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Ultrasound-Guided Fascial Plane Blocks of the Thorax

Pectoral I and II, Serratus Anterior Plane, and Erector Spinae Plane Blocks

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Keywords

• Thoracic wall • Chest wall • Ultrasound • Regional anesthesia • Nerve blocks • Pectoral • Serratus anterior • Erector spinae

Key points

- Ultrasound-guided thoracic fascial plane blocks provide alternative analgesic options to well-established techniques such as thoracic epidural and paravertebral blocks.
- These techniques are relatively simple and safe to perform and thus can increase the use of regional anesthesia by less-experienced practitioners and in turn extend the benefits of regional anesthesia to more patients.
- Fascial plane blocks rely on indirect and passive spread of injected local anesthetic to nerves located either within the fascial plane itself or within adjacent compartments; variable efficacy is therefore expected.
- The evidence base for these techniques is accumulating steadily and initial results are very encouraging, especially for added benefit compared with systemic analgesia alone.

Continued

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Continued

- These techniques involve injection of relatively large volumes of local anesthetic into well-vascularized areas, and practitioners must be vigilant for delayed local anesthetic systemic toxicity from systemic absorption.

INTRODUCTION

Regional analgesia of the thorax has traditionally been limited to thoracic epidural analgesia, thoracic paravertebral blocks, or intercostal blocks. In recent years, a new class of ultrasound-guided peripheral nerve blocks has emerged. Instead of targeting individual nerves or plexi, local anesthetic is injected into a plane between 2 fascial layers and subsequently spreads to nerves traveling within that interfascial plane or to adjacent tissue compartments containing nerves. At the time of this writing, the most prevalent of these fascial plane blocks of the thorax are the pectoral type I and II blocks (PECS I and II), serratus anterior plane (SAP) block, and the erector spinae plane (ESP) block. The aim of this article is to describe the technical performance of each block and summarize the indications, current evidence base, and future avenues for research.

ANATOMIC CONSIDERATIONS

The innervation of the thorax is primarily derived from the T1-T6 spinal nerves. These divide soon after emerging from the intervertebral foramina into dorsal rami, which ascend posteriorly to innervate the muscles and skin (that lie along the vertebral column) of the back, and ventral rami, which are continuous with the intercostal nerves (Fig. 1). Each intercostal nerve travels anteriorly in the intercostal space between internal and innermost intercostal muscles and along the inner and caudal aspect of the relevant rib. Numerous branches arise along the course of each intercostal nerve to supply the various bony and muscular structures of the thoracic cage [1]. A lateral cutaneous branch arises from the main nerve trunk near the costal angle and close to the midaxillary line, ascends superficially through the overlying muscle layers to split into anterior and posterior divisions, and supplies the skin and subcutaneous tissues over the anterolateral and posterolateral thorax. The lateral cutaneous branch of the T2 spinal nerve is particularly important, as it is the main contributor to the intercostobrachial nerve, which innervates most of the axilla [2,3]. At the same time, it must be noted that there is significant communication and anastomosis between adjacent spinal nerves and their branches, and thus the pattern of sensory innervation to any given area of tissue is complex and nonsegmental. Each intercostal nerve terminates in an anterior cutaneous branch that innervates the parasternal area and midline, with a significant degree of crossover innervation [4].

Several other important nerves supply the thorax and may need to be targeted for complete analgesia or anesthesia [3]. The lower branches of the

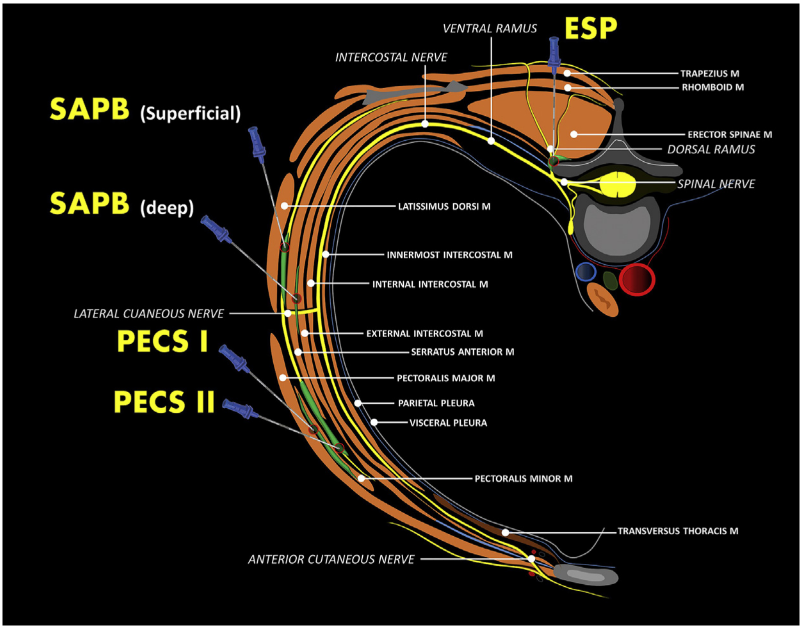

Fig. 1. Each thoracic spinal nerve divides into a dorsal ramus and ventral ramus. The dorsal ramus divides into medial, intermediate, and lateral branches as it ascends and supplies the posterolateral aspect of the thorax. The ventral ramus is continuous with the intercostal nerve and runs anteriorly between internal and innermost intercostal muscles. Numerous branches are given off along its course to supply muscles and rib. A lateral cutaneous branch arises at the costal angle in the midaxillary line and its anterior and posterior divisions innervate the anterolateral aspect of the superficial thoracic wall. The intercostal nerve terminates in the parasternal area as an anterior cutaneous branch. What is not illustrated are the numerous anastomoses between adjacent intercostal nerves and the crossover innervation that overlaps the midline. The location of injection of the PECS I and II blocks, the SAP block, and ESP block are illustrated. (*Courtesy of* Dr Vicente Roqués, Murcia, Spain.)

superficial cervical plexus, the supraclavicular nerves, provide cutaneous innervation of the "cape" of the shoulder and thus the anterior-superior aspect of the thorax. Several branches of the brachial plexus are responsible for motor and nociceptive innervation of thoracic muscles and are often overlooked as contributors to thoracic pain; these include (1) the medial and lateral pectoral nerves to pectoralis minor and major muscles, (2) the thoracodorsal nerve to latissimus dorsi, and (3) the long thoracic nerve to serratus anterior muscle.

ULTRASOUND-GUIDED PERIPHERAL NERVE BLOCK TECHNIQUES

General considerations

Ultrasound-guided peripheral nerve blocks of the thorax are, almost without exception, fascial plane blocks. As the individual nerves are too small to consistently visualize and target, the general principle is to inject relatively large volumes of local anesthetic (20–40 mL in adults; 0.2–0.4 mL/kg in children) into an interfascial plane, whereupon it spreads to nerves traveling within that plane or spreads to adjacent compartments (eg, the paravertebral space) that contain the target nerves. The pattern and extent of spread, not surprisingly, exhibits interindividual variability, which in turn contributes to a variable mass of local anesthetic reaching and acting on the nerves. As a result, differential blockade is a commonly observed phenomenon (analgesia > sensory > motor block) [5,6], and a degree of interindividual variation in block efficacy can be expected.

A common error with all fascial plane blocks is injection into muscle rather than the fascial plane. Intramuscular injection can be recognized by localized and diffused expansion of the muscular layer, as opposed to the appearance of an anechoic "pocket" of fluid that peels the muscle away from the adjacent bony or muscular layer. It is helpful to use nonactive fluid (normal saline or 5% dextrose) for *"hydrolocation"* of the correct plane, thus minimizing inaccurate deposition and "wastage" of local anesthetic.

Depending on the technique chosen, the point of injection may be in the anterior, lateral, or posterior thorax (see Fig. 1). The choice between techniques is therefore influenced not only by the desired neural targets but also by procedural considerations related to patient positioning, presence of wound dressings or drains, and interference with the surgical field.

Preparation for performance of any of these techniques must include informed consent, monitoring of vital signs (electrocardiogram, pulse oximetry, and noninvasive blood pressure), supplemental oxygen, intravenous access, and availability of emergency equipment including a local anesthetic systemic toxicity (LAST) rescue kit [7]. The blocks may be performed in awake, sedated, or anesthetized patients as the situation dictates.

Local anesthetic dosing

The efficacy of fascial plane blocks depends on physical spread, and thus local anesthetic volumes of 20 to 40 mL or 0.2 to 0.4 mL/kg are used for single-injection techniques. There is a potential risk of LAST from systemic absorption, and maximum recommended weight-based local anesthetic dose limits must be strictly observed. Epinephrine 5 mcg/mL should be routinely incorporated into the solution, even with ropivacaine. Epinephrine has been demonstrated to decrease the systemic absorption of local anesthetic when used for truncal blocks of the abdomen [8]. As these are primarily analgesic blocks, a dilute concentration (eg, 0.125%–0.25% bupivacaine or 0.2%–0.5% ropivacaine) is appropriate, with the exact concentration determined by the planned injectate volume and maximum allowable mass of drug.

If a continuous catheter technique is used, a loading dose of 20 mL or 0.2 mL/kg may be followed by either a continuous infusion regimen of dilute local anesthetic (0.125% bupivacaine or 0.2% ropivacaine) at 8 to 12 mL/h or a programmed intermittent bolus regimen of 10 to 15 mL every 1 to 3 hours.

PECTORAL I AND II BLOCKS

The PECS I block is an interpectoral injection of local anesthetic targeting medial and lateral pectoral nerves [9] (Box 1, Fig. 2). The PECS II block is a combination of interpectoral (ie, a PECS I) and subpectoral injections that additionally target lateral cutaneous branches of intercostal nerves, long thoracic nerves, and thoracodorsal nerves [9].

Positioning and approach

The patient should be in a supine position with the ipsilateral arm abducted 45 to 90 degrees. The head of the bed may be elevated for patient comfort and the

Box 1: PECS I and PECS II block performance

Preparation

- Consent
- Intravenous access
- Monitoring
- Sedation as required (if performing before GA)

Positioning

- Supine
- Arm abducted 45 to 90 degrees
- Head turned to contralateral side
- Ultrasound machine placed within line of sight

Approach

- High-frequency linear-array transducer
- 50 to 80 mm 22G block needle
- In-plane (superior medial to inferior lateral)

Technique Steps—PECS I—Interpectoral injection

- Place transducer in parasagittal plane below clavicle
- Identify PM and Pm, AA and AV, second to third ribs, and pleura below
- Rotate caudad part of transducer toward axilla over third and fourth ribs
- Deposit 10 to 20 mL or 0.1 to 0.2 mL/kg of LA between PM and Pm near pectoral branch of TAA

Technique Steps—PECS II—Subpectoral injection

- A PECS II block consists of the PECS I plus this subpectoral injection
- Advance needle from PECS I endpoint, through Pm to identify plane between Pm and SA
- Deposit 20 to 30 mL or 0.2 to 0.3 mL/kg of LA in this plane

Clinical Pearls

- Use color flow Doppler to identify blood vessels and aspirate before injection to avoid intravascular injection
- Identify the pleura before needle insertion
- Inject nonactive fluid (saline or dextrose) to identify fascial plane before LA injection so as to minimize wastage
- Use the rib as a landmark and backstop for safety when performing the subpectoral injection

Potential Complications

- Pneumothorax
- Vascular injury and hematoma formation
- LAST

Abbreviations: AA, axillary artery; AV, axillary vein; GA, general anesthesia; LA, local anesthetic; PM, pectoralis major; Pm, pectoralis minor; SA, serratus anterior; TAA, thoracoacromial artery.

patient's head turned to the contralateral side to aid needle insertion. The practitioner stands either at the head of the patient or on the contralateral side, ensuring that the ultrasound screen is appropriately positioned in the line of sight. A high-frequency linear-array transducer, 50 to 80 mm block needle,

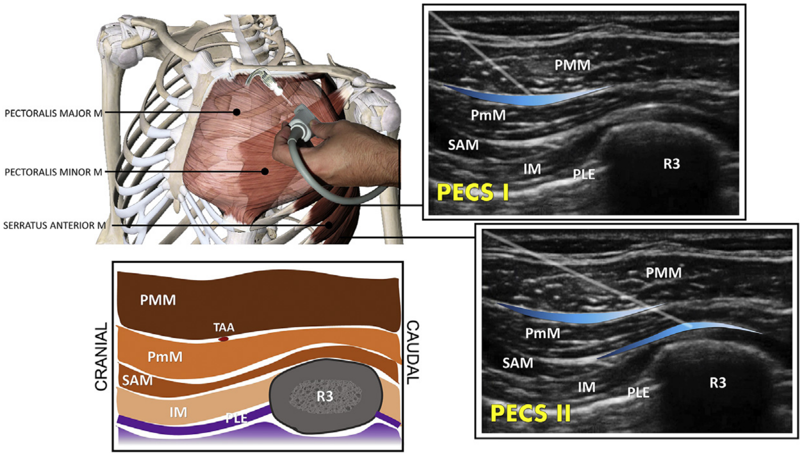

Fig. 2. When performing PECS I and II blocks, the transducer is placed in an oblique orientation parallel to the deltopectoral groove over the third rib (R3). In the PECS I block, the needle is advanced in-plane and an interpectoral injection is made between the pectoralis major muscle (PMM) and pectoralis minor muscle (PmM). In the PECS II block, the needle is advanced deeper, and a second additional injection is made between the PmM and serratus anterior muscle (SAM). The SAM is usually quite thin at this location and can be difficult to distinguish from the intercostal muscle (IM). Using the rib as a backstop prevents inadvertent puncture of the pleura (PLE). (*Courtesy of* Dr Vicente Roqués, Murcia, Spain.)

and in-plane needle approach technique in the superior-medial to inferior-lateral direction are recommended.

Technical steps

To perform the PECS I block, place the transducer in a midclavicular parasagittal plane and identify pectoralis major, minor, axillary vessels, and the pleura. Slide the transducer caudad to identify the second and third ribs and then rotate the inferior end of the transducer toward the axilla to bring it parallel to the deltopectoral groove. This rotation, combined with an in-plane needle approach, provides for better spread, particularly to the intercostobrachial nerve [9]. The needle tip is placed into the interpectoral fascial plane (between the pectoralis major and pectoralis minor) adjacent to the pectoral branch of the thoracoacromial artery and 10 to 20 mL or 0.1 to 0.2 mL/kg of local anesthetic is injected here (the higher volume is recommended if performing an isolated PECS I block).

To perform the PECS II block, in addition to the step discussed earlier, the needle is then advanced from its position in the interpectoral plane, through pec minor, into the fascial plane between pectoralis minor and serratus anterior; 20 to 30 mL or 0.2 to 0.3 mL/kg of local anesthetic is injected here. An alternative approach is to perform the deeper subpectoral injection first and then withdraw the needle into the interpectoral plane after this step.

Clinical pearls

- Use color flow Doppler to identify blood vessels in the path of the needle trajectory (cephalic vein and thoracoacromial artery) and aspirate before injection to avoid intravascular injection.
- Ensure identification of pleura before needle insertion
- Use the rib as a landmark and backstop for safety when performing the subpectoral injection.

Potential complications

- Pneumothorax
- Vascular injury to pectoral branch of thoracoacromial vessel or cephalic vein
- Local anesthetic systemic toxicity
- Temporary ‘‘winging’’ of the scapula if the long thoracic nerve is anesthetized (with subsequent motor block of the serratus anterior muscle) by local anesthetic spread

SERRATUS ANTERIOR PLANE BLOCK

The SAP block is an injection of local anesthetic into a fascial plane that is either superficial or deep to the serratus anterior muscle and primarily targets the lateral cutaneous and muscular branches of the intercostal nerves [10] (Box 2, Fig. 3). The long thoracic and thoracodorsal nerves lie in the fascial plane superficial to the serratus anterior muscle and can also be anesthetized. The superficial SAP block is anatomically similar to

Box 2: Serratus anterior plane block performance

Preparation

- Consent
- Intravenous access
- Monitoring
- Sedation as required (if performing before GA)

Positioning

- (1)Supine, arm abducted 90 degrees, or
- (2) Lateral, operative side up, arm flexed forward
- Ultrasound machine placed within line of sight

Approach

- High-frequency linear-array transducer
- 50 to 80 mm 22G block needle
- In-plane (cranial-to-caudal or caudal-to-cranial)

Technique Steps

- Place transducer in parasagittal plane below clavicle
- Identify the fourth rib by counting down
- Slide transducer laterally into the mid- or posterior axillary line over fourth rib
- Identify LD superficial to SA and SA superficial to the ribs and intercostal muscles
- Deposit 20 to 40 mL or 0.2 to 0.4 mL/kg of LA into either (1) the plane between LD and SA (superficial SAP block) or (2) the plane between SA and ribs (deep SAP block)

Clinical Pearls

- Larger LA volumes (30–40 mL) increase extent of blockade but also risk of LAST
- Inject nonactive fluid (saline or dextrose) to identify fascial plane before LA injection so as to minimize wastage
- Use the rib as a landmark and backstop for safety when performing the deep SAP block

Potential Complications

- Pneumothorax
- Vascular injury and hematoma formation
- LAST

Abbreviations: AA, axillary artery; AV, axillary vein; GA, general anesthesia; LA, local anesthetic; LD, latissimus dorsi; SA, serratus anterior; SAP, serratus anterior plane.

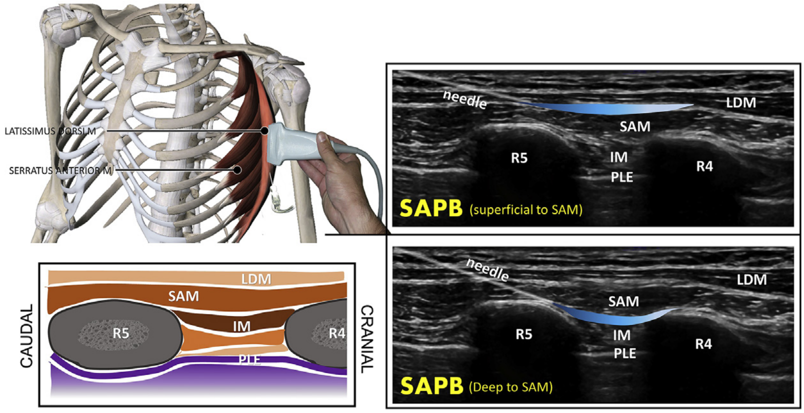

Fig. 3. When performing the SAP block, the probe is placed in a parasagittal plane over the fourth and fifth ribs (R4 and R5) in the midaxillary or posterior axillary line. In the superficial SAP block, the needle is advanced in-plane in either a caudal-to-cranial direction (illustrated here) or a cranial-to-caudal direction and an injection is made between the latissimus dorsi muscle (LDM) and the serratus anterior muscle (SAM). In the deep SAP block, the needle is advanced through SAM and an injection is made between SAM and the intercostal muscle (IM) and ribs. Note that the SAM at this level is thicker and more visible than in the PECS II block. The rib should be used as a backstop to prevent inadvertent puncture of the pleura (PLE). (*Courtesy of* Dr Vicente Roqués, Murcia, Spain.)

the subpectoral injection in the PECS II block. There is currently little evidence to support the superiority of the superficial over deep SAP block or vice versa [11,12], although it may be more intuitive to perform the deep SAP block if analgesia of the deeper bony and muscular structures is desired. Local anesthetic may also be deposited into both superficial and deep planes if desired.

Positioning and approach

The SAP block may be performed anywhere in the anatomic area between the anterior and posterior axillary line and the second to seventh ribs. The patient may be placed in either (1) a supine position with the ipsilateral arm abducted 90 degrees or (2) a lateral decubitus position with the operative side uppermost and the ipsilateral arm flexed forward out of the way. The practitioner stands either at the head of the patient or on one side, ensuring that the ultrasound screen is appropriately positioned in the line of sight. A high-frequency linear-array transducer, 50 to 80 mm block needle, and an in-plane needle approach in either a cranial-to-caudal or a caudal-to-cranial direction (a choice based primarily on ergonomics) are recommended.

Technical steps

The SAP block is generally performed at the level of the fourth rib; this can be identified by placing the transducer in a parasagittal plane just inferior to the clavicle and counting down from the second rib. The probe is moved laterally into the midaxillary or posterior axillary line, and the serratus anterior muscle is identified as the muscular layer overlying the anechoic rib shadow. Latissimus dorsi lies superficial to the serratus anterior muscle and will be thicker and more evident in the posterior axillary line. The needle tip is placed into the fascial plane either superficial or deep to the serratus anterior muscle, and 20 to 40 mL of local anesthetic is injected.

Clinical pearls

- Larger injectate volumes increase the extent of blockade [13,14] but also increase the risk of LAST.
- When performing a deep SAP block, it is advisable to aim for contact with the rib so as to minimize the risk of inadvertent pleural puncture
- If performing injection into both superficial and deep planes, injection into the deep plane first is recommended because superficial injection can hinder subsequent visualization of deeper structures.

Potential complications

- Pneumothorax
- Vascular injury to thoracodorsal artery that lies in the plane superficial to serratus anterior
- Local anesthetic systemic toxicity
- Temporary ‘‘winging’’ of the scapula if the long thoracic nerve is anesthetized by local anesthetic spread

ERECTOR SPINAE PLANE BLOCK

The ESP block is an injection of local anesthetic into the fascial plane between the erector spinae muscle and the tips of the transverse processes (Box 3, Fig. 4). The dorsal rami of spinal nerves pass through this plane and are effectively anesthetized. Blockade of the ventral rami and their branches is achieved by local anesthetic spread anteriorly into the paravertebral and epidural space [15–17]; there may also be lateral spread to the posterior divisions of the lateral cutaneous branches [18]. The targeted vertebral level should be congruent with the center of the desired area of coverage; however, a single-injection spreads to anesthetize at least 3 and as many as 6 to 8 spinal nerve territories [15,16], and thus targeting the T4 or T5 level is appropriate in most cases.

Positioning and approach

The ESP block may be performed in a lateral, sitting, or prone position as access to the patient’s back is required. A high-frequency linear-array or lower-frequency curved-array transducer may be used; the choice is determined by depth from skin to transverse processes. This is usually 4 cm or less in adults at the midthoracic region (T4–T6) but is greater at higher levels (T1–T3), and thus a curved-array transducer may occasionally be required for optimal image quality. An in-plane needle parasagittal approach in either a cranial-to-caudal or a caudal-to-cranial direction (a choice based primarily on ergonomics) is recommended.

Box 3: Erector spinae plane block performance

Preparation

- Consent
- Intravenous access
- Monitoring
- Sedation as required (if performing before GA)

Positioning

- (1) Lateral decubitus (both sides accessible from the same position), or
- (2) Sitting, or
- (3) Prone
- Ultrasound machine placed within line of sight

Approach

- High-frequency linear-array transducer
- 50 to 80 mm 22G block needle
- In-plane (cranial-to-caudal or caudal-to-cranial)

Technique Steps

- Identify target vertebral level (usually T4 or T5) by counting down from C7 spinous process or scanning down from first rib
- Place transducer in parasagittal plane 2 to 3 cm lateral to spinous processes
- Identify TPs by their squared-off profile and absence of clearly visible pleural line between them
- Insert the needle in a shallow trajectory (30–40°) to contact the far edge of the target TP
- Deposit 20 to 30 mL or 0.2 to 0.3 mL/kg of LA into the plane between ESM and TPs.

Clinical Pearls

- Transverse view of vertebrae can aid identification of the tip of the TP
- Shift the needle, and not the transducer, to achieve needle-beam alignment without losing visualization of the target TPs
- Inject nonactive fluid (saline or dextrose) to identify fascial plane before LA injection so as to minimize wastage
- Advance the needle slightly deeper off the edge of the TP if necessary, to achieve accurate fluid deposition in the plane

Potential Complications

- Pneumothorax
- LAST

Abbreviations: AA, axillary artery; AV, axillary vein; ESM, erector spinae muscle; GA, general anesthesia; LA, local anesthetic; TP, transverse process.

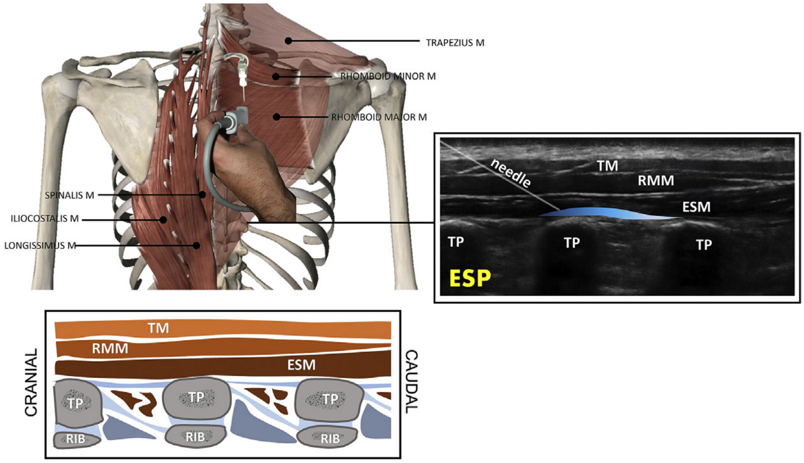

Fig. 4. When performing the ESP block, the probe is placed in a parasagittal plane over the tips of the transverse processes (TP). These are distinguished from the ribs by a more squared-off profile and absence of a hyperechoic pleural line between them. The needle is advanced in-plane in either a cranial-to-caudal direction (illustrated here) or a caudal-to-cranial direction through the trapezius muscle (TM), rhomboid major muscle (RMM), and erector spinae muscle (ESM), and an injection is made between the ESM and the TPs. The TP can be used as a back-stop to prevent excessively deep insertion, but occasionally the needle tip may have to be advanced slightly deeper off the edge of the TP to enter the fascial plane and produce the characteristic linear spread pattern of injectate. (*Courtesy of* Dr Vicente Roqués, Murcia, Spain.)

Technical steps

The desired target vertebral level is identified by either palpation of the C7 spinous process or ultrasonographic visualization of the first rib and counting down from there. The transducer is placed on the patient's back in a parasagittal plane 2 to 3 cm lateral to the midline spinous processes. The transverse processes are distinguished from the proximal ribs by their profile, which is squared-off rather than rounded, and the absence of a clearly visible pleural line between adjacent transverse processes. In the event of uncertainty, the probe can be placed initially in a transverse plane to visualize the contours of spinous process, lamina, and transverse process. The location of the transverse process tip is then marked on the skin before transducer rotation into the parasagittal plane. The fascial plane between the deep surface of erector spinae muscle and the posterior surface of the transverse processes is identified.

The needle tip is advanced in a shallow trajectory (30–40°) to contact the lateral edge of the target transverse process and placed into the fascial plane deep to erector spinae muscle; 20 to 30 mL or 0.2 to 0.3 mL/kg of local anesthetic is injected here.

Clinical pearls

- A rule of thumb for identifying the T6 transverse process is that rhomboid major muscle tapers off into its inferior border at this level.

- In-plane needle-beam alignment should not involve shifting the probe because this will result in loss of alignment with the tip of the transverse process. Instead, the *needle* should be shifted or repositioned to bring it into alignment with both the ultrasound beam and target. Scouting out the optimal insertion site and trajectory with a local anesthetic infiltration needle is also helpful.
- Correct needle tip placement is indicated by linear spread of injectate in both cranial and caudal directions that lifts erector spinae muscle off the transverse processes.
- Resistance to injection usually signifies that the needle tip is embedded in periosteum. It may be necessary to advance the needle tip slightly deeper off the edge of the transverse process to accurately position it within the fascial plane. A shallow trajectory helps in this regard.

CLINICAL INDICATIONS, CONTRAINDICATIONS, AND CURRENT EVIDENCE

The PECS I and II, SAP, and ESP blocks may be used to provide analgesia of the anterolateral thorax in many different acute and chronic pain scenarios, including postsurgical pain and thoracic trauma. The most common of these are briefly discussed later. There are few absolute contraindications to performing these blocks apart from patient refusal and physical or anatomic barriers to needle insertion. The ESP block may be the most suited to continuous catheter insertion, as the site is distant from the surgical field in most instances. These blocks can be considered in anticoagulated patients if necessary, as the site of needle insertion is relatively shallow and compressible, and hematoma formation is unlikely to have serious consequences. They are most usefully viewed as alternatives to more complex and invasive techniques such as thoracic epidural or paravertebral blocks, especially when these are not feasible or have an unfavorable risk-benefit ratio.

Pectoral I and II blocks

There are limited indications for an isolated PECS I block that only anesthetizes the pectoral muscles; examples include subpectoral implantation of a breast prosthesis or pulse generator. The PECS II block provides additional myocutaneous coverage, particularly into the axilla, and can be used in any surgical procedure on the breast and axillary region. The primary indication for the PECS II block is in breast cancer surgery. It has been shown to provide superior analgesia compared with systemic analgesia alone and seems to be as effective as thoracic paravertebral blocks in this setting [19]. It has also been combined with paravertebral blockade to provide surgical anesthesia for breast surgery [20]. A major advantage over the other regional anesthesia techniques is that the PECS II block can be performed in the supine position. Limitations include surgical concerns regarding needle insertion close to the tumor site (with a possible risk of seeding) and disruption of surgical planes of dissection by the injected fluid. The analgesic benefit may also be marginal for very minor or localized breast surgery.

Other described analgesic indications for PECS I and II blocks include cardiac surgery (both via median sternotomy [21] and minimally invasive approaches [22]), clavicular surgery [23], Port-a-Cath implantation and removal [24], and management of zoster-associated chest wall pain [25].

Serratus anterior plane block

The SAP block has been successfully used to provide analgesia in breast surgery and seems to have similar efficacy compared with PECS II block, despite not targeting the pectoral nerves [26]. The deep variant of the SAP block is preferable if there are surgical concerns regarding disruption of the axillary nodal planes of dissection or if there is postsurgical scarring of the superficial serratus anterior plane [12].

At present most of the randomized controlled trial (RCT) evidence for the SAP block is in thoracic surgery. It provides effective analgesia in video-assisted thoracoscopic surgery (VATS) [27,28] as well as thoracotomy for lung resection [29,30] or minimally invasive cardiac surgery [31]. In one RCT, a single-injection SAP block provided a longer duration of analgesia compared with multilevel intercostal nerve block, although not as long as a single-injection thoracic paravertebral block [31]. This limitation may be overcome by catheter insertion, as indicated by another RCT that found that continuous SAP blockade was as effective as thoracic epidural analgesia following thoracotomy [29].

The SAP block is also a useful option in thoracic trauma, although evidence is limited at present to case reports [32–35]. Advantages over thoracic epidural or paravertebral block include the ability to perform it in the supine position, in the presence of head or spine injuries, multisystem trauma, or coagulopathy. The site of injection does however limit its effectiveness to mainly injuries of the anterolateral chest wall.

Erector spinae plane block

The ESP block has been described in the management of a multitude of painful conditions of the thorax, including breast surgery [36–38], thoracic surgery [39,40], cardiac surgery [41–43], thoracic trauma [44,45], cancer pain [46], and persistent postsurgical pain [47,48]. The chief advantage of the ESP block over the SAP and PECS II block is that the dorsal rami and their branches are blocked, providing coverage of the posterolateral thorax [45,49]. There may also be an additional component of visceral analgesia from blockade of the sympathetic chain, although this has yet to be conclusively demonstrated.

Because the ESP block was only first described in late 2016 [47], RCTs have only recently begun to emerge; the results are highly encouraging. ESP blockade at the T5 level provided superior analgesia compared with systemic analgesia alone in breast surgery [36], although another trial suggested that the PECS II block may be more effective [37]. This may reflect a difference in axillary (T2) coverage and could be addressed by performing the ESP block at a higher vertebral level. Bilateral ESP blocks are highly effective in cardiac surgery, not only providing excellent pain control after median sternotomy but also improving patient-centered outcomes such as time to ambulation and oral intake [41]. Continuous bilateral ESP blockade has shown to be comparable to thoracic epidural analgesia in this setting [42] and may have an important role in enhanced recovery pathways after cardiac surgery [43]. A recent study comparing ESP and SAP blocks in VATS reported that although both were effective, the ESP block provided for lower dynamic pain scores and longer time to first request for analgesia [39]. Finally, as with the SAP block, it is an effective analgesic option in thoracic trauma with few contraindications; in a recently published retrospective cohort study of 79 patients, there was significant improvement in respiratory function following ESP blockade together with hemodynamic stability [44].

CURRENT CONTROVERSIES AND FUTURE CONSIDERATIONS

The mechanism of action of the SAP and ESP block remains controversial, given that some cadaveric studies [18,50] have failed to demonstrate consistent injectate spread to the ventral rami or intercostal nerves that would explain the analgesia observed in clinical practice. This is most likely because of the physical limitations of cadaver models, and additional imaging studies in live subjects [17] may shed light on this area.

It is worth noting that several other ultrasound-guided techniques for thoracic analgesia have been described in recent years, including the retrolaminar block [15,16], the midpoint transverse process to pleura block [51], the rhomboid-intercostal and subserratus plane block [52], and parasternal blocks such as the transversus thoracis plane block [53,54]. Further research is required to determine the place of these techniques in the anesthesiologist's armamentarium of analgesic options. In addition, a transverse (axial) in-plane technique has recently been described for ESP, and further studies are needed to assess its proposed advantages to the initially described parasagittal in-plane technique for ESP [55,56].

The biggest risk associated with these fascial plane blocks at present is that of LAST, with one center reporting a 1.6% incidence [57]. Pharmacokinetic studies will help to further quantify this risk and guide appropriate dosing.

One major limitation of all single-injection techniques is their limited duration of action. It is presently unclear if adjuncts such as dexamethasone or dexmedetomidine will significantly prolong the duration of fascial plane blocks in the same way as other peripheral nerve blocks. Fortunately, the SAP and ESP blocks lend themselves readily to catheter insertion. However, research is needed to determine if programmed intermittent boluses are superior to continuous infusion regimens, as suggested by anecdotal reports [58] and anatomic principles, as well as to define optimal dosing parameters.

SUMMARY

The ultrasound-guided peripheral nerve blocks of the thorax have been enthusiastically embraced principally because they are simple and safe to perform, and thus represent a more accessible alternative to the traditional regional anesthesia options of thoracic epidural and thoracic paravertebral blockade. The preliminary evidence is highly encouraging, and further comparative studies, particularly of the SAP and ESP blocks, are needed to determine if they are equally efficacious. It is possible that they may fall short, given that the very nature of these blocks involves deposition of local anesthetic distant to the desired neural targets. However, even if thoracic epidural and paravertebral blocks prove superior, this will still have to be weighed against the complexity of performance, the demands of postoperative care, secondary failure, and risk of complications and side effects, particularly hypotension.

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