

ULTRASOUND-GUIDED PAEDIATRIC RA

Sonoanatomy differences in children

- The size, position and Ultrasound (US) reflective properties of muscles, nerves, vessels changes with growth
- Differences are more marked in the younger patients
 - o Nerve structures are smaller and more superficial
 - o Poorly mineralized bone have increased US transparency in infants, allowing better neuraxial imaging
 - Spinal canal contents can be well-visualised in <6 months, 'intermittently' seen in inter-spinous spaces by 1 yr, and poorly seen in >30 months
 - Nerves are poorly echogenic in a fatty and more hydrated environment
 - Aponeuroses are more echogenic
 - Plane / compartment blocks are easier
 - Lower arterial and venous pressures makes vessels easily compressible
- High frequency probe >10 MHz, with smaller surface area proportionate to the size of the child should be used. (US beam will be narrower and less penetrating as a result)

Remember:

High frequency= high resolution, poor penetration

Low frequency= low resolution, great penetration

Epi / perineurium is hyperechoic (white)

Nerve tissue is hypoechoic (black)

Why US in kids?

- Warning signs of intra-vascular and intra-neural injection may be masked as the child is under GA
- Less margin for error as the smaller nerves are closer to structures such as the pleura
- Variable landmarks with age
- The US may be clearer as structures are more superficial and bones less ossified
- Congenital abnormalities can lead to misleading landmarks
- Less LA volume used makes it safer for neonates / infants with lower LA toxicity threshold and for multiple / repeat blocks to be performed

EQUIPMENT

- An ultrasound machine eg. Sonosite which is properly configured. (depth, gain and focus adjusted)
- High frequency hockey stick or linear probes, as neural structures are more superficial
- Short bevel needles with flexible injection tubing (e.g. Pajunk or Bbraun), well-flushed with saline / LA to avoid air artifacts on US image
- Sterile swabsticks for skin prep, sterile gel, drape, probe disinfectant, sterile 'probe covers', LA drug, syringes, drawing needles

DRUGS

LA

Racemic bupivacaine, levobupivacaine, ropivacaine and lignocaine are available.

The concentration used should be adjusted to the toxic limit of the LA for a given volume used.

Usual LA concentrations used are 0.2-0.25%.

LA volume: Ultrasound guidance vs landmark technique

Technique	Ultrasound guidance dosages ($\text{ml} \cdot \text{kg}^{-1}$)	Landmarks dosages ($\text{ml} \cdot \text{kg}^{-1}$)
Supraclavicular block	0.3	0.5
Infraclavicular block	0.2	0.5
Sciatic block	0.2	0.3
Femoral block	0.15-0.2	0.3
Rectus sheath block	0.1 (each side)	0.3
Thoracic PVB	Up to 0.5 (each side)	NA
TAP block	Up to 0.5 (each side)	NA
Ilio-inguinal block	0.1 (each side)	0.4

There is little evidence for the use of LA Adjuvants in PNB, except for clonidine It appears to prolong block duration by 20-50%.

References:

1. *Anesth Analg* 2007; 104:532-537.

TECHNICAL DETAILS

'SCANNING'

S: Supplies

- Equipment and drugs as above

C: Comfort

- Position yourself to the patient, and machine in an ergonomic way

A: Ambience

- Adjust room light settings if you need

N: Name of patient, procedure and site 'Time-out'

N: Nominate

- Choose your needle, transducer, helper
- Flush out all air from the needle and injectate. For children <10 kg, it may be prudent to start off with saline in your syringe, using LA only after you have confirmed the position of the needle tip.
- Choose the right size probe
 - o 25 mm footprint for <15 kg

I: Infection control:

- Disinfection of skin with swab sticks (chlorhexidine with alcohol)
- Disinfection of probe with alcohol wipes,
 - o 'no-touch' or 'sterile tegaderm for SS
 - o Full probe sheath for catheters
- Sterile gel to provide air-free interface

N: Note the machine settings

- Machine set to 'small parts' or 'nerve' and high resolution
- (unless target is >4 cm deep)
- Ensure 'multibeam' is activated

G: Gain and depth

- Adjust 'near' and 'far' gain
- Focus on the target by placing it in the center of the image and adjusting the depth

G: Go!

- Probe in non-dominant hand
- Check probe orientation
- Steady scanning hand on patient to improve proprioception and better probe fixation when needling
- If you lose your needle image, first check your hands, not the machine
- Avoid vessels by applying Color Doppler to check for vessels in all scans

Approach:

- In-plane (IP)
- Out-of-plane (OOP)
- If using PNS: aim for 'no twitch' at $<0.5\text{mA}$, with injection pressure $< 15\text{ PSI}$
- Aspirate before injection, assess for LA spread on US

☹ Pitfalls

- Advancing the needle without visualizing its tip (most common mistake!)
- Poor choice of needle entry point
- Failure to correlate sidedness of the image with regards to patient
- Failure to recognize intra-muscular injection
- Anisotropy and artifacts (enhancement, reverberation etc)

😊 Tips

- Start with easier blocks first (femoral before PVBs)
- Catheters are generally difficult to identify, their position can be confirmed by gentle pulling (look for tissue movement) and by scanning for the spread of injectate
- Machine can fail, anatomy is still important

Common US-guided blocks

Truncal - TAP

Anatomy	Indications	Side effects	Tips
Deposit LA between the internal oblique and transversus abdominis muscles, where the ant rami of T1-T6, L1 lie	<p>Useful for unilateral abdominal surgeries (below the umbilicus) eg. open appendectomy, inguinal hernia repair, iliac crest bone graft</p> <p>Performed bilaterally for laparoscopic procedures</p> <p>Subcostal approach covers surgeries above the umbilicus eg. cholecystectomy</p>	<p>Intra-peritoneal injection</p> <p>Bowel perforation</p> <p>Visceral injury</p>	<p>Does not provide visceral analgesia</p> <p>Probe is placed transversely between the iliac crest and the costal margin</p> <p>Insert needle IP in anterior-posterior direction to reach the plane posterior to the mid-axillary line. (to block the lateral branches)</p>

Truncal - Thoracic Paravertebral blocks

Anatomy	Indications	Side effects	Tips
LA is deposited in the wedge-shaped space bounded by the vertebral column, parietal pleura, and the superior costotransverse ligament	<p>Useful for unilateral thoracotomies (T5) and upper abdominal surgeries (T10), renal surgeries (T12)</p> <p>May be done bilaterally for sternotomies</p>	<p>Avoid in empyema and tumour extending into the paravertebral space</p> <p>Pneumothorax, epidural spread, dural tap</p>	<p>Probe in transverse paramedian position</p> <p>IP approach allows good needle visualization</p>

Truncal - Rectus sheath

Anatomy	Indications	Side effects	Tips
<p>LA is injected between the rectus muscle and posterior sheath</p> <p>The rectus muscle is adherent to the anterior sheath between the xiphisternum and umbilicus</p> <p>The posterior sheath is not adherent and allows spread up and down</p>	<p>Pyloromyotomy</p> <p>Umbilical hernia</p> <p>Duodenal atresia</p> <p>Laparoscopic procedures</p>	<p>Intra-peritoneal injection</p>	<p>Probe transversely above umbilicus</p> <p>Careful of epigastric vessels within rectus muscle</p> <p>IP approach is safer</p> <p>Advance needle until a 'give' is felt. Avoid intra-muscular injection</p>

Truncal - Ilioinguinal/iliohypogastric nerve block

Anatomy	Indications	Side effects	Tips
The nerves are seen as small hypoechoic ellipses between the internal oblique and transversus abdominis muscles	<p>Inguinal hernia repair</p> <p>Hydrocele</p> <p>Orchidopexy (scrotal incision not covered)</p>	Femoral nerve block (up to 10% in landmark technique)	<p>Place one end of the probe on the ASIS, the other end pointing towards the umbilicus</p> <p>Scan for the 3 muscle layers, with the external oblique muscle thinning out to form its aponeurosis</p> <p>Both IP or OOP approaches may be used</p>

Limb blocks - Sciatic nerve block

Anatomy	Indications	Side effects	Tips
<p>Enters the gluteal region from the pelvis through the greater sciatic foramen</p> <p>Passes between the ischial tuberosity and greater trochanter down the leg</p> <p>Often accompanied by the posterior cutaneous nerve medially. Usually divides into the tibial and peroneal components at the apex of the popliteal fossa</p>	<p>Ankle and foot surgeries</p> <p>Combined with saphenous or femoral nerve block for all surgeries below the knee</p>	<p>Intravascular injection</p> <p>LA toxicity</p>	<p>Lateral IP popliteal approach is commonly used</p> <p>Place probe transversely on the popliteal crease, with patient in a lateral position, operative side up</p> <p>Color Doppler to identify popliteal vessels</p> <p>Trace the nerve distally to visualize it dividing</p> <p>Flex the ankle to visualize nerves rocking in its fascial plane ('see-saw sign')</p>

Limb blocks - Femoral nerve block

Anatomy	Indications	Side effects	Tips
<p>At the level of the inguinal ligament, it lies deep to the fascia lata and fascia iliaca, lateral to the femoral vessels, which lie in a separate fascia compartment</p> <p>LA is deposited after 2 'pops' (fascia lata, followed by fascia iliaca), above the iliacus muscle</p>	<p>Fractures of the femur</p> <p>Analgesia for knee surgeries</p> <p>Combined with sciatic nerve for all surgeries below the knee</p>	<p>Vessel puncture leading to haematoma</p>	<p>Use color Doppler to identify the femoral vessels and superficial circumflex iliac artery, which pass directly over the femoral nerve</p> <p>The nerve is found lateral to the artery in a triangular hyperechoic area</p>

Limb blocks - Adductor canal (Subsartorial canal block)

Anatomy	Indications	Side effects	Tips
The saphenous nerve (the largest sensory nerve branch of the femoral nerve) may be blocked at the adductor canal, where it crosses the femoral artery from lateral to medial, beneath the sartorius along the medial side of the knee	Saphenous nerve block when combined with sciatic block provides opioid-sparing analgesia for knee surgeries, with the theoretical advantage of avoiding quadriceps weakness		<p>Place the probe on the medial aspect of the mid-thigh</p> <p>Trace the femoral artery to the point just before it dives posteriorly to form the popliteal artery</p> <p>The LA is deposited at the adductor hiatus at this point</p>

Limb blocks - Supraclavicular brachial plexus block

Anatomy	Indications	Side effects	Tips
The 'bunch of grapes' (cluster of hypoechoic nodules) appearance of the plexus is found posterolateral to the subclavian artery, which lies on or just anterior to the first rib. The cervical pleura at both sides of the rib 'slides' with respiration	For upper limb surgeries, excluding the shoulder	Pneumothorax, phrenic nerve palsy, Horner's syndrome, vascular injury	<p>Probe is placed parallel to and just behind the clavicle, pointing into the thorax</p> <p>Color Doppler must be used to check for vessels</p> <p>IP lateral to medial approach, injecting LA as you go, aiming to reach the ulnar portion of the plexus, next to the subclavian artery</p>

References

1. C Gerrard, S Roberts. *Ultrasound-guided regional Anaesthesia in the paediatric population*. *ISRN Anesthesiology* Volume 2012 (2012), Article ID 169043, 7 pages
2. Alderhey Children's Hospital Sonosite course resource
3. Ecoffey, C. (2012), *Safety in pediatric regional anesthesia*. *Pediatric Anesthesia*, 22: 25–30