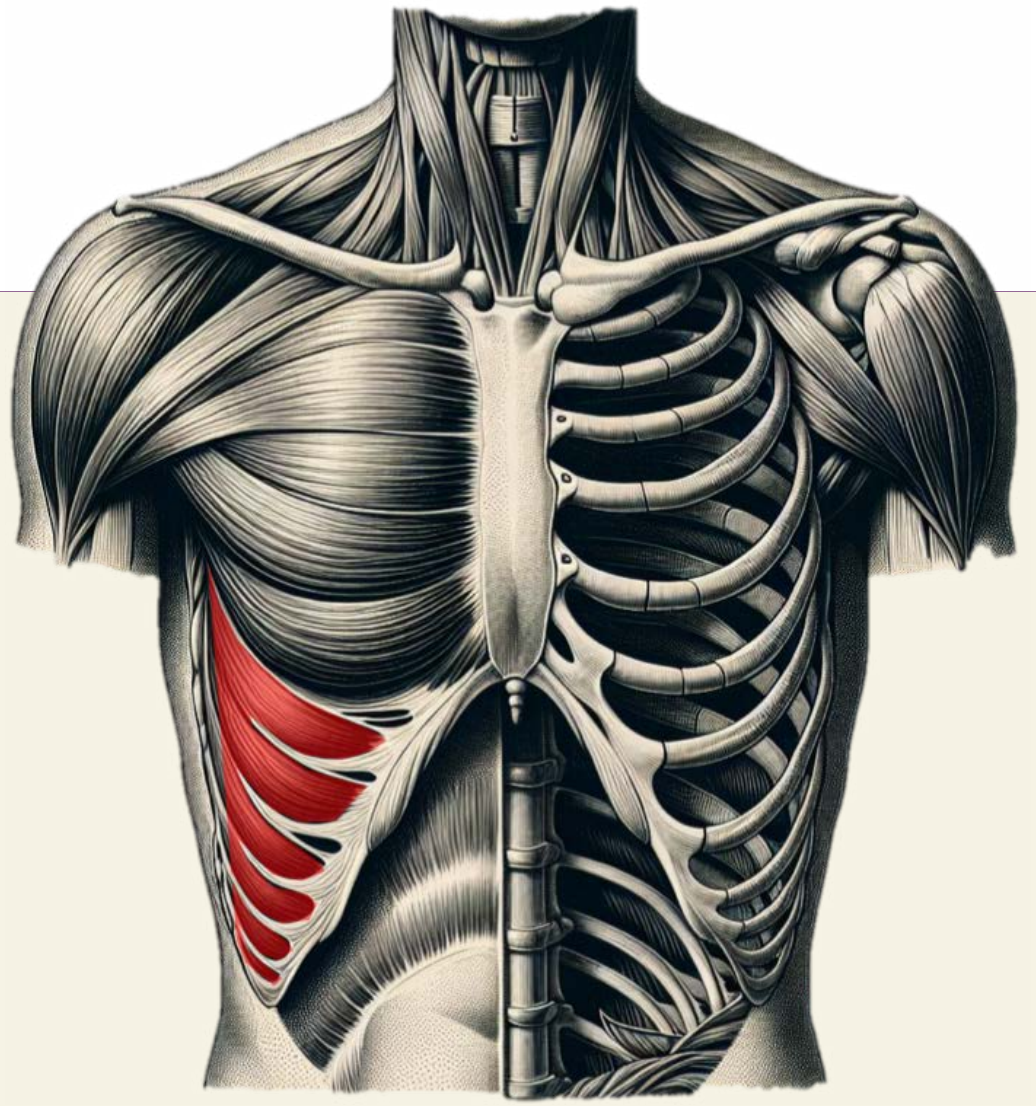
SERRATUS ANTERIOR PLANE BLOCK

EVIDENCE-BASED EDUCATION PACKAGE



Dr Christopher Partyka | Dr Daniel Gaetani | Dr Timothy Manion | Prof Kate Curtis

Authors

Dr Christopher Partyka

Staff Specialist, Emergency Medicine, Royal North Shore Hospital

Staff Specialist, Prehospital and Retrieval Medicine, NSW Ambulance (Aeromedical Operations)

Clinical lecturer, Faculty of Medicine and Health, University of Sydney

Dr Daniel Gaetani

Staff Specialist, Emergency Medicine, Campbelltown and Camden Hospitals

Conjoint lecturer, Western Sydney University and University of New South Wales

Dr Timothy Manion

Advanced Trainee, Emergency Medicine, Royal North Shore Hospital

Prof Kate Curtis

Professor Trauma and Emergency Nursing, Faculty of Medicine and Health, University of Sydney

Registered Nurse, Emergency Department, Wollongong Hospital

Director Emergency Research, Illawarra Shoalhaven Local Health District

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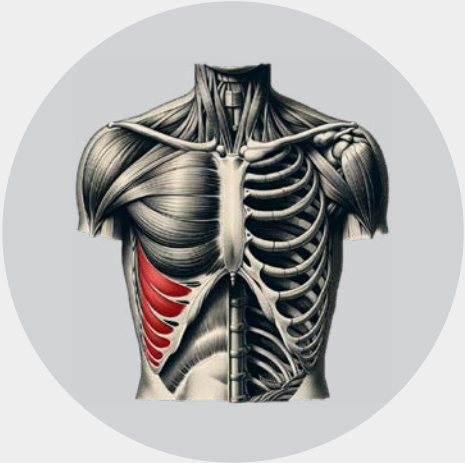

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Contents

Introduction

General principles of rib fracture management

Rib fractures are a common consequence of blunt thoracic trauma, associated with significant morbidity and mortality due to pain-induced respiratory compromise.[1] Physiologically, the innervation of the ribs by the intercostal nerves leads to significant pain that inhibits deep breathing, coughing, and mobilisation.

This leads to atelectasis, retained secretions, and ultimately pneumonia in up to 33% of elderly patients (with a mortality of 22%), and 17% of younger patients (with a mortality of 10%).[2] The mainstay of management is therefore analgesia in order to maintain pulmonary hygiene.[3]

The emergence of rib fracture bundles of care throughout Australia, such as Chest Injury Pathway (ChIP) protocols, have provided evidence-based recommendations to medical officers, nursing staff and allied health for the coordination of early, aggressive and multidisciplinary management of patients with rib fractures.[4]

The core principles are early identification, optimal analgesia, breathing exercises and mobility, with input from emergency medicine clinicians, physiotherapists, pain services and trauma services, and support from cardiothoracic, intensive care and aged care teams as required.[5]

ChIP protocols have been shown to improve the delivery of healthcare services and reduce the rate of pneumonia among patients with isolated chest trauma.[6]

Optimal analgesia for rib fractures necessitates a multimodal approach to achieve effective pain relief.

Systemic opioids, while commonly used, are associated with risks such as sedation and respiratory depression, and excessive use has been linked to poorer outcomes in patients with rib fractures.[7]

Regional anaesthesia, which has long been used in anaesthetic and pain management practices, is increasingly being adopted in emergency departments as an adjunct for pain control in rib fracture management.

General principles of regional anaesthesia (including plane blocks)

Regional anaesthesia involves the administration of local anaesthetic near nerves to inhibit pain transmission, providing targeted analgesia without compromising consciousness.[8]

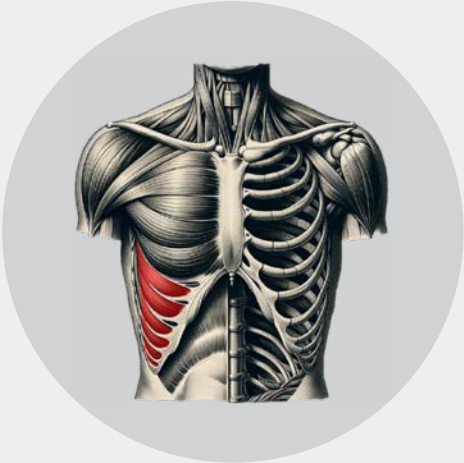
Plane blocks, a subset of peripheral nerve blocks, involve the deposition of local anaesthetic within a fascial plane, aiming to anaesthetise both the nerves traversing that plane and the peripheral nociceptors of surrounding structures.[9]

The adoption of plane blocks has increased notably alongside the widespread use of ultrasound guidance, offering clinicians a safer alternative by allowing the administration of high-volume, low-concentration local anaesthetic into fascial planes distant from critical anatomical structures.[9]

Objective

Plane blocks are now a common technique among Australian emergency clinicians, with the fascia iliaca block being considered a standard of care for managing neck of femur fractures.

This guide is intended for clinicians already proficient in the principles of plane blocks – including aseptic technique, risk management, patient monitoring following high-dose local anaesthetic administration, and ultrasound application – and aims to provide guidance on the application of these skills in performing a serratus anterior plane block.



Serratus anterior plane block

The serratus anterior plane block (SAPB) is an ultrasound-guided regional anaesthesia technique that provides analgesia to most of the hemithorax.[10] It is a technically simple and relatively safe intervention for the emergency treatment of rib fracture pain and can be completed in an efficient manner[11] without the complexities and risks attributed to techniques such as thoracic epidurals and intercostal or paravertebral blocks.[12]

The addition of this block to standard rib fracture care significantly increases the proportion of patients who experience a meaningful reduction in their pain score while also reducing in-hospital opioid requirements.[13]

Mode of action

The SAPB requires the injection of a low-concentration, high-volume local anaesthetic solution into a tissue plane either superficial or deep to the serratus anterior muscle. This results in the blocking of the lateral cutaneous branches of the intercostal nerves (T2–T9), and sometimes the long thoracic and thoracodorsal nerves.[14]

The SAPB provides analgesic effect to anterolateral rib fractures between T2–9 but notably does not cover the pleura. Whilst the initial teaching of this technique suggested that only anterolateral rib fractures benefit from a SAPB, evidence suggests that posterior rib fracture may also benefit from this block, due to the spread of anaesthetic through the disrupted tissue planes created by the fractures.[15-17]

The deposition of local anaesthetic to the superficial serratus plane may provide broader spread of analgesic effect,[18] and carries a lower risk of pneumothorax, as the needle remains distant from the pleura.[19] As such, this will be the technique focused on in this guide. However, under conditions where there is distorted sonoanatomy (e.g. subcutaneous emphysema or haematoma), and the superficial plane is not readily identified, a deep serratus plane block could be performed.

Local anaesthetic options

Three agents, ropivacaine, bupivacaine, and levobupivacaine are effective for serratus anterior plane blocks. Ropivacaine and levobupivacaine may be preferred over bupivacaine particularly in patients at risk for cardio- or neurotoxicity.[20] Ropivacaine may offer superior pain relief and may be especially advantageous when higher volumes are required.[21]

The addition of dexamethasone to serratus anterior plane blocks is supported by clinical evidence for its ability to prolong and enhance postoperative analgesia,[22] however, there is a paucity of evidence into its use for acute rib fractures in the emergency department. There are concerns that the combination of ropivacaine and dexamethasone can rapidly crystalise even at very low concentrations of dexamethasone – therefore this solution is not recommended in routine practice.[23,24]

Table 1: Comparison of commonly used regional anaesthetic agents

Drug	Concentration	Max dose	Maximum volume (ml)**					
			40kg	50kg	60kg	70kg	80kg	90kg+
Ropivacaine 0.375%*	3.75mg/ml	3mg/kg	32	40	48	56	64	72
Levobupivacaine 0.25%	2.5mg/ml	2mg/kg	32	40	48	56	64	72
Bupivacaine 0.25%	2.5mg/ml	2mg/kg	32	40	48	56	64	72

* *20 mL ropivacaine 0.75% diluted with 20 mL NaCl 0.9% (total 40 mL of ropivacaine 0.375%).*

** *Note these are maximum safe dosing. Clinical effects will be seen at lower dosing, therefore we recommend standardised dosing (see below).*

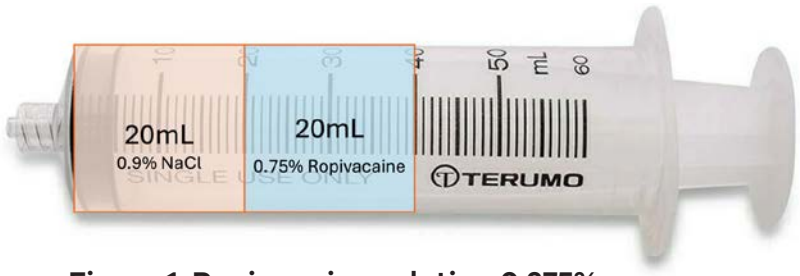


Figure 1. Ropivacaine solution 0.375%

For ease and safety of dosing ropivacaine 0.375%, consider adopting a simplified safe dosage guideline (see Table 2).

Table 2: Suggested safe dosing of ropivacaine 0.375%

Drug	Safe and effective dose (ml)		
	<60kg	60-70kg	>70kg
Ropivacaine 0.375%*	30	35	40

* *20 mL ropivacaine 0.75% diluted with 20 mL NaCl 0.9% (total 40 mL of ropivacaine 0.375%).*

Dose limits

Adhere to weight-based maximum doses of individual local anaesthetics.

Be conscious of concurrent local anaesthetic administration. For example, patients with concurrent neck of femur fracture, lacerations requiring repair, or further procedures required.

→ **Always adhere to local guidelines regarding medication use and dosage.**

Ultrasound needle guidance

Ultrasound guidance is a key skill required for the safe completion of the SAPB.

A detailed understanding of ultrasound needle guidance (including in-plane and out-of-plane techniques) is required. Familiarity and general competence with image optimisation or ultrasound-guided procedures is strongly recommended prior to the commencement of this training.

Ultrasound technique specific to SAPB

- High-frequency linear probe is used in a sterile probe cover
- In-plane approach, advancing under real-time ultrasound to the target fascial plane
- Hydrodissection is visualised with small aliquots of saline/local anaesthetic to confirm correct plane before injection of total amount

Indications

- Rib fractures
  - Anterolateral rib fractures between T2–9
  - May benefit posterior rib fractures, as described above
- Pleural drain insertion and tolerance

→ **Note: SAPB does not anaesthetise the pleura.**

Contraindications

Absolute contraindications

Alternatives to serratus anterior plane block should be sought in patients with:

- Localised infection at the site of injection
- Patient refusal
- Absolute contraindication to ropivacaine administration
  - Known allergy to local anaesthetics

Relative contraindications

Alternatives to serratus anterior plane block should be considered in patients with:

- Distorted or difficult to visual anatomy, for example:
  - Subcutaneous emphysema
  - Obesity
  - Atrophy of chest wall musculature (e.g. in the elderly)
  - Fibrosis or scarring from previous surgery (e.g. mastectomy)

→ **Consider deep block as an alternative.**

- Severe coagulopathy (e.g. DIC)
- Relative contraindications to ropivacaine administration
  - 2nd and 3rd degree heart block without a pacemaker
  - Amiodarone therapy
  - Documented severe liver disease

→ **Note: that particularly in the superficial, ultrasound-guided SAPB, the risk of vascular injury is minimal, and hence therapeutic anticoagulation itself should not be considered a contraindication.**

Alternatives

- **Other regional blocks:** Erector spinae plane (ESP) block (especially for posterior rib fractures), intercostal nerve block, paravertebral block, thoracic epidural
- **Systemic analgesia:** Opioids, non-steroidal anti-inflammatory drugs (NSAIDs), paracetamol

Consent

Please refer to local guidelines regarding the requirements for written vs. verbal consent for peripheral nerve blocks (i.e. as in a fascia iliaca block (FIB)). For this guide, verbal consent, documented in the procedure note in the patient's medical record, is satisfactory for a SAPB.

Consent should involve a discussion of the indication – to reduce pain, opioid use and reduce risk of morbidity due to rib-fracture related pneumonia.

Risks of pneumothorax, local anaesthetic systemic toxicity, and haematoma should be made known to the patient (or a person responsible).

If the patient is unable to consent (e.g. due to a history of cognitive impairment), consent should be sought from a person responsible. If this is not feasible, it is reasonable to proceed under emergency consent and duty of care.

Potential complications

- **Pneumothorax:** Due to proximity to pleura, but risk is low with ultrasound guidance and a superficial SAPB approach
- **Local anaesthetic systemic toxicity (LAST):** From inadvertent intravascular injection or overdose (see Appendix A)
- **Infection, bleeding, hematoma:** Rare, minimised with aseptic technique and ultrasound
- **Nerve injury:** Rare, but possible
- **Block failure:** Due to technical error or anatomical variation

Equipment & medications

Equipment

- Large dressing pack as a sterile field, gauze and sharps tray
- Sterile gel and ultrasound probe cover
- 20–22G peripheral nerve block needle
- Sterile gloves, drapes, and chlorhexidine for skin prep
- 40–50 mL syringe for local anesthetic
- Blunt (drawing-up) needle

Medications

- Local anesthetic (e.g., ropivacaine, levobupivacaine, bupivacaine)
- 0.9% saline for dilution and hydrodissection
- Lipid emulsion available for LAST

Ultrasound setup

- Ultrasound machine placed on opposite side of needle insertion to maintain direct line-of-sight
- Linear transducer (6-13MHz), set to highest frequency
- Nerve / small parts pre-set
- Perform low level disinfection before and after procedure
- A sterile probe cover MUST be used
- Probe marker pointing anterior in relation to the patient:
  - towards the operator in the supine position
  - away from the operator in the lateral decubitus position

Patient positioning

Supine position

Most common, with the shoulder abducted to 90 degrees to expose the axilla and lateral chest wall.

The recommended supine position

- This can either be with the patient's hand behind their head, OR simply out to their side with the shoulder abducted and the elbow flexed, lying on the bed. All that is required is enough space for the probe to access the chest wall.
- Recommended position for continuity of practice and familiarity of technique, as frequently patients will have injuries that preclude moving from the supine position e.g. cervical spine precautions, or severe pain.

Needle insertion in the longitudinal plane

Including drapes and probe cover

Lateral decubitus

Alternative if needed for access or patient comfort, with the affected side up and the ipsilateral arm behind the patient's head. It is recommended to now have the probe marker facing away from the operator (to maintain known familiar sonoanatomy), and needle will enter from the RIGHT (opposite) side of the screen.

The alternative lateral decubitus position

Including drapes and probe cover

Needle insertion in the longitudinal plan

→ PRACTICE TIP

For many operators accustomed to the orientation of a FIB, consider that in the supine position for a SAPB, the tactile movement of the needle regarding the orientation of the image on screen will be reversed (i.e. the base of the needle will be pulled towards the operator to increase the depth of the needle tip).

→ PRACTICE TIP

The recommended technique for drawing up ropivacaine is to take the full 20ml NaCl 0.9% and 20ml ropivacaine 0.75% into the syringe (40ml total) and then discard as necessary for appropriate weight-based dosing. This routine both leads to consistent strength of solution and avoids potential inadvertent injection of excessive solution by an assistant.

Sonoanatomy

Supine position

Probe placement

Transverse orientation in the mid-axillary line at the nipple or fifth rib level. Palpation of the latissimus dorsi and placement of the probe at this point may be of assistance. Probe marker should be facing anteriorly.

Lateral decubitus position

Lateral decubitus

Note that the sonoanatomy will remain familiar, however the needle will be entering from the right hand (opposite) side of the screen.

→ PRACTICE TIP

Alternative positioning: Standing on the uninjured side of the patient and leaning over the patient's anterior chest wall with the US machine on the block side results in a needling orientation the same as performing FIB / vascular access. This may be difficult however in morbid obesity or space constraints.

→ PRACTICE TIP

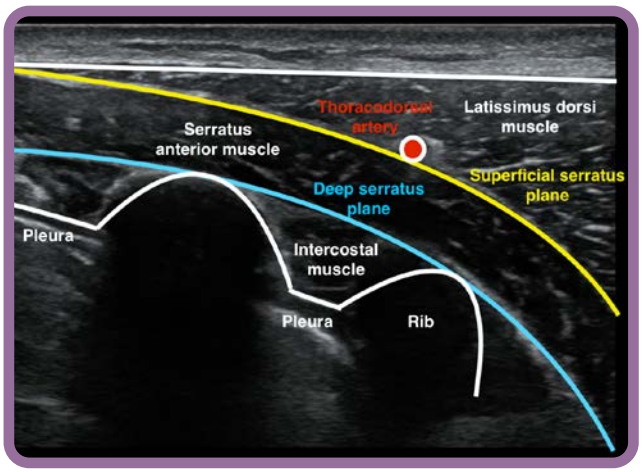
Once hydrodissection has been satisfactorily visualised, advance the needle tip into this pocket of fluid and administer the rest of the anaesthetic dose.

Anatomy visualisation

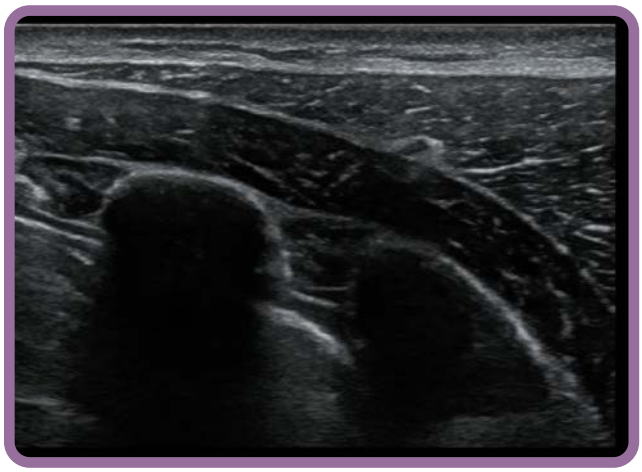
- Serratus anterior muscle overlying the ribs and intercostal muscles
- Latissimus dorsi muscle:
  - Superficial, triangular structure extending over the serratus anterior muscle
  - If not seen, slide the probe posteriorly towards the bed (in supine position)
- Rib(s)
- Intercostal muscles between the ribs
- Pleura / lung tissue
- Superficial serratus plane between the latissimus dorsi and the serratus anterior muscle
- Deep serratus plane between the serratus muscle and the ribs/IC muscles
- Thoracodorsal artery, within the superficial serratus plane, which can be further identified using colour doppler

Depth adjustment

Ensure pleura is in the bottom third of the image.



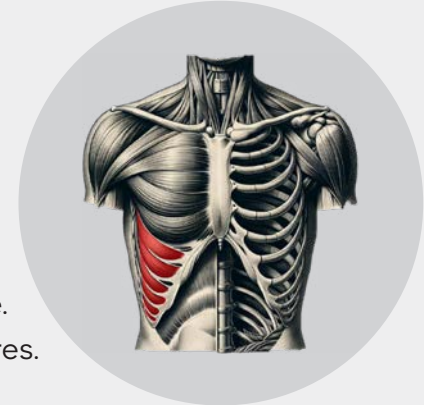
Annotated sonoanatomy



Serratus anterior plane block sonoanatomy

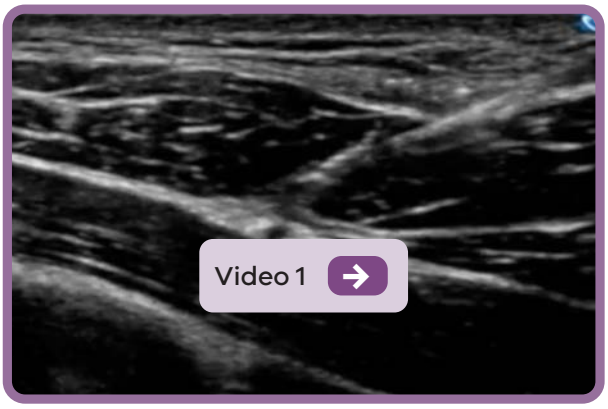
Colour doppler revealing the thoracodorsal artery

Procedural sequence



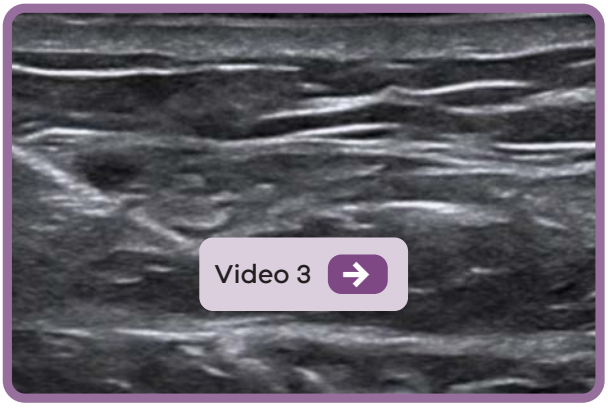
1. **Preparation**
   Cardiac monitoring, SpO_2 monitoring, IV access, 360-degree access to patient, assistant/supervisor present, informed verbal consent, and time-out to confirm side.
   Use local safety checklists/timeout procedures.
2. **Patient positioning**
   Supine with arm abducted, or lateral decubitus with the affected side up and arm behind the head.
3. **Skin prep**
   Sterile technique with chlorhexidine, drape, sterile probe cover and gloves.
4. **Ultrasound identification**
   Locate anatomical landmarks.
5. **Needle insertion**
   In-plane under ultrasound, advance anterior-to-posterior (in supine) to target plane between the latissimus dorsi and the serratus anterior muscle.
   It is essential to visualise the needle tip at all times.
6. **Aspiration**
   Ensure not intravascular.
7. **Hydrodissection**
   Inject normal saline, or a small amount of local anaesthetic, to observe the 'peeling' off the latissimus dorsi from the serratus anterior muscles, confirming placement of the needle tip within the superficial plane.
8. **Reposition**
   If hydrodissection not seen, or resistance to injection, reposition needle tip until this is satisfactory.
9. **Injection**
   If satisfactory hydrodissection, slowly inject local anesthetic, observing spread in the correct plane.
10. **Completion**
    Remove needle, apply small dressing, dispose of sharps.

Training videos



Video 1: SAPB performed to the superficial serratus plane in the lateral decubitus position, therefore the needle insertion is from the right (marker) side.

Video 2: SAPB performed to the deep serratus plane with local anaesthetic delivered adjacent to the rib.



Video 3: Hydrodissection of the superficial serratus plane.

Post-procedural care

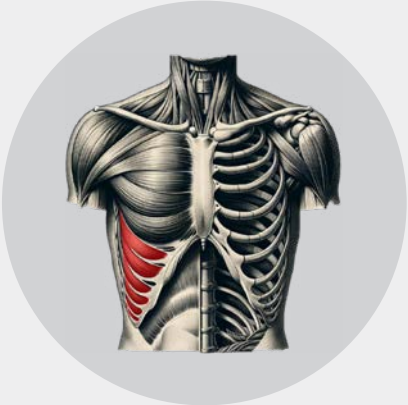
- **Monitoring:** Observe for adverse reactions (vital signs at 5, 10, 15 and 30 minutes post-procedure), remaining on cardiac monitoring until 30 minutes post procedure.
- **Documentation:** Record the procedure, medications, and patient response.
- **Follow-up:** Assess block efficacy at 30 minutes and chart additional analgesia.
  - Recommend regular simple oral analgesia + PRN oral opioid as a minimum
  - +/- PRN parenteral opioid
  - +/- Patient Controlled Analgesia (PCA)
- **Emergency preparedness:** Be ready to manage complications, including Local Anaesthetic Systemic Toxicity (LAST) and pneumothorax.

Training

The SAPB technique should be taught through a formal standardised training program. This should ideally occur locally (within a department or hospital, or across a health district) to ensure knowledge of all crucial technical components are taught and aligned with local policies and referral pathways.

It is strongly recommended that all candidates review this document as pre-reading material prior to any workshop attendance.

Path to serratus anterior block independent practice



1. **CLINICAL EXPERIENCE**
   Clinically independent in the management of patients with complex rib fractures.
2. **EDUCATION AND THEORY**
   Completion of prior learning: either evidence-based educational package or bespoke online resource.
3. **WORKSHOPS**
   Attendance of a dedicated serratus anterior block workshop.
4. **OBSERVE A BLOCK**
   Directly observe a skilled provider undertake a clinically-indicated block.
5. **PERFORMANCE OF DIRECTLY-OBSERVED BLOCK**
   A clinically-indicated block with a supervisor observing.
6. **INDEPENDENT PRACTICE**
   Supervisor endorses independent practice.

Review performance and maintain procedural currency

Training workshops

Face-to-face workshops are strongly recommended and allow for education on a larger scale. These workshops must include the demonstration of key aspects of this technique with the ability to undertake supported practice.

Table 3. A recommended timetable for a two-hour training workshop

Session		Allocated time
1	Lecture: Serratus anterior plane block: a refresher	15 min
2	SAPB in the local context of rib fracture management	30 min
3	Deliberate practice: ultrasound-guided needle placement	30 min
4	Sonoanatomy identification on volunteers	45 min

Ultrasound demonstration

Candidates should be provided the opportunity to demonstrate their ability to perform real-time, in-plane needle guidance on a model/phantom.

These models do not have to be specific for the SAPB, or other regional anaesthesia techniques.

Sonoanatomy

Candidates should be provided the opportunity to undertake the scanning of live volunteers to learn and reinforce relevant sonoanatomy. This also allows for the practice required to optimise volunteer/patient positioning and to develop procedural muscle memory for this skill.

Candidates must demonstrate how to position volunteers appropriately, undertake a scanning ultrasound and demonstrate the key anatomical landmarks listed below.

- Serratus anterior muscle
- Latissimus dorsi muscle
- Rib(s)
- Pleura
- Superficial serratus plane
- Deep serratus plane
- Thoracodorsal artery

Additionally, a discussion should be held around the anatomical variations and changes to sonographic appearance of structures between patients of different age/sex, for example the loss of latissimus dorsi muscle bulk with older age.

Credentialing

It is strongly recommended that the training phase for SAPB is undertaken in-person with direct supervision of technique and block performance. Before undertaking their own blocks, candidates should first, directly observe a clinically indicated serratus anterior block performed by a skilled provider.

How is a SAPB assessed as 'successful'?

There are two methods by which a SAPB is deemed 'successful':

1. **Observed deposition of anaesthetic solution into the serratus plane.**
2. **Patient reported pain reduction or reduction in opiate requirements.**

Following the initial face-to-face training, candidates who do not have a direct supervisor in their workplace can demonstrate competency through a remote supervisor.

For those undergoing remote supervision, a series of recorded ultrasound cine-loops demonstrating before and after local anaesthetic solution deposited to a serratus plane is a suitable method of demonstrating procedural success.

Assessment of independent practice

Candidates must undertake a clinically indicated, successful serratus anterior block that is directly supervised by a skilled provider.

Individual facilities can set their own recommendations regarding a number of directly supervised scans required prior to independent practice. However, the literature also supports supervisor endorsement as an adequate replacement for a mandatory, standardised minimum number of supervised blocks.

A checklist should be used in any summative assessment of procedural independence (see Appendix B).

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Appendix A – Local anaesthetic systemic toxicity

Always refer to local guidelines regarding the management of LAST

Signs and symptoms

LAST manifests as dose-dependent progression of neurological and cardiovascular symptoms.

- Early CNS signs include perioral numbness, metallic taste, tinnitus, and agitation, progressing to seizures or coma.
- Cardiovascular involvement may begin with hypertension or tachycardia, followed by bradycardia, conduction abnormalities (e.g., QRS widening), and ultimately ventricular tachyarrhythmias and cardiac arrest.

Management

Immediate interventions

- Stop local anaesthetic administration and remove infusion devices.
- Call for resuscitation support.
- Airway and oxygenation: Secure the airway if needed; supply 100% oxygen and hyperventilate to counteract acidosis (which exacerbates toxicity).

Seizure control:

- Administer benzodiazepines (preferred) e.g. Midazolam.
  - Mild symptoms: midazolam boluses to raise seizure threshold.
- Low dose propofol if haemodynamically stable.

Lipid emulsion therapy 20% (intralipid)

- Give in all circulatory arrest, and consider in patients with more than mild symptoms.
- Bolus: 1.5 mL/kg lean body mass over 1 minute.
  - Can be given up to 3 times, 3-5 minutes apart, if cardiovascular stability not restored OR adequate circulation deteriorates.
- Infusion: 0.25 mL/kg/min (15ml/kg/hr).
  - Double to 0.5 mL/kg/min if hypotension persists (30ml/kg/hr).
- Upper limit: 12 mL/kg within 30 minutes.

Cardiovascular support ALS modifications:

- Consider small dose adrenaline boluses (≤1 mcg/kg) to avoid potentiating dysrhythmias.
- QRS widening: Administer sodium bicarbonate (1–2 mEq/kg).
- Refractory arrest: Consider extracorporeal membrane oxygenation (ECMO).
- Initiate lipid emulsion at the first sign of severe toxicity, alongside standard resuscitation.

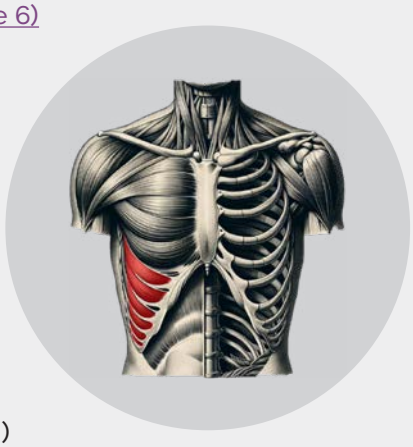
Appendix B – Checklist for independent SAPB practice

- ◯ Knowledge of indications / contraindications / complications of procedure
- ◯ Appropriate patient positioning
- ◯ Appropriate physiological monitoring
- ◯ Local anaesthetic solution preparation (including knowledge of drug dose/concentration/limits)
- ◯ Appropriate aseptic technique
- ◯ Demonstration of consistent in-plane needle guidance
- ◯ Placement of needle tip to serratus plane of choice
- ◯ Identification of the thoracodorsal artery (if visible)
- ◯ Hydrodissection of target tissue plane

Appendix C – Serratus anterior plane block flowchart

1 **IDENTIFY**
- Anterolateral, and probably posterior rib fractures
- Incorporate to ChIP pathway or alternative
- Indications + Contraindications (page 6)

2 **CONSENT**
- Document verbal consent
- Emergency consent acceptable if unable/ no NOK
- Consent (page 7)



3 **LOCATION**
- Monitored bed, assistant available
- Rescue drugs available (e.g. intralipid)

4 **EQUIPMENT**
- Ropivacaine 0.375% recommended
- Local anaesthetic options (page 4)
- Equipment (page 8)

5 **SONOANATOMY**
- Supine position recommended
- Patient positioning (page 9)
- Sonoantomy (page 17)

6 **PROCEDURE**
- Consider local safety checklists/timeouts
- Key points: sterile technique, needle tip visualisation, aspiration prior to injection, hydrodissection of the plane
- Procedural sequence (page 13)

7 **POST PROCEDURE**
- Monitoring, documentation, follow up at 30 minutes
- Emergency preparedness
- Post-procedural care (page 15)