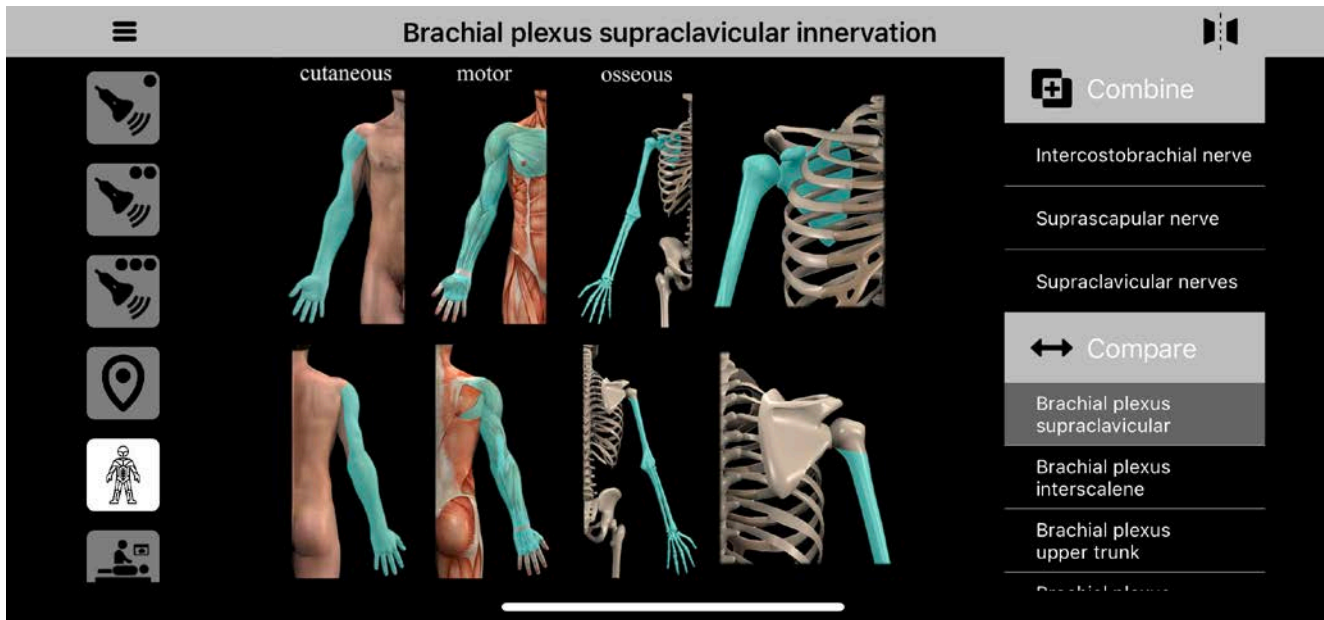


Infraclavicular



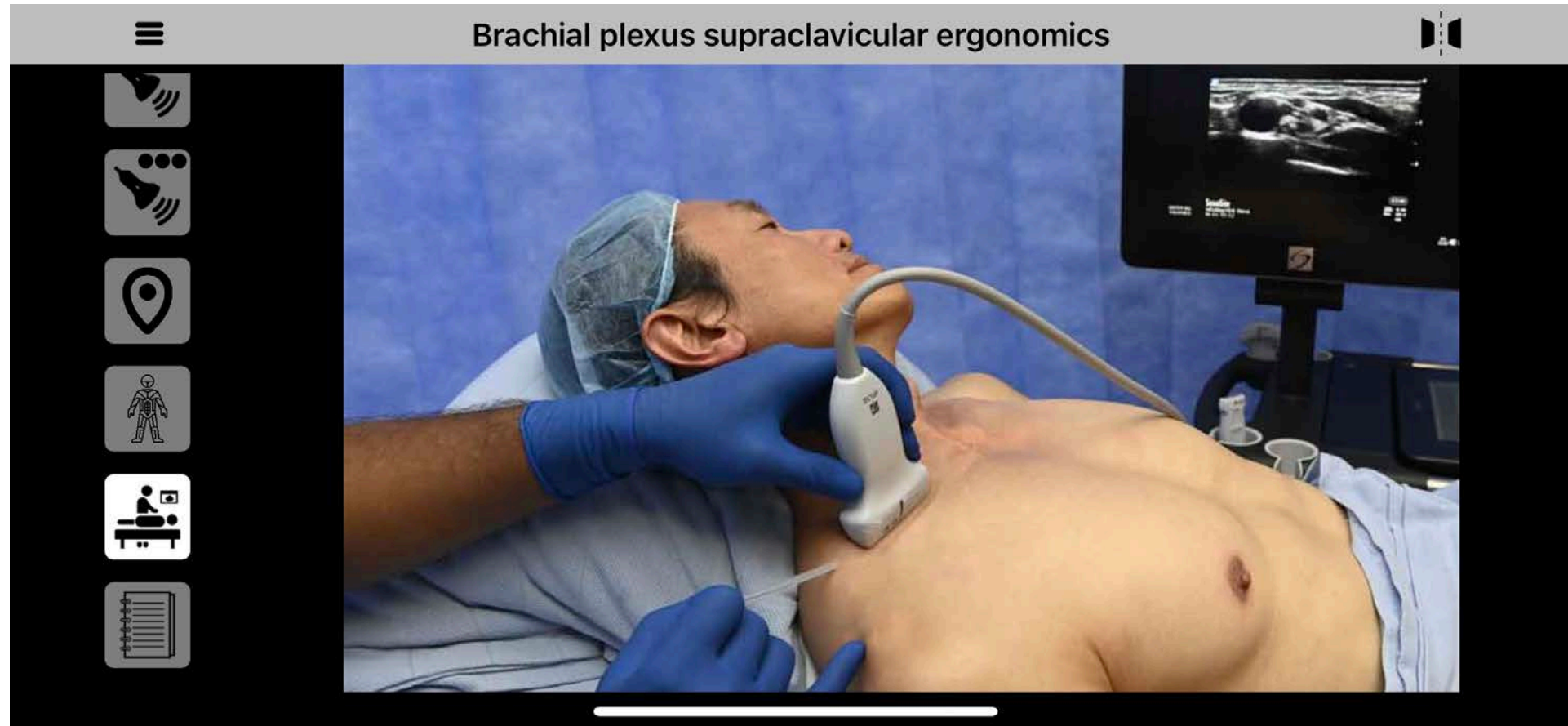
Axillary

# Elbow and Below: Supraclavicular

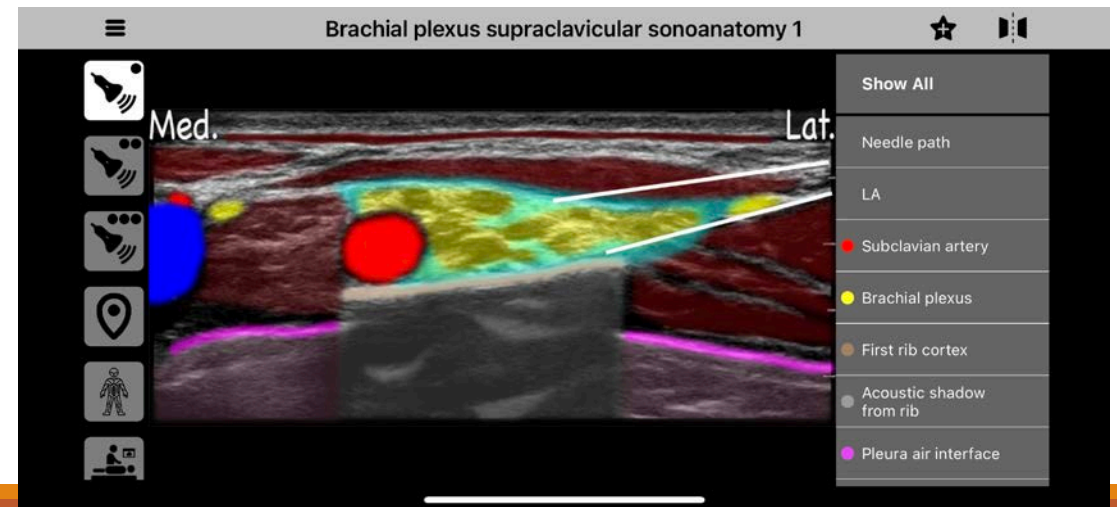
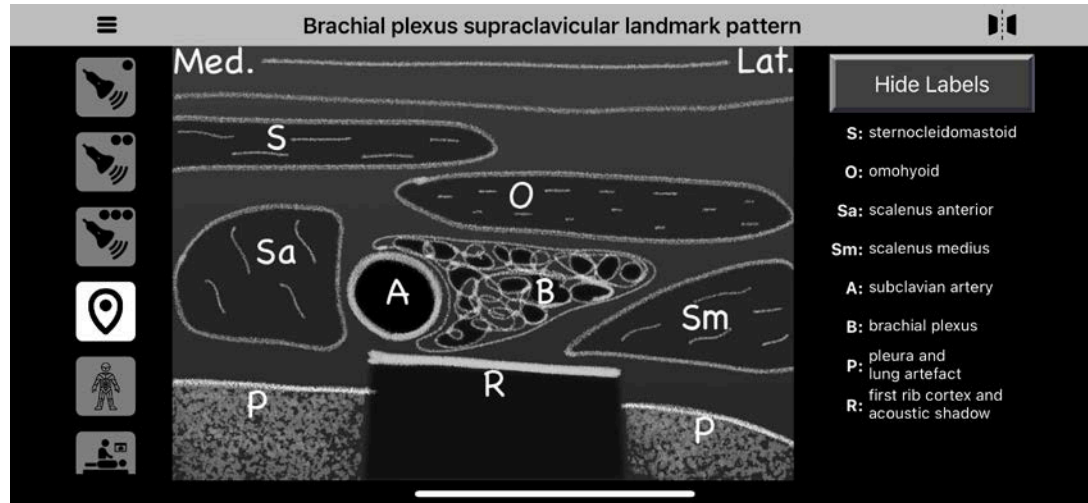


- Indications: anesthesia to forearm, wrist, or hand
  - Combine with intercostobrachial for anesthesia to elbow or distal humerus surgery; does provide analgesia to shoulder joint
- Side effects
  - Horner's syndrome (spread to cervical sympathetics)
  - Hoarseness
  - ~50% likelihood of phrenic nerve palsy
    - Caution in patient with COPD or contralateral hemidiaphragmatic paresis)
- Complications
  - Pneumothorax, vessel injury in non-compressible location (caution in patients on anticoagulation)

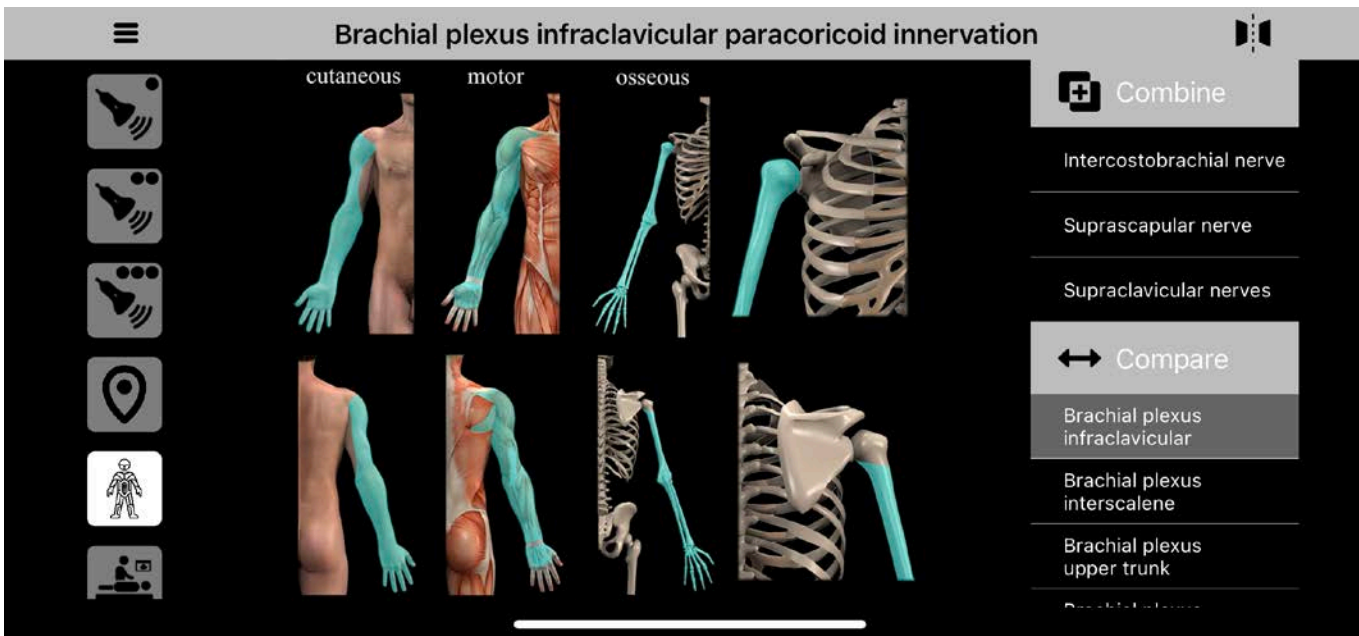
# Elbow and Below: Supraclavicular



# Elbow and Below: Supraclavicular

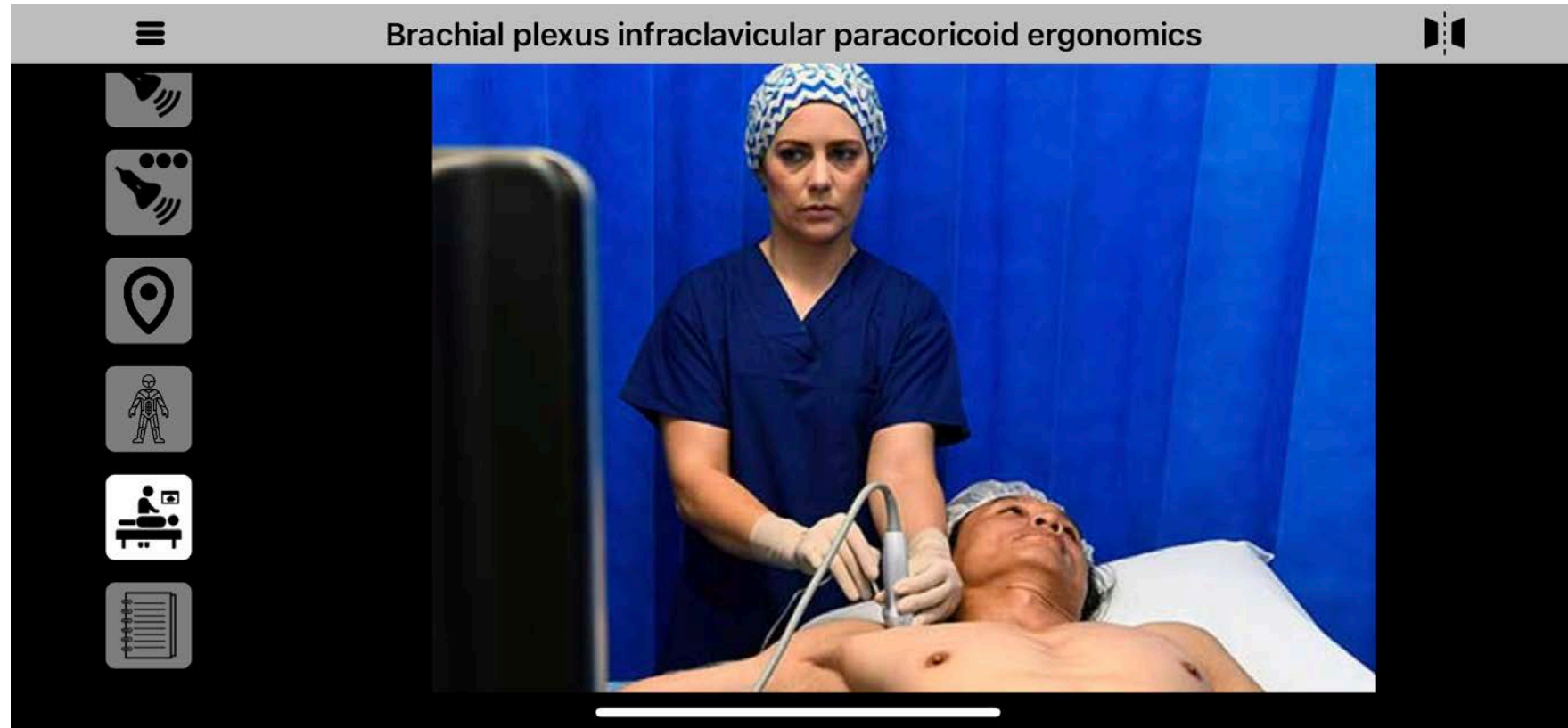


# Elbow and Below: Infraclavicular



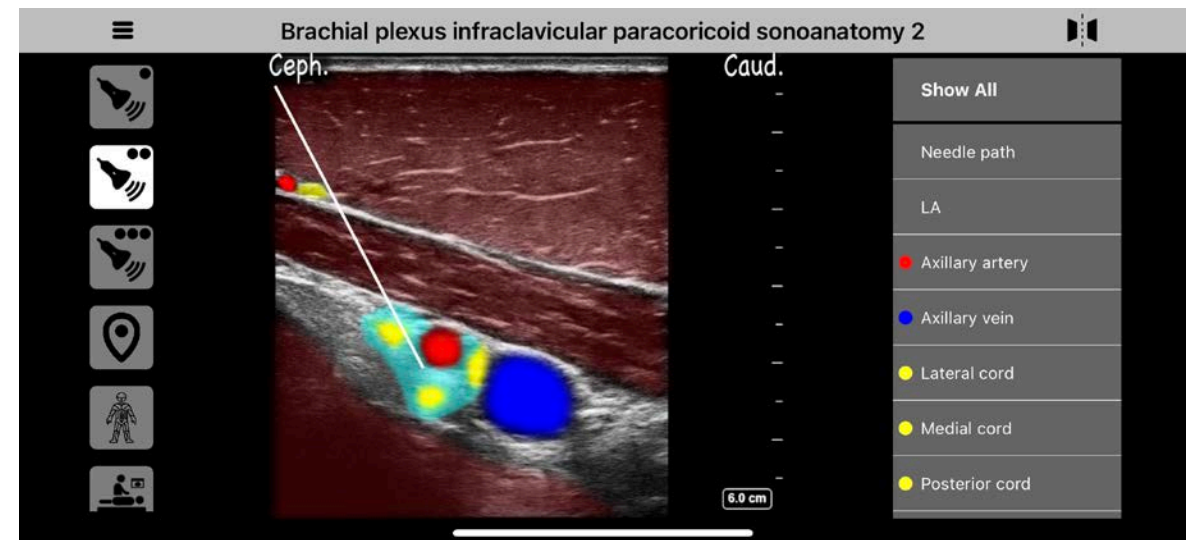
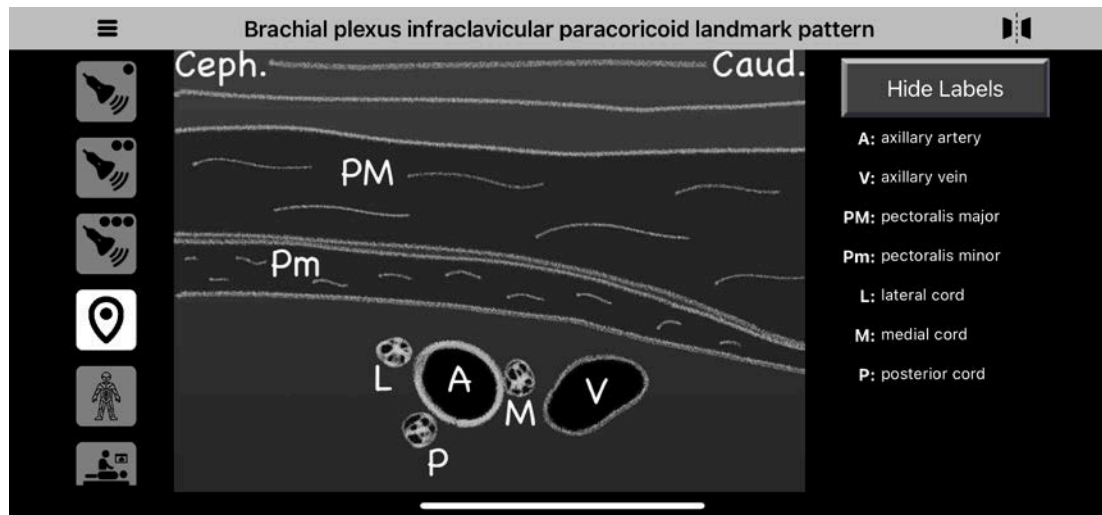
- Indications: anesthesia to forearm, wrist, or hand
  - Combine with intercostobrachial for anesthesia to elbow or distal humerus surgery; does NOT provide analgesia to shoulder joint
- Side effects
  - Muscle weakness in expected distribution
  - ~15% risk of phrenic nerve palsy
- Complications
  - Pneumothorax, vessel injury in non-compressible location (caution in patients on anticoagulation), IV injection

# Elbow and Below: Infraclavicular

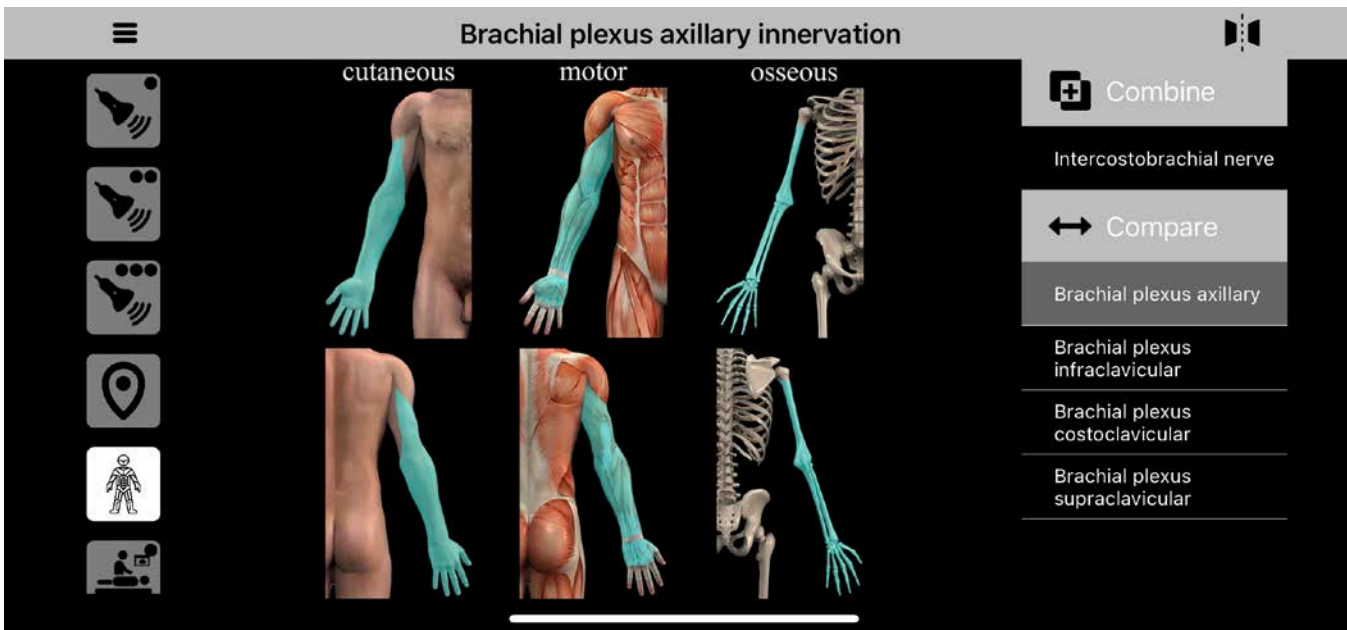




# Elbow and Below: Infraclavicular

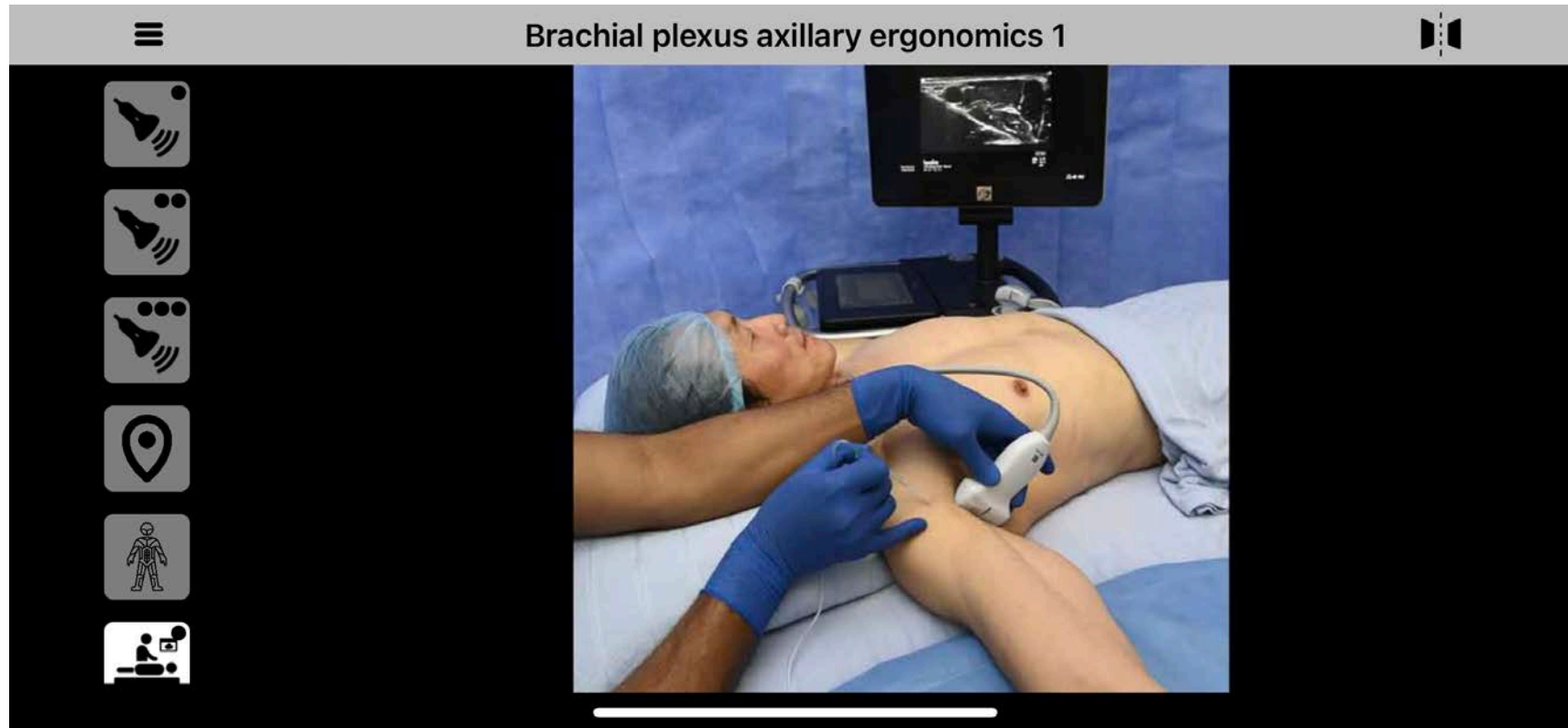


# Elbow and Below: Axillary BPB

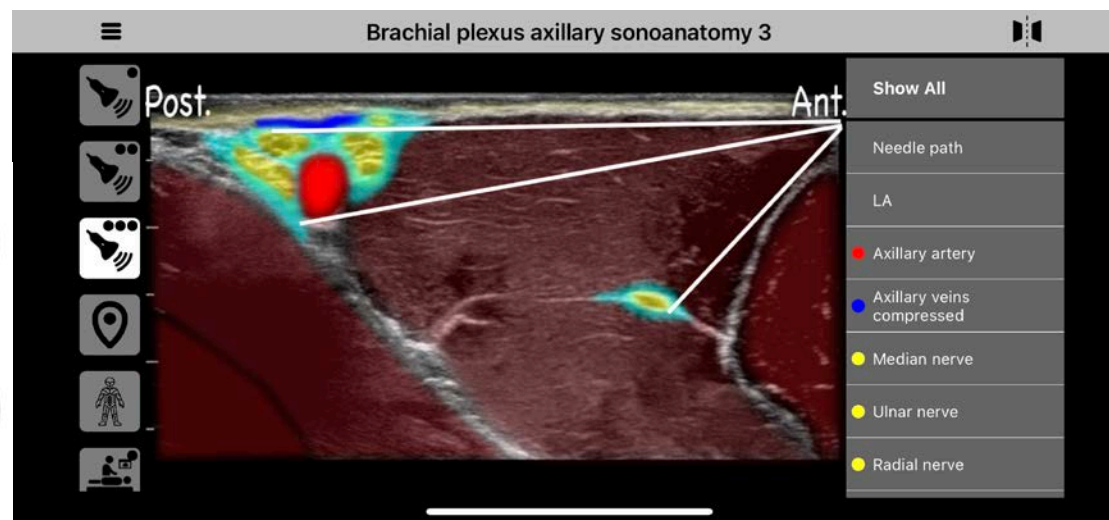
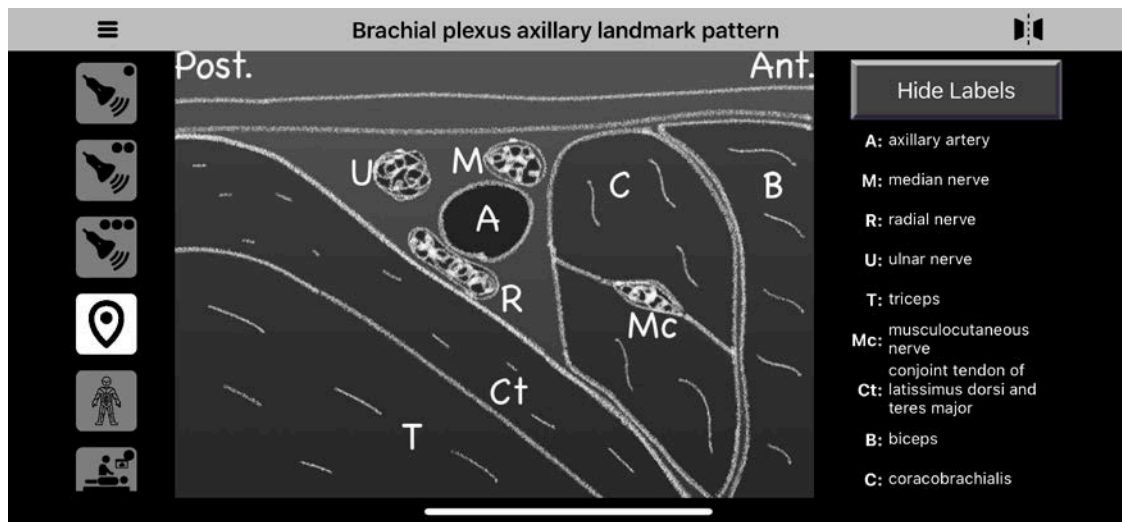


- Indications: anesthesia below the shoulder joint
  - Combine with intercostobrachial for anesthesia to elbow or distal humerus surgery; does NOT provide analgesia to shoulder joint
- Side effects
  - Muscle weakness in expected distribution
- Complications
  - Vessel injury, IV injection, LAST
  - No risk of phrenic nerve palsy

# Elbow and Below: Axillary BPB



# Elbow and Below: Axillary BPB



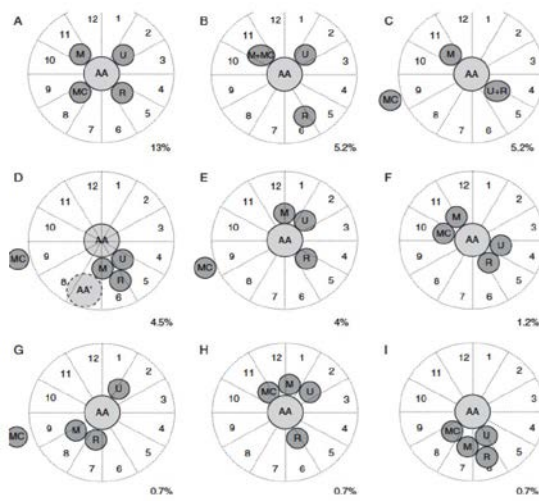
## Anatomical Variation of the Brachial Plexus and Its Clinical Implications

Dr. Neel Desai  
Speciality Registrar in Anaesthetics, St George's Hospital, UK

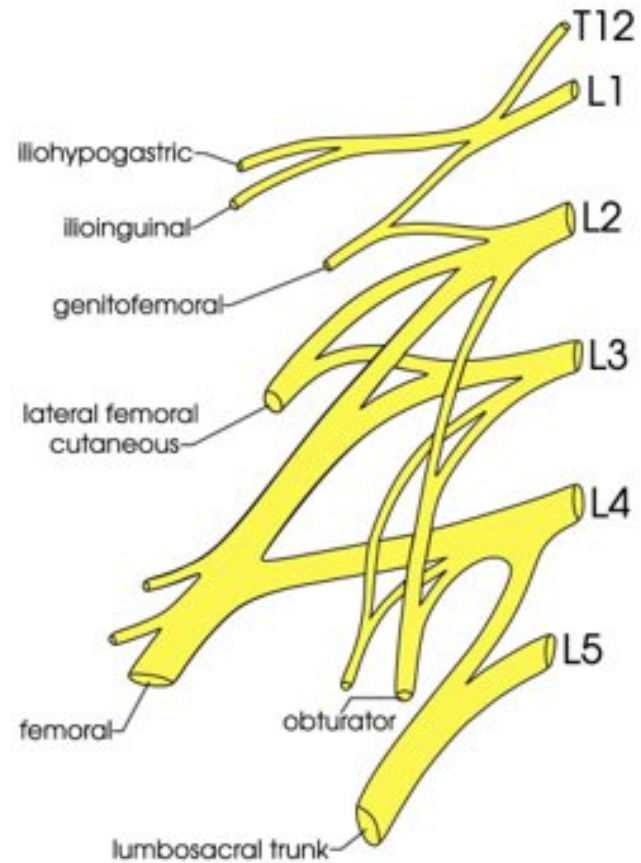
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Edited by  
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Consultant Anaesthetist, Rotherham Hospital, UK

Correspondence to [atotw@wfsahq.org](mailto:atotw@wfsahq.org)  
26th Dec 2017



# Lumbar Plexus



Lumbar plexus: T12-L4

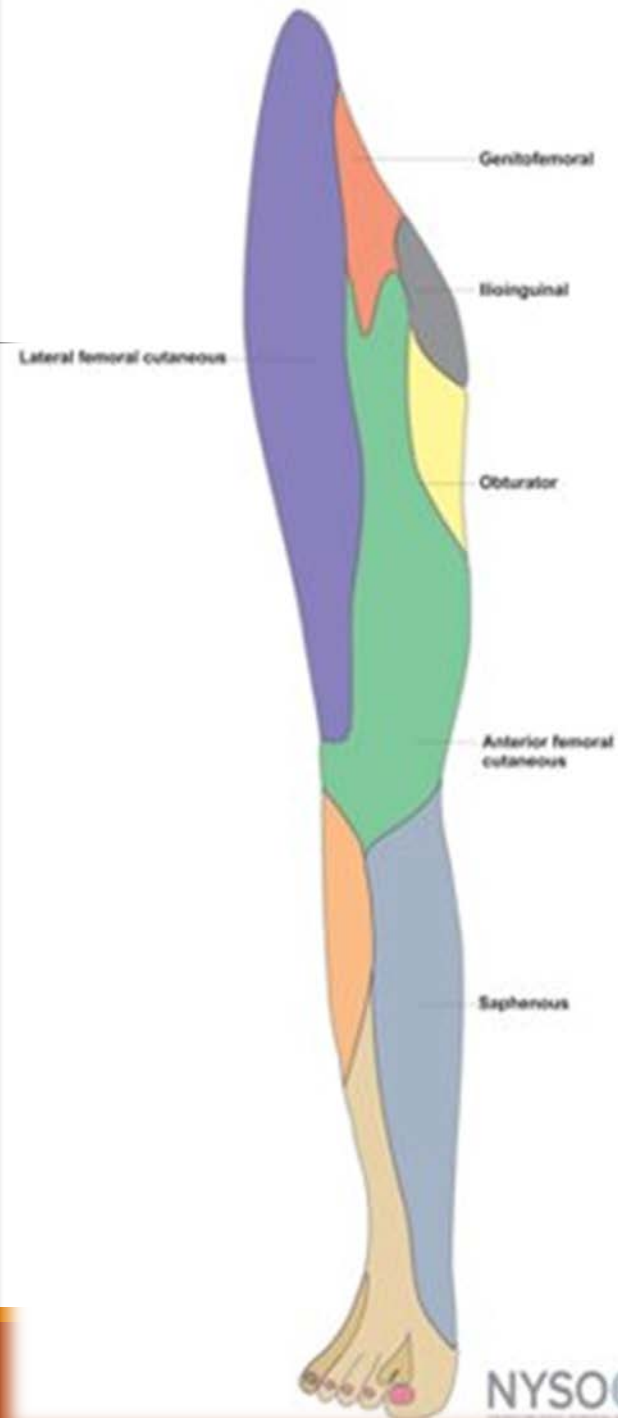
Major branches:

1. Iliohypogastric (L1)
2. Ilioinguinal (L1)
3. Genitofemoral (L1/L2)
4. LFCN (L2,3,4)
5. Femoral (L2,3,4)
6. Obturator (L2,3,4)

T12 contributes to iliohypogastric nerve 50% of cases



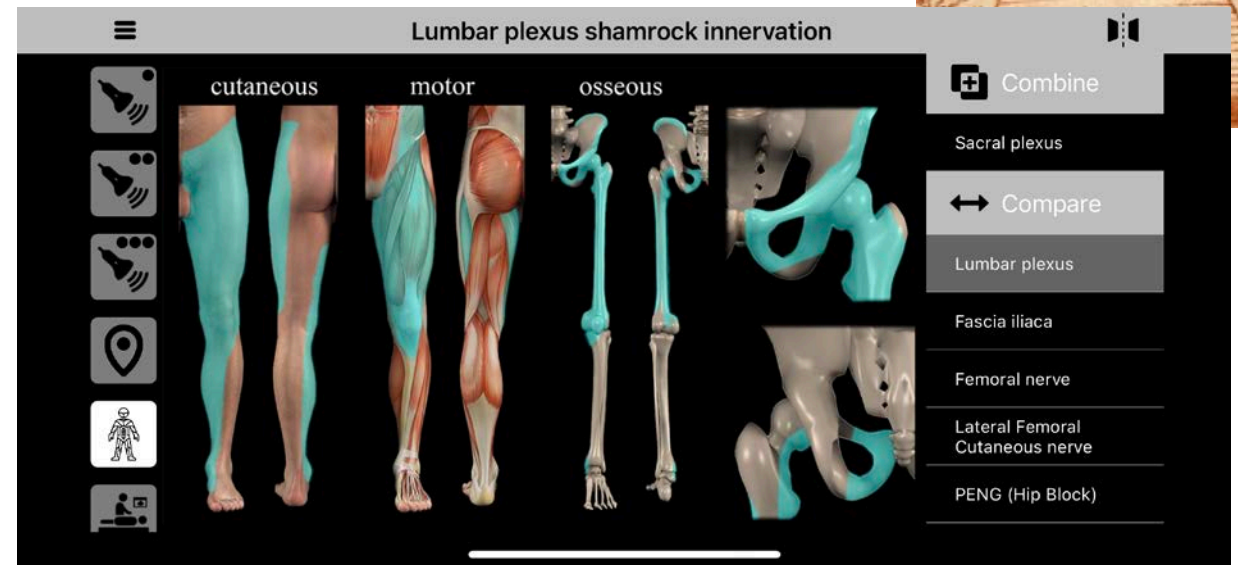
# “Tomes”



# Total Hip: Lumbar Plexus Block

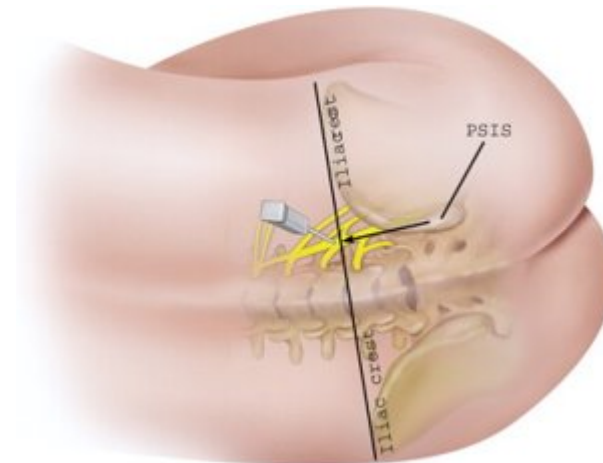
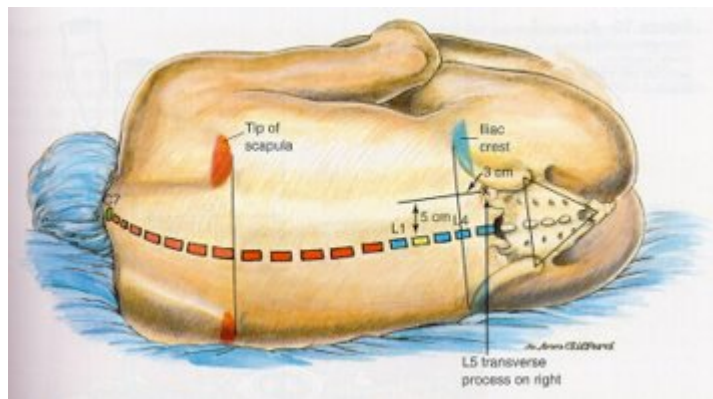


- **Indications**
  - Surgery of the anterolateral proximal leg/Knee (THA, TKA etc...)
- **Expected coverage: LFCN, Femoral (Saph), and Obturator nerves**
- **Contraindications**
  - Anticoagulation – considered a deep peripheral nerve block
  - Local infection
  - Desire to avoid quadriceps weakness
- **Complications**
  - Nerve injury
  - Hematoma
  - Vascular puncture
  - Local anesthetic toxicity
  - Sympathectomy – secondary to epidural spread – generally accept higher stimulation current threshold: 0.6 – 0.8mA
  - Block Failure



# Total Hip: Lumbar Plexus Block

- TP is usually 4cm's in appropriately sized patients
- Plexus is 1.5 – 2cm's deep to TP
- Start with 5-6 cm passes to maximize chance of finding plexus
- Work caudal and medial first before cephalad / lateral





# Total Hip: Fascia Iliaca Block



- Indications

- Surgery of the anterolateral proximal leg/knee (ex....THA, Hip Fracture etc...)

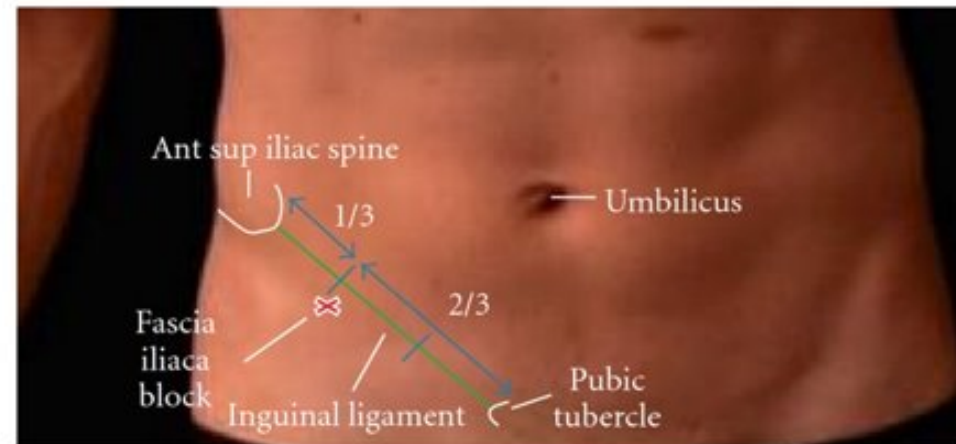
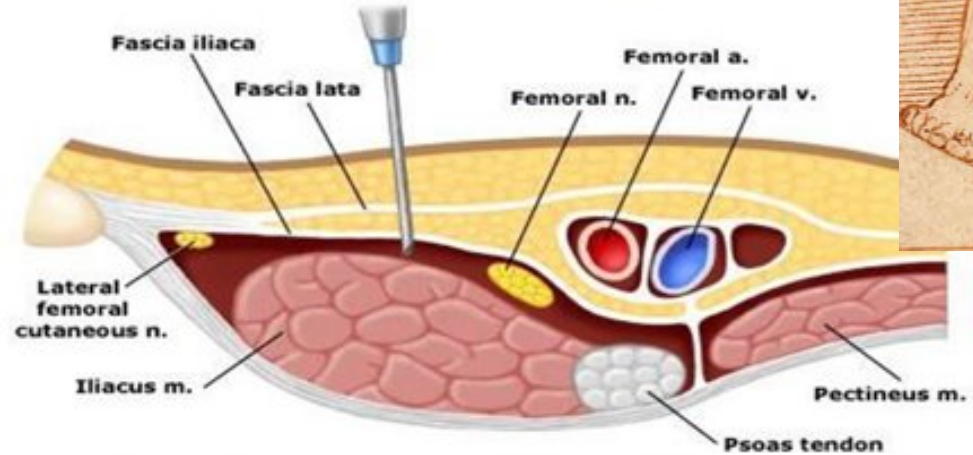
- Expected coverage: LFCN, Femoral (saph), and possibly Obturator

- Contraindications

- Local Infection
- Desire to avoid quadriceps weakness

- Complications

- Nerve Injury
- Hematoma
- Local Anesthetic Toxicity
- Intra-abdominal injury
- Block Failure



# Total Hip: Fascia Iliaca Block



**Fascia iliaca suprainguinal innervation**

cutaneous    motor    osseous

Combine

- Obturator nerve
- Sacral plexus

Compare

- Fascia iliaca
- Femoral nerve
- Lumbar plexus
- Lateral femoral cutaneous nerve

This panel displays three columns of anatomical diagrams: 'cutaneous' showing the skin and superficial nerves, 'motor' showing the muscles and their innervation, and 'osseous' showing the skeletal structure and its innervation. A 'Combine' button is present, and a list of innervation sources is provided on the right.

**Fascia iliaca suprainguinal landmark pattern**

Ceph.    Caud.

I    FI    S

D    IP

P

B    R

Hide

- I: interna
- S: sartori
- IP: iliopso
- anterio
- B: iliac sp
- deep c
- D: iliac vesseis
- P: peritoneum and intraperitoneal
- R: Rectus femoris insertion
- FI: fascia iliaca

This panel shows a longitudinal B-mode ultrasound image of the fascia iliaca suprainguinal landmark pattern. The image is labeled with 'Ceph.' (cephalic) and 'Caud.' (caudal) at the top. Various landmarks are marked with letters: I (internal iliac vessels), FI (fascia iliaca), S (sartorius muscle), D (deep circumflex iliac artery and vein), IP (iliopsoas muscle), P (peritoneum and intraperitoneal structures), B (iliac spine cortex), and R (rectus femoris insertion).

**Fascia iliaca suprainguinal sonoanatomy 2**

Ceph.    Caud.

Show All

- Fascia iliaca
- Deep circumflex iliac artery and vein
- Iliopsoas
- Sartorius
- Internal oblique
- Anterior inferior iliac spine cortex
- Acoustic shadow from bone

This panel shows a longitudinal B-mode ultrasound image of the fascia iliaca suprainguinal sonoanatomy. The image is labeled with 'Ceph.' (cephalic) and 'Caud.' (caudal) at the top. A legend on the right lists the structures shown: Fascia iliaca (orange), Deep circumflex iliac artery and vein (red), Iliopsoas (blue), Sartorius (brown), Internal oblique (dark brown), Anterior inferior iliac spine cortex (light brown), and Acoustic shadow from bone (grey).

**Fascia iliaca suprainguinal ergonomics**

This panel shows a clinical photograph of a patient lying on their side, receiving a fascia iliaca suprainguinal block. A healthcare professional wearing blue gloves is performing the procedure. An ultrasound monitor is visible in the background, showing the needle tip in real-time.

# Total Hip: PENG Block

## **P**ericapsular **N**erve **G**roup Block

Indications: analgesia to anterior hip capsule

### Side effects

- Usually nothing
- Possible quad weakness of local spreads to femoral nerve

### Complications

- Vessel puncture
- Femoral nerve injury



# Total Hip: PENG Block

### PENG (hip block) innervation

Combine

Compare

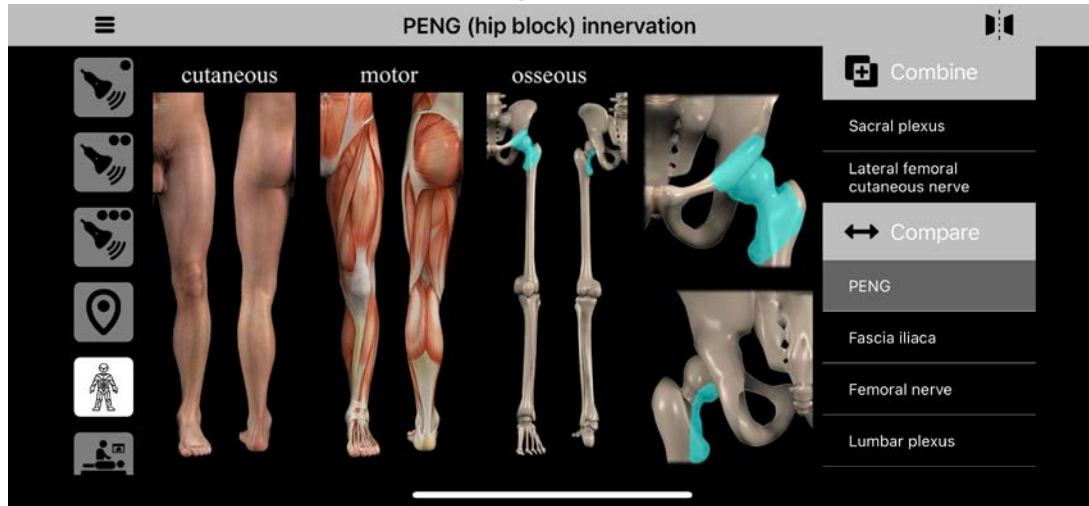
PENG

Fascia iliaca

Femoral nerve

Lumbar plexus

cutaneous motor osseous



### PENG (hip block) landmark pattern

Med. Lat.

V O

P

IPE IP

AIIS

Hide

AIIS: ante iliac

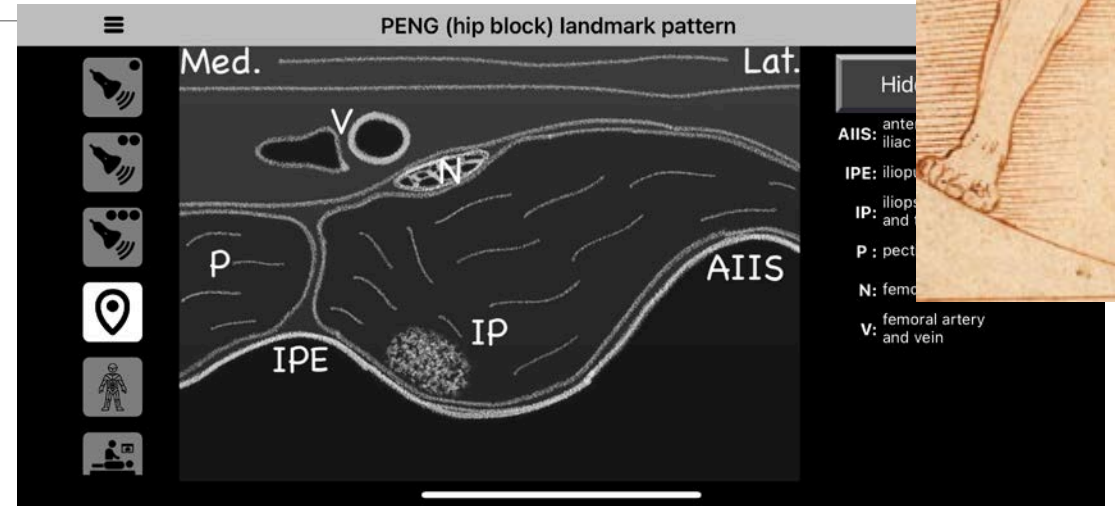
IPE: iliop and

IP: iliop and

P: pect

N: femo

V: femoral artery and vein



### PENG (hip block) sonoanatomy 1

Med. Lat.

Show All

Needle path

LA

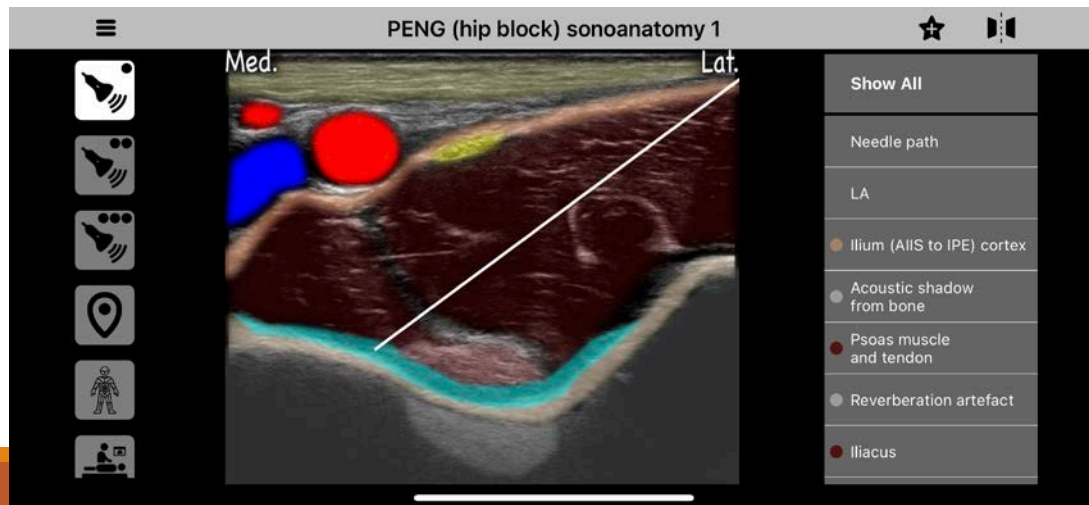
Ilium (AIIS to IPE) cortex

Acoustic shadow from bone

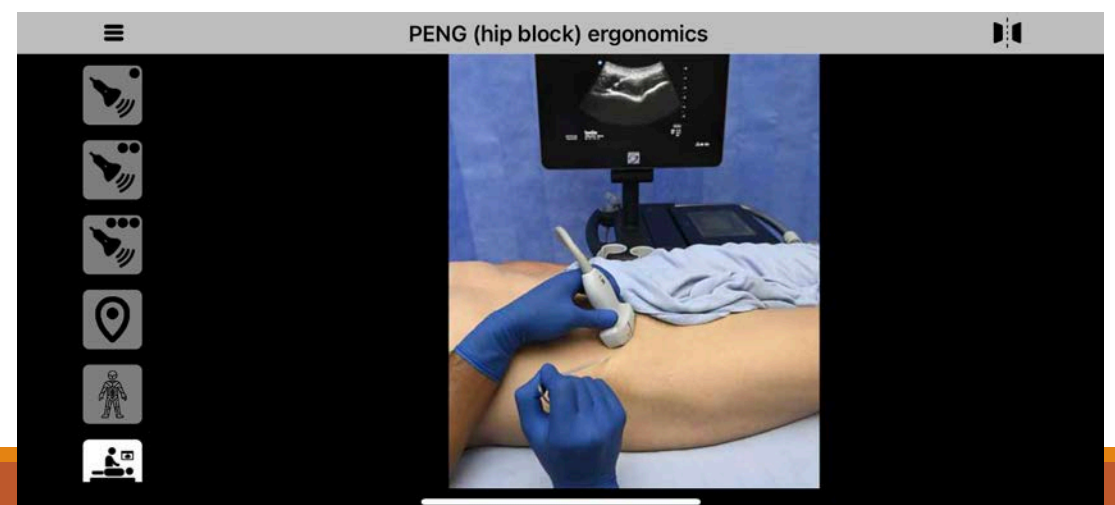
Psoas muscle and tendon

Reverberation artefact

Iliacus



### PENG (hip block) ergonomics



# Total Knee Arthroplasty

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## Novel Regional Techniques for Total Knee Arthroplasty Promote Reduced Hospital Length of Stay: An Analysis of 106 Patients

Salman Thobhani, MD,<sup>1</sup> Lauren Scalercio, MD,<sup>1</sup> Clint E. Elliott, MD,<sup>1,2</sup> Bobby D. Nossaman, MD,<sup>1,2</sup> Leslie C. Thomas, MD,<sup>1</sup> Dane Yuratich, MD,<sup>1</sup> Kim Bland, MD,<sup>1</sup> Kristie Osteen, MD,<sup>1,2</sup> Matthew E. Patterson, MD<sup>1,2</sup>

<sup>1</sup>Department of Anesthesiology, Ochsner Clinic Foundation, New Orleans, LA <sup>2</sup>The University of Queensland School of Medicine, Ochsner Clinical School, New Orleans, LA

**Results:** We found no significant differences in the 3 groups with regard to baseline patient demographics. Although we observed no differences in pain scores between the 3 groups, opioid consumption was significantly reduced in the FNC with IPACK group. Physical therapy performance was significantly better on POD 1 in the ACB with IPACK group compared to the other 2 groups. Hospital length of stay was significantly shorter in the ACB with IPACK group.

**Conclusion:** This study demonstrated that an IPACK block reduced opioid consumption by providing effective supplemental analgesia following TKA compared to the FNC-only technique. ACB with IPACK provided equivalent analgesia and improved physical therapy performance, allowing earlier hospital discharge.

# Total Knee: Adductor Canal Block



## Indications

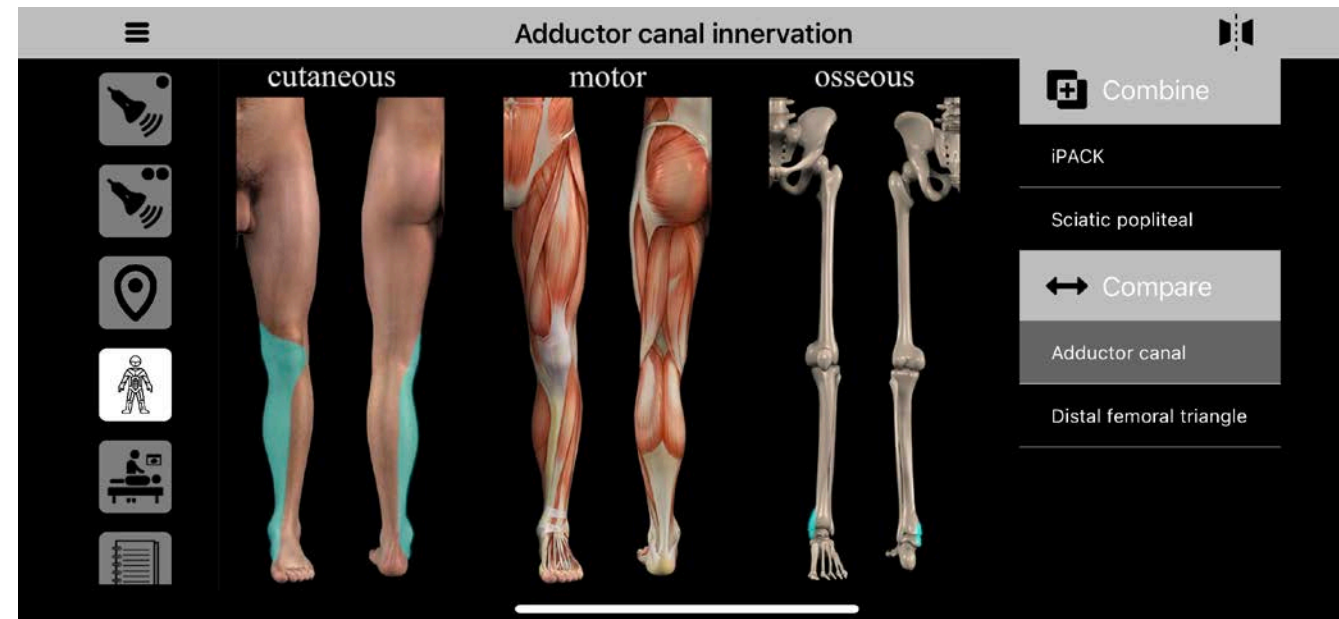
- Analgesia to anteromedial knee

## Side effects

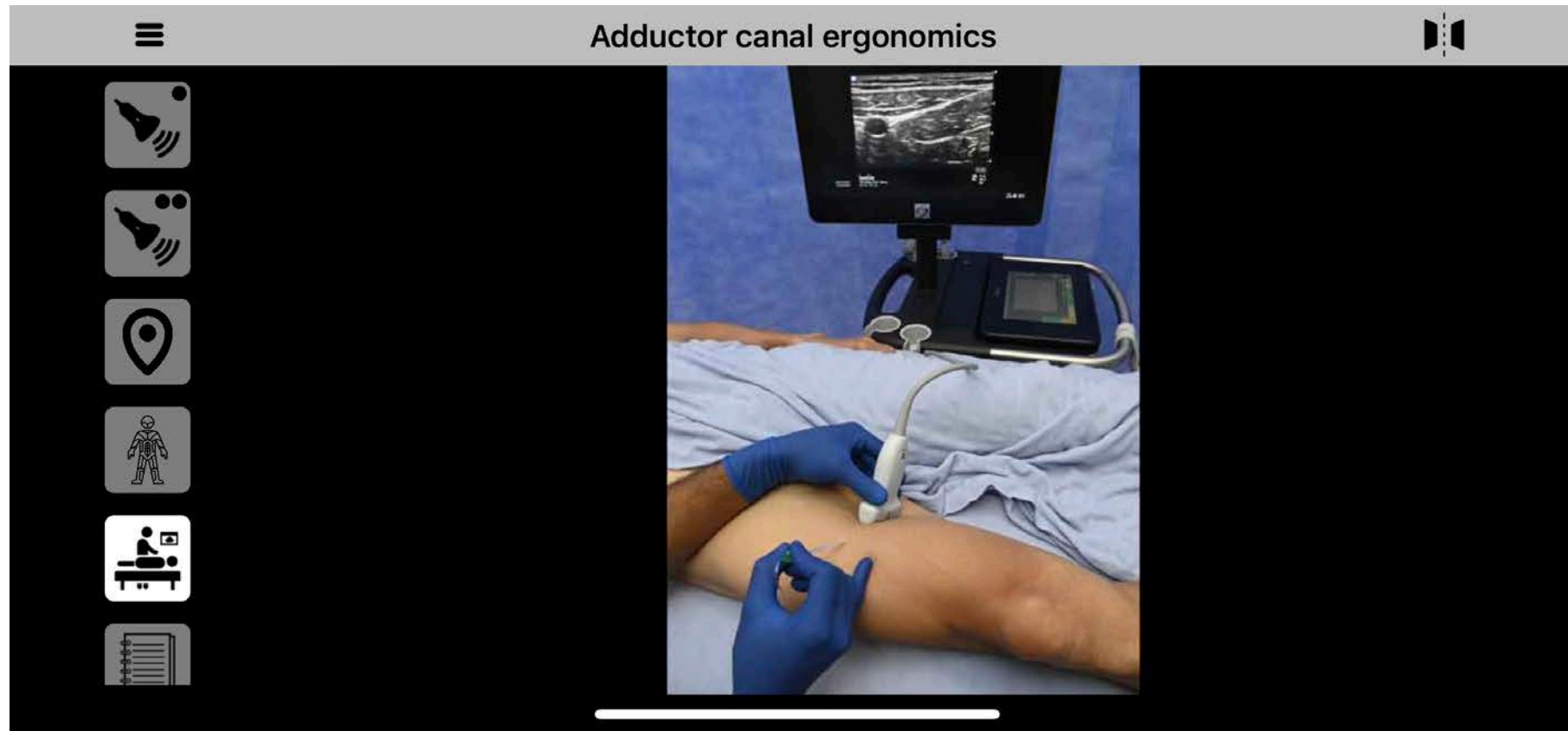
- Quadriceps weakness if LA spreads to motor branches of femoral nerve

## Complications

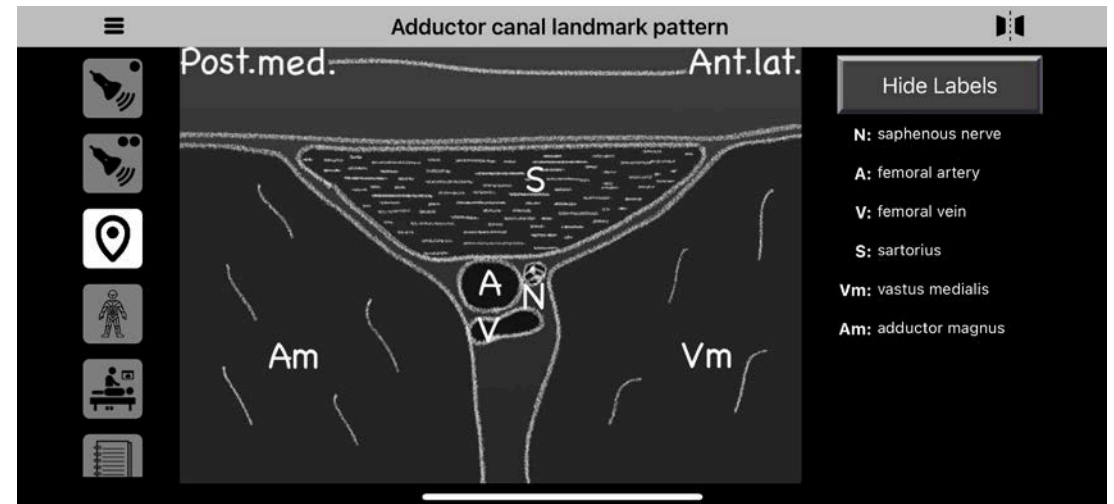
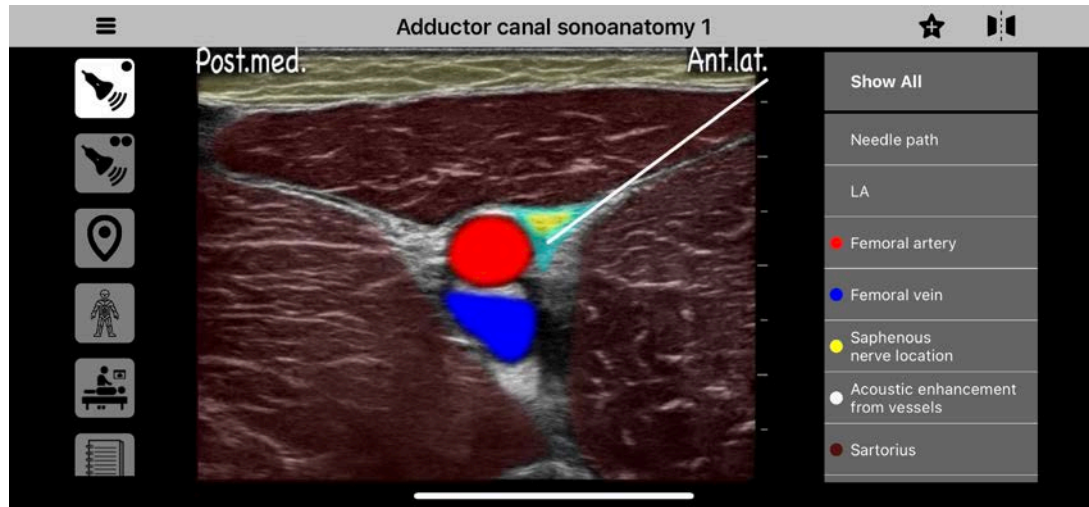
- Vascular injury
- Intravenous injection
- Nerve injury



# Total Knee: Adductor Canal Block



# Total Knee: Adductor Canal Block



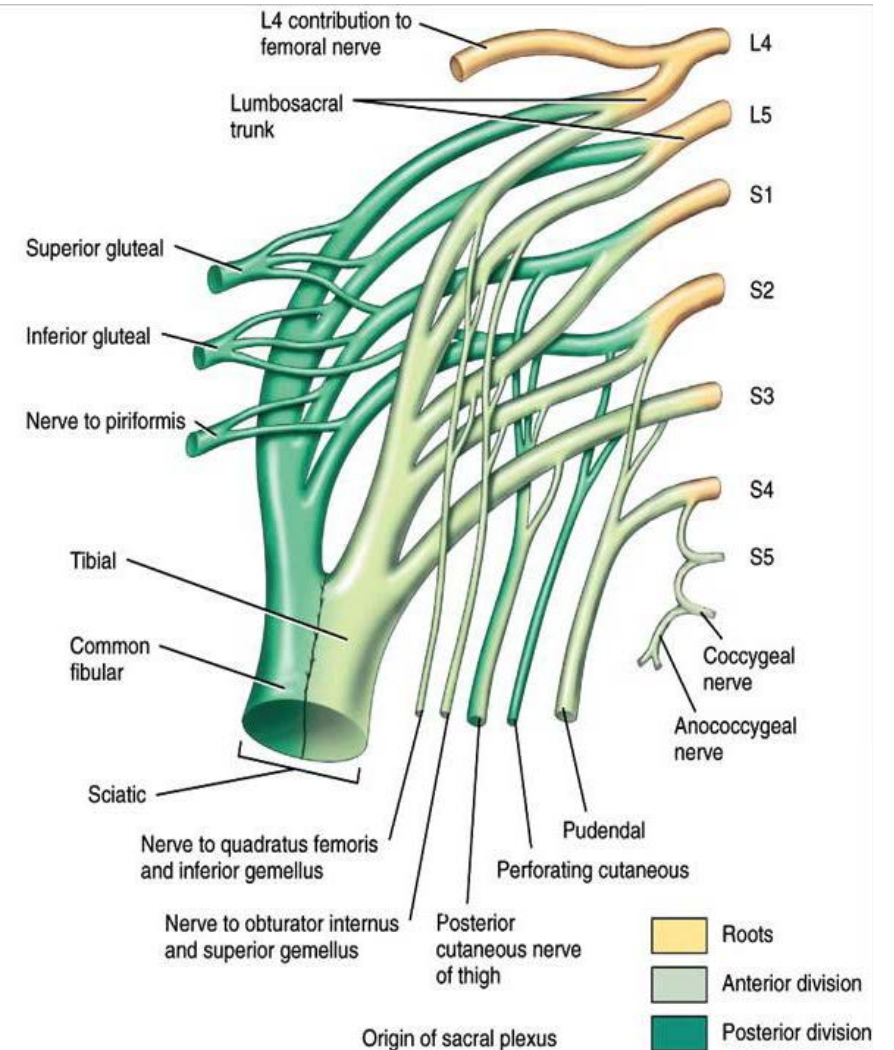


# Sacral Plexus

Sacral plexus is formed by the lumbosacral trunk, and the ventral ramus of the first, second, and third sacral nerves

Sciatic block: Anesthesia of the skin of the posterior thigh, hamstring, and biceps femoris muscles; parts of the hip/knee joints and the entire leg below the knee with the exception of the saphenous nerve (medial distal lower extremity)

Knee Joint: Femoral nerve, obturator nerve, sciatic nerve

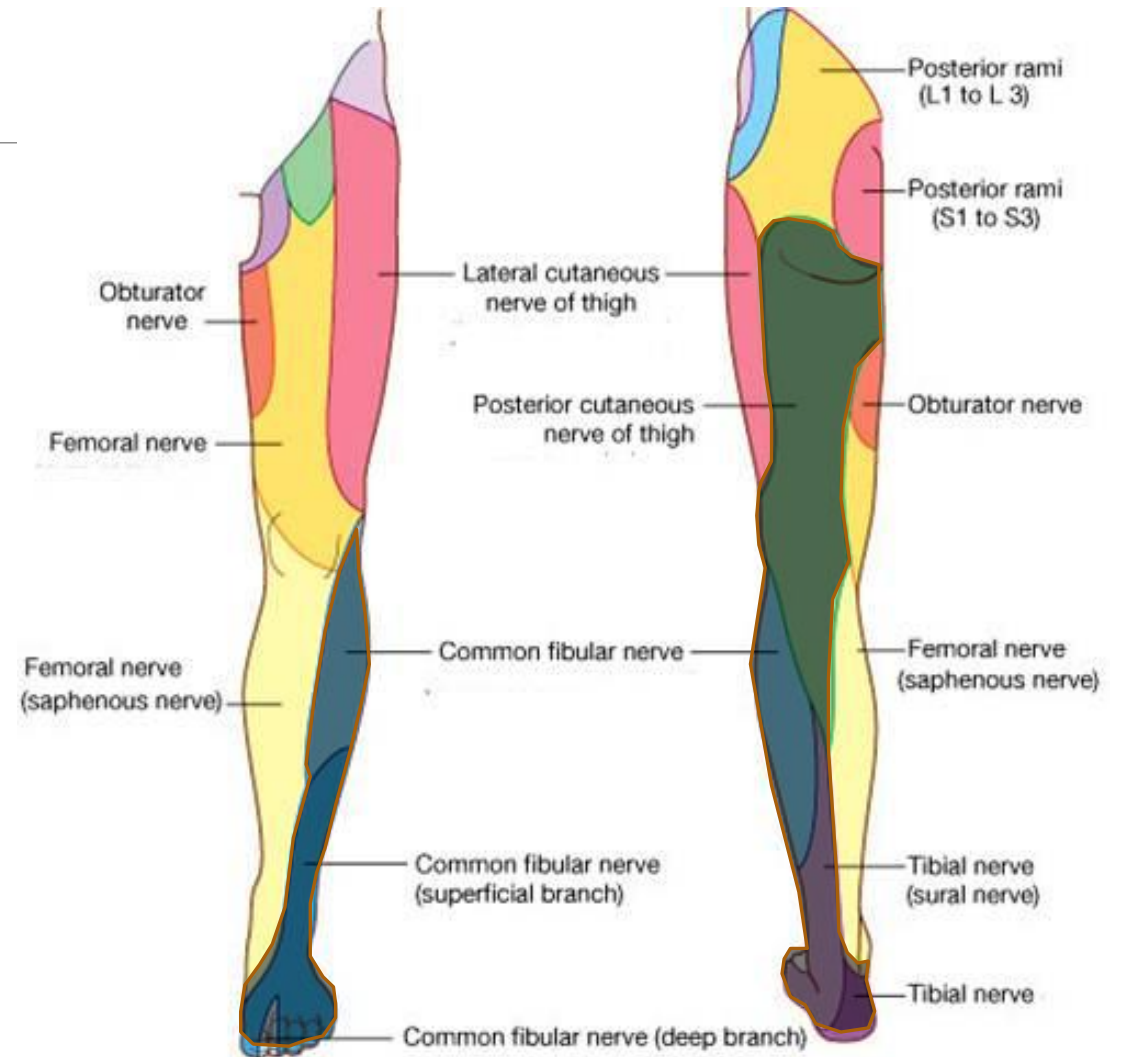


# Sacral Plexus

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Caution with very proximal sciatic blocks, such as Labat or subgluteal sciatic blocks, as those will take away muscle contraction in entire distribution of lower extremity

We'll focus on iPACK, motor sparing sciatic block specific to TKA



# Total Knee: iPACK

Infiltration between the **Popliteal Artery** and the **Capsule of the Knee**

## Indications

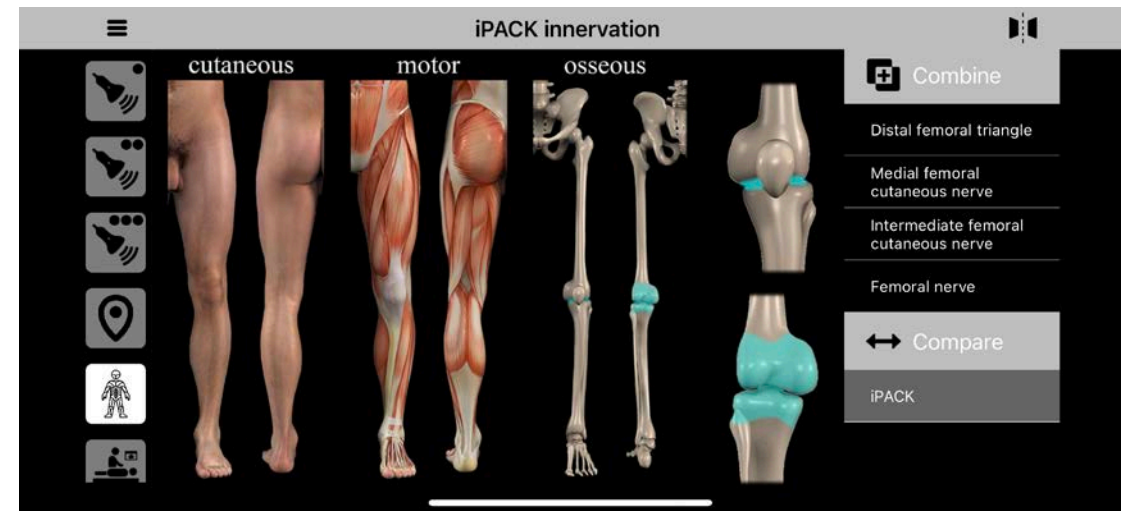
- Analgesia to the posterior capsule of the knee

## Side effects

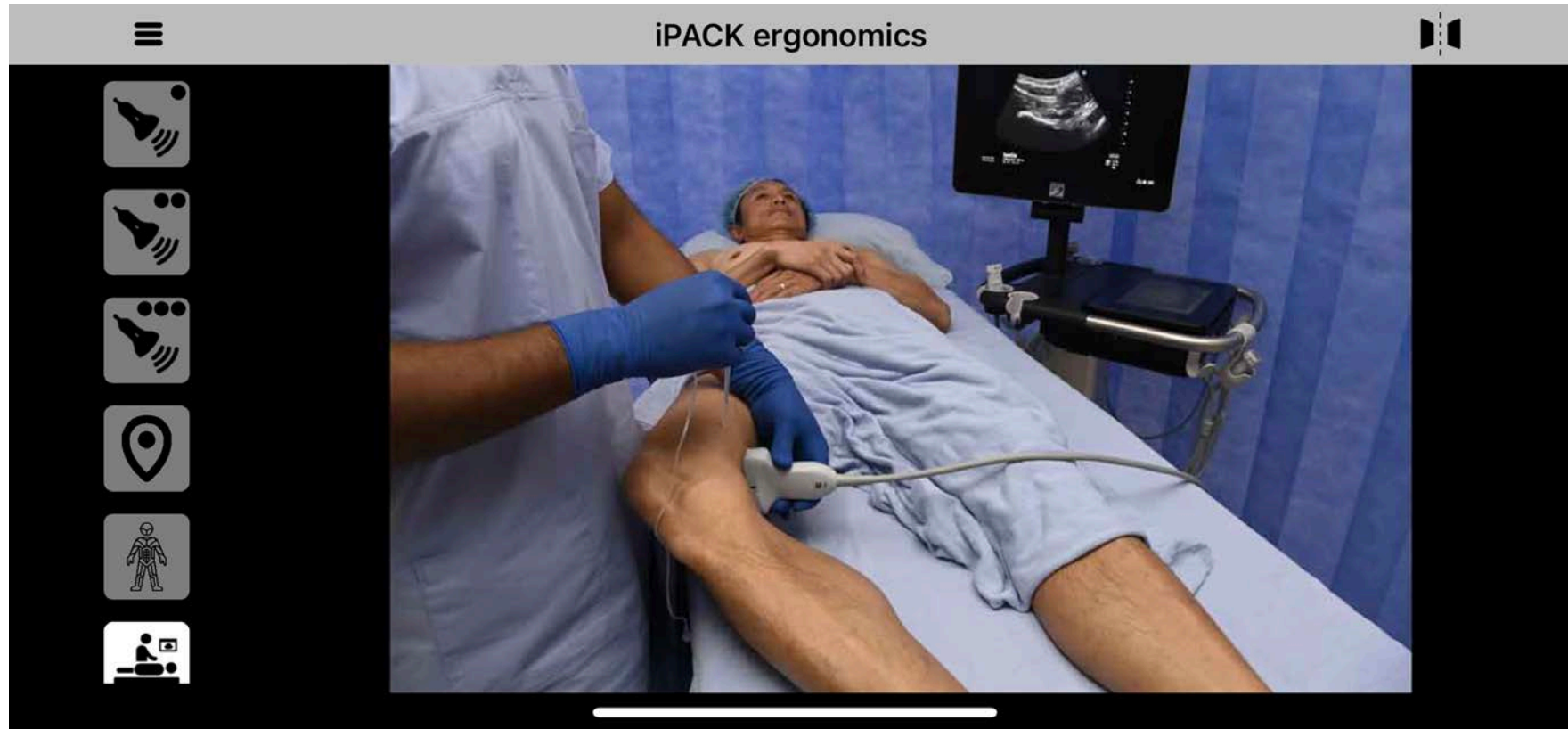
- None. Motor sparing, if local doesn't spread too far posteriorly to sciatic nerves (peroneal/tibial)

## Complications

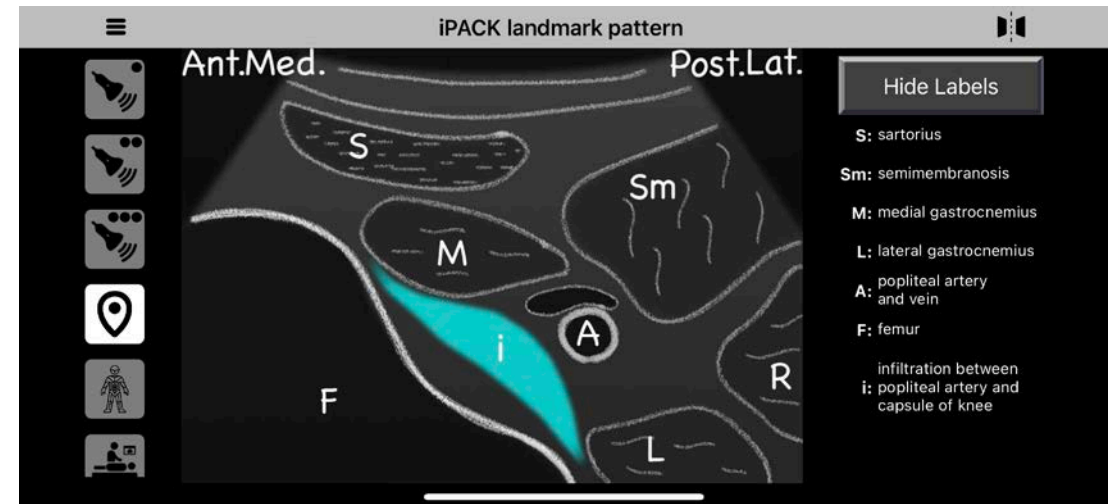
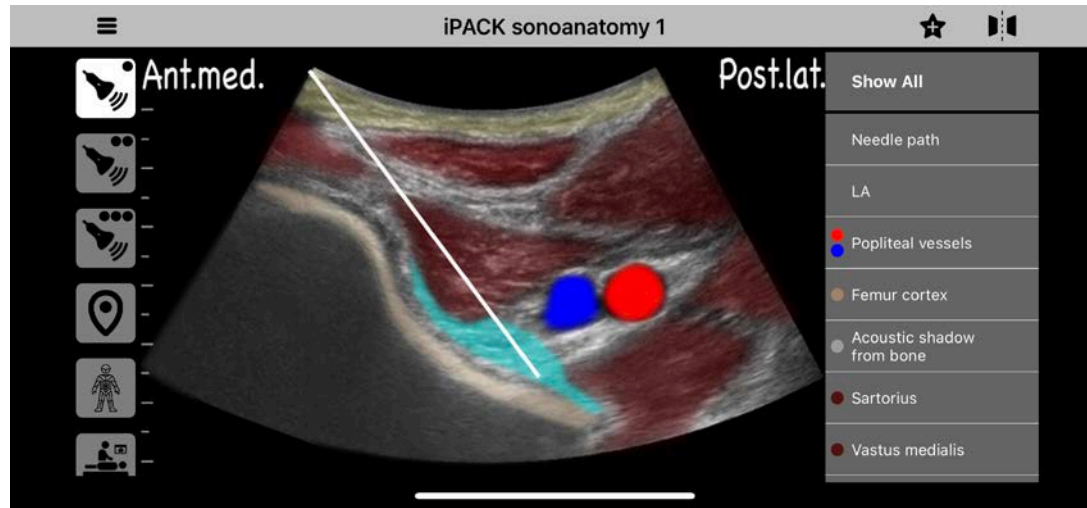
- Vascular injury, motor weakness with LA spread



# Total Knee: iPACK



# Total Knee: iPACK



# Example of Regional Anesthesia

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## Shoulder Surgery

- ISB + GA or surgical strength local anesthetic
- Phrenic sparing block + GA

## Elbow Surgery

- BPB + intercostobrachial

## Hip Surgery

- Lumbar Plexus block + Spinal Anesthetic (GA)
- Fascia Iliaca block + Spinal Anesthetic (GA)
- PENG + Spinal Anesthetic (GA)
- Combined Spinal Epidural or Lumbar Epidural + GA

## Knee Surgery

- Adductor Canal block + Sciatic Block (IPACK) + Spinal (GA)
- Femoral block + Sciatic Block (IPACK) + Spinal (GA)
- Lumbar Plexus block + Sciatic Block (IPACK) + Spinal (GA)

# Patient Education

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- “Numbing Medicine” placed around the nerves that run down and innervating the area you’re having surgery
- Similar to a numbing injection at the dentist
- We give you sedation while the block is being performed
  - Most people don’t remember having the block placed because the sedation provides some amnesia around the time of administration
- Compared to a patient who had the same procedure, but no numbing block, patient’s who have a block do much better from a pain-control perspective afterwards
- PNB are not required
- Sensation tends to return quickly after the block begins wearing off-take pain meds!
- Consider need for patient ambulation

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