Regional Anesthesia in Cardiac Surgery: An Overview of Fascial Plane Chest Wall Blocks

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Optimal analgesia is an integral part of enhanced recovery after surgery (ERAS) programs designed to improve patients' perioperative experience and outcomes. Regional anesthetic techniques in a form of various fascial plane chest wall blocks are an important adjunct to the optimal postoperative analgesia in cardiac surgery. The most common application of fascial plane chest wall blocks has been for minimally invasive cardiac surgical procedures. An abundance of case reports has been described in the anesthesia literature and reports appear promising, yet higher-level safety and efficacy evidence is lacking. Those providing anesthesia for minimally invasive cardiac procedures should become familiar with fascial plane anatomy and block techniques to be able to provide enhanced postsurgical analgesia and facilitate faster functional recovery and earlier discharge. The purpose of this review is to provide an overview of contemporary fascial plane chest wall blocks used for analgesia in cardiothoracic surgery. Specifically, we focus on relevant anatomic considerations and technical descriptions including pectoralis I and II, serratus anterior, pectointercostal fascial, transverse thoracic muscle, and erector spine plane blocks. In addition, we provide a summary of reported local anesthetic doses used for these blocks and a current state of the literature investigating their efficacy, duration, and comparisons with standard practices. Finally, we hope to stimulate further research with a focus on delineating mechanisms of action of novel emerging blocks, appropriate dosing regimens, and subsequent analysis of their effect on patient outcomes. (Anesth Analg 2020;131:127–35)

GLOSSARY

ERAS = enhanced recovery after surgery; **ESP** = erector spine plane; **FDA** = Food and Drug Administration; **HCl** = hydrogen chloride; **ICU** = intensive care unit; **IV** = intravenous; **LA** = local anesthetic; **LAST** = local anesthetic systemic toxicity; **MRI** = magnetic resonance imaging; **PECS I** = pectoralis I; **PECS II** = pectoralis II; **PIF** = pectointercostal fascial block; **RCT** = randomized controlled trial; **SAM** = serratus anterior muscle; **SAP** = serratus anterior plane; **TAP** = transversus abdominis plane; **TTMP** = transversus thoracic muscle plane

Poorly controlled acute surgical pain can be highly debilitating and has been associated with chronic pain observed in about 20% and 25%–60% of patients after sternotomy and thoracotomy, respectively.[1–4] This contributes to prolonged use of opioids after discharge, potentially facilitating national opioid epidemic. Regional anesthetic techniques may help reduce acute postoperative pain and potential development of chronic pain by reducing sensitization from noxious surgical injury as well as opioid-induced hyperalgesia.[5]

Analgesia in cardiac surgery has traditionally relied on large doses of intravenous (IV) opioids. This practice has changed because of "fast tracking" or the expectation to tracheally extubate patients shortly after admission in the intensive care unit (ICU).[6] With a wider implementation of minimally invasive surgical approaches over the last 2 decades and novel techniques in ultrasound-guided regional anesthesia, it is not unusual to achieve intraoperative conditions enabling extubation even in the operating room.[7] The use of neuroaxial techniques in cardiac surgery with full heparinization and potential hemodynamic instability has been controversial. As an alternative, due to the simplicity as well as perceived low complication risks, fascial plane chest wall blocks are gaining popularity for procedures requiring thoracotomy or sternotomy. The described fascial planes contain nerves providing sensory innervation to chest wall regions of interest (Table 1). Deposition of local anesthetic

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Table 1. Chest Wall Fascial Plane Blocks: Key Points

Block	Key Points
PECS I	• Blocks medial and lateral pectoral nerves • Local anesthetic is deposited between pectoralis major and pectoralis minor muscles at the level of the third rib • Provides analgesia to the upper anterolateral chest wall
PECS II	• Blocks lateral cutaneous branches of intercostal nerves approximately T2–T6 (long thoracic and thoracodorsal nerves) • Local anesthetic is deposited between pectoralis minor and serratus anterior muscles at the level of the third rib • Provides analgesia to the upper anterolateral chest wall
SAP	• Blocks lateral cutaneous branches of intercostal nerves approximately T3–T9 (long thoracic and thoracodorsal nerves also if superficial SAP) • Local anesthetic can be deposited above or below the serratus anterior muscle at the level of the fourth to fifth ribs • Provides analgesia to the lateral chest wall
PIF/TTMP	• Block anterior cutaneous branches of intercostal nerves • PIF: local anesthetic is deposited between the pectoralis major and intercostal muscles • TTMP: local anesthetic is deposited between internal intercostal and transversus thoracic muscle • Provide analgesia to the anterior (parasternal) chest wall
ESP	• Blocks spinal nerve dorsal and ventral rami • With injection ventral to the ESP muscle at the level T5, block from T2 to T9 is expected • Provides analgesia to the anterior, lateral, and posterior chest wall

Abbreviations: ESP, erector spine plane; PECS I, pectoralis I; PECS II, pectoralis II; PIF, pectointercostal fascial; SAP, serratus anterior plane; TTMP, transverse thoracic muscle plane.

(LA) within the fascial plane is expected to block the targeted nerves responsible for nociception related to surgical incision (Table 2). The LA spread within a fascial plane is influenced by the volume injected, and high-volume injections are expected to provide a better spread within the targeted plane.

The purpose of this review is to provide an overview of chest wall fascial plane blocks used for perioperative analgesia in cardiac surgery. Specifically, we focus on anatomical considerations, technical descriptions, and the current state of the literature investigating their efficacy, duration, and comparisons with standard practices.

CHEST WALL INNERVATION

Thoracic intercostal nerves (T1–T11) are primarily responsible for sensory innervation of the chest wall. Each spinal nerve exits an intervertebral foramen and then divides into a dorsal and ventral ramus which communicates with the sympathetic trunk via the white and gray rami communicantes. The dorsal rami supply the muscles, bones, joints, and skin of the mid back. The ventral rami run together with blood vessels initially between pleura and endothoracic fascia and then between the internal and innermost intercostal muscles, innervating lateral and anterior chest wall. At the level of the midaxillary line, an intercostal nerve branch pierces the internal and external intercostal and serratus anterior muscles (SAMs) and gives rise to the lateral cutaneous branches responsible for sensory innervation of the lateral chest wall. The rest of the nerve courses anteriorly toward the sternum and pierces the internal intercostal muscle, external intercostal membrane, and pectoralis major muscle providing sensory innervation for the anterior chest wall (Figure 1).[8] The intercostal nerves provide segmental innervation with an overlap between the adjacent nerves requiring blockade of at least the nerve above and below the desired segment to achieve adequate distribution.[9]

Table 2. Chest Wall Fascial Plane Blocks for Specific Cardiac Surgical Approaches

Surgical Approach	Block Options	UL/BL
Sternotomy	PIF or ESP	BL
Minimally invasive right anterolateral thoracotomy	PECS I, PECS II, and PIF or ESP	UL right
Minimally invasive right thoracotomy (robotic)	PECS II and SAP or ESP	UL right
Transapical TAVR	SAP or ESP	UL left

Abbreviations: BL, bilateral; ESP, erector spine plane; PECS I, pectoralis I; PECS II, pectoralis II; PIF, pectointercostal fascial; SAP, serratus anterior plane; TAVR, transcatheter aortic valve replacement; UL, unilateral.

Medial (C8–T1) and lateral (C5–C7) pectoral, long thoracic (C5–C7), and thoracodorsal (C6–C8) nerves originate from the brachial plexus and provide primarily motor innervation to the muscles of the chest wall, but are also known to carry sensory nerve fibers (Figure 2). It is unclear as to what extent blocking these branches of the brachial plexus contributes to postoperative analgesia compared to the intercostal nerves.[10] Because mastectomies can be performed under paravertebral block alone, the brachial plexus branches likely do not contribute significantly to nociception after a mastectomy.[11] However, unlike a simple mastectomy, thoracotomy requires resection of the muscle planes, and it is possible that blockade of these nerves contributes to postoperative analgesia to a much greater extent.

PECTORALIS I AND II BLOCKS

The pectoralis I (PECS I) block was first described as a fascial plane block by Blanco[12] in 2011. It was administered to approximately 50 patients after breast surgery and a minimal need for additional analgesia was observed. The following year, Blanco et al[13] reported the pectoralis II (PECS II) block that was designed because of untreated pain over the serratus muscle area during breast expander and subpectoral prosthesis insertion. The block was intended to reach the

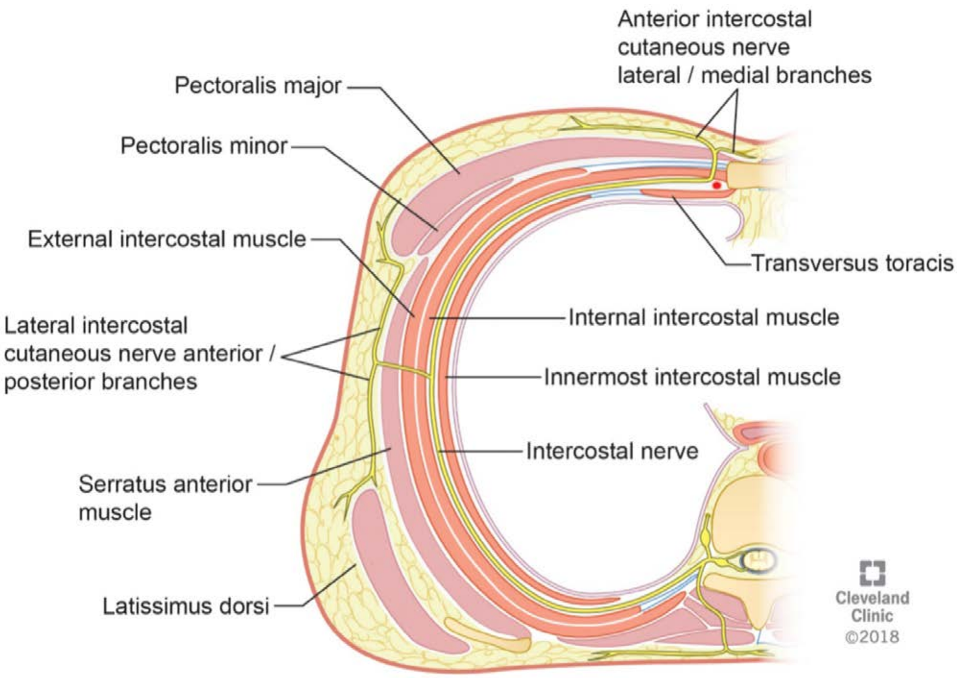

Figure 1. Transverse section of the hemithorax at approximate level T7. The intercostal muscles are exaggerated, and ribs not depicted to illustrate the course of the intercostal nerve. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2019. All rights reserved.

long thoracic, intercostobrachial, and III–VI intercostal nerves.

Sonoanatomy and Block Technique

PECS I and II blocks are typically performed under ultrasound guidance using an in-plane aseptic technique with the patient in a supine position (Supplemental Digital Content 1, Figures 1–4, http://links.lww.com/AA/D17). A 12- to 15-MHz linear ultrasound probe is placed at a midclavicular line below the clavicle, and the subclavian vessels are identified. The probe is moved inferolaterally to the level of the third rib. With a slight medial tilt, the 3 layers of muscles are identified: pectoralis major, pectoralis minor, and serratus anterior (Supplemental Digital Content 2, Video 1, http://links.lww.com/AA/D18). When performing both blocks simultaneously, single puncture site can be used to preserve near-field imaging with deposition of the LA between the layers of the serratus anterior and pectoralis minor (PECS II) (Supplemental Digital Content 1, Figures 3–4, http://links.lww.com/AA/D17), followed by needle withdrawal and injection between the pectoralis minor and pectoralis major (PECS I) (Supplemental Digital Content 1, Figures 1–2, http://links.lww.com/AA/D17). Useful anatomical landmarks when performing the PECS blocks are the pectoral branch of the thoracoacromial artery that runs together with the lateral pectoral nerve between the 2 pectoralis muscles, and the third rib with needle trajectory targeted toward the rib to avoid accidental pleural puncture. The PECS I blocks both medial and lateral pectoral nerves as they travel between the pectoralis major and minor muscles (Supplemental Digital Content 1, Figure 1, http://links.lww.com/AA/D17). The site of PECS I injection affects the distribution of the block, with a more lateral injection spreading toward the axilla and blocking intercostobrachial nerve and a more medial injection spreading toward the midline potentially blocking the anterior intercostal nerve branches.[14,15] The PECS II blocks the long thoracic and thoracodorsal nerves and lateral cutaneous branches of the intercostal nerves providing innervation to the SAM and lateral chest wall (Supplemental Digital Content 1, Figure 3, http://links.lww.com/AA/D17).

VIDEO+

Clinical Applications

The cardiothoracic literature related to the use of PECS blocks is currently limited to case descriptions, and randomized trials evaluating these blocks are underway (Supplemental Digital Content 1, Table 1, http://links.lww.com/AA/D17). Randomized studies in breast surgery patients comparing PECS I/II blocks to placebo consistently demonstrate improved analgesia with the blocks.[16,17] On the other hand, randomized studies comparing PECS I/II blocks to the paravertebral blocks in similar patient populations show conflicting results; both techniques seem to be reliable and provide analgesia, but results differ in terms of analgesia duration and quality.[18–20] This may in part be due to differences in the extent of surgical dissection, techniques used when performing the blocks, and type and amount of LA injected. Also, unlike the paravertebral block, the PECS II will block thoracodorsal and long thoracic nerves, but spare

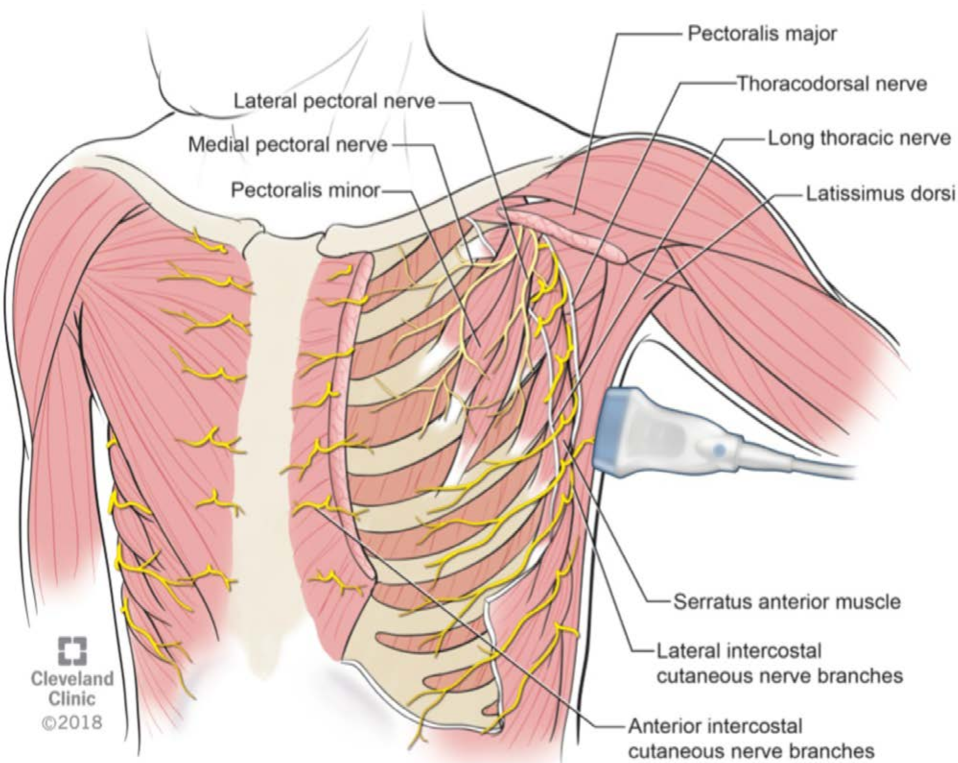

Figure 2. Anterolateral chest wall anatomy muscles and nerves. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2019. All rights reserved.

the anterior branches of the intercostal nerves, with subsequent differences in coverage with respective blocks.

Complications

PECS blocks are considered safe procedures with predicted low complication rates.[21,22] Although rare or unreported, potential complications include infection, thoracoacromial artery injury and hematoma, pneumothorax, intravascular injection, and LA systemic toxicity (LAST).

SERRATUS ANTERIOR PLANE BLOCK

In 2013, Blanco et al[23] described a third fascial plane block designed to block primarily the thoracic intercostal nerves and provide analgesia of the lateral thorax. The serratus anterior plane (SAP) block can be considered an extension of the PECS II block, with a more inferolateral level of injection and a wider spread (Supplemental Digital Content 1, Figures 5–6, http://links.lww.com/AA/D17). The reported spread of the SAP block involves approximate levels between T2 and T9 including anterior, lateral, and posterior chest wall, but sparing the mid chest.[23] It is important to emphasize that the spread is primarily influenced by the volume of LA injected as well as injection site deep or superficial to the SAM. It is suggested that achieving a spread from approximate dermatomal levels T1–T8 requires the LA volume >40 mL.[24]

Sonoanatomy and Block Technique

SAP block can be performed in supine or lateral position. Using a 12- to 15-MHz linear ultrasound probe, scanning starts from the midclavicular line just below the clavicle. The ribs are counted with caudal and lateral probe movement until the fourth and fifth ribs are identified in the midaxillary line. In this position, latissimus dorsi muscle can be seen superficial and cranial to the SAM (Supplemental Digital Content 1, Figure 6, http://links.lww.com/AA/D17). The SAM overlies the ribs, originates on the surface of the first 8 ribs, and attaches to the medial border of the scapula and the posterior aspect of the latissimus dorsi.[25] The in-plane needle approach and injection is usually performed in an anteroposterior or craniocaudal direction in the midaxillary line at the level of the fourth to fifth ribs with LA deposition above (superficial SAP) or below (deep SAP) the SAM (Supplemental Digital Content 3, Video 2, http://links.lww.com/AA/D19). VIDEO+

Clinical Applications

The SAP block provides analgesia to the lateral chest wall by primarily blocking lateral cutaneous branches of the intercostal nerves. Superficial SAP also blocks the long thoracic nerve and thoracodorsal nerve because they lie on top of the SAM. This fascial plane represents an ideal site for nerve catheter placement and continuous infusion of LA.[26–29] Two techniques have been described with injection of the LA either above or below the SAM.[23] It is unclear whether deep or superficial injection is superior. Many practitioners prefer the superficial approach to the SAP for safety reasons, but deep injection could be a better choice in selected cases where fibrosis and scarring of the superficial plane may prevent appropriate LA spread or the superficial plane has been compromised by surgical manipulation.[23,30] Some authors suggested better anterior spread of the block with the deep injection, while superficial injection may be preferred for a more posterior spread and may have longer duration of action.[23,31] Multiple case reports suggest SAP efficacy in providing analgesia in procedures involving incision of the lateral chest wall (thoracotomy).[24,26–28,32–35]

Complications

SAP block has few reported complications in the cardiothoracic population. Theoretically, complications include infection, pneumothorax, hematoma from vascular injury, winging of the scapula (from long thoracic nerve blockade), and LAST from either intravascular injection or high rate of LA reabsorption.

PECTOINTERCOSTAL FASCIAL AND TRANSVERSE THORACIC MUSCLE PLANE BLOCKS

A parasternal infiltration of the LA close to the branches of the intercostal nerves to improve analgesia after sternotomy was described in 2005.[36] However, without the ultrasound guidance, actual placement of the anesthetic was not reported. More recently, an ultrasound-guided pectointercostal fascial (PIF) block was introduced as an adjunct to PECS blocks providing analgesia to the anterior chest wall innervated by anterior cutaneous branches of the intercostal nerves with an injection placed 2 cm lateral from the sternum between the pectoralis major and (internal) intercostal muscles.[37] A deeper version of the PIF, namely a transverse thoracic muscle plane (TTMP) block, with the injection between the internal intercostal and transverse thoracic muscles was described as well.[38,39] However, the transverse thoracic muscle is a very thin structure lying posterior to the sternum and can be difficult to appreciate with ultrasound.[40]

Sonoanatomy and Block Technique

The PIF block is performed under ultrasound guidance, with either craniocaudal or lateromedial needle advancement (Supplemental Digital Content 1, Figures 8, 9A, 9B, http://links.lww.com/AA/D17). The latter has been proposed to avoid inadvertent puncture of the perforating branch of the internal mammary artery or the anterior perforating veins joining the internal thoracic vein, with the goal to deposit LA between the pectoralis major and intercostal muscles.[37,41] The craniocaudal in-plane needle approach and injection is usually performed 1 cm lateral to the sternum at the midsternal level with LA deposition between the pectoralis major and intercostal muscles (Supplemental Digital Content 4, Video 3, http://links.lww.com/AA/D20). VIDEO+

The intercostal nerves run between the innermost and inner intercostal muscles. As they reach the most anterior part of the chest wall, they run between the transverse thoracic (deeper) and internal intercostal muscle (superficial) in the same plane as the internal mammary artery (Supplemental Digital Content 1, Figure 9A, B, http://links.lww.com/AA/D17). They then pierce through the internal intercostal muscle and external intercostal membrane anteriorly to give medial and lateral cutaneous branches. Although different names are given to these blocks, they all target anterior branches of the intercostal nerves in the approximate T2–T6 dermatomal distribution unilaterally.[41]

Clinical Applications

Literature on PIF block is limited, but it is suggestive of improved analgesia in breast surgery patients[37] as well as improved respiratory function in patients with anterior chest wall blunt trauma.[42,43] Similarly, the efficacy of the TTMP block is shown in breast surgery (as an adjunct to PECS blocks) and in patients undergoing median sternotomy.[39,44]

Complications

Due to recent emergence of these blocks, reports describing potential complications are scarce. The utilization of ultrasound-guided needle tip visualization before LA deposition results in a very low risk for infection, hematoma, or pneumothorax.[45] A superficial location of the PIF, compared to the TTMP block, avoids the plane of internal mammary artery and increases the distance from the heart and lung tissue, thus providing similar efficacy with potentially increased safety.[41] Given the reported efficacy, easiness to perform, and safety, PIF and TTMP blocks have a potential for a wide-spectrum clinical application.

ERECTOR SPINE PLANE BLOCK

Initially described for the treatment of chronic thoracic neuropathic pain, the erector spine plane (ESP) block has recently seen utilization for acute postoperative analgesia involving chest, thoracic, cardiac, and abdominal surgeries.[46–55] Referred to as a "paravertebral block by proxy," the ESP block deposits LA solutions ventral to the erector spine muscle along 5–9 thoracic levels within the costotransverse foramen region preventing nociception along both the ventral and dorsal rami of spinal nerves.[56]

Sonoanatomy and Block Technique

The ESP block is performed in a sitting, prone, or lateral decubitus position under ultrasound guidance.

Using an aseptic technique, a high frequency (12–15 MHz) linear array transducer is placed in a parasagittal plane and moved from a lateral to medial direction until the ribs are no longer visualized and transverse processes of T3–T5 with overlying trapezius, rhomboid major, and erector spine muscles are identified. The most caudal vertebral attachment of the rhomboid major muscle is the T5 spinous process, and tapering out of the rhomboid at this level may be useful confirmation of desired probe position. An in-plane needle is inserted in the craniocaudal direction and advanced below the erector spine muscle with the tip contacting the T5 transverse process (Supplemental Digital Content 1, Figure 9C, http://links.lww.com/AA/D17). LA is injected, and lifting of the erector spine muscle off the transverse process with craniocaudal spread of the LA is confirmed (Supplemental Digital Content 1, Figure 7, http://links.lww.com/AA/D17; VIDEO+ Supplemental Digital Content 5, Video 4, http://links.lww.com/AA/D21). If a continuous-delivery catheter is desired, the plane must be hydro-dissected to create space for catheter advancement.

Clinical Applications

Utilization of ESP blocks for cardiac surgical patients remains a novel approach to postoperative analgesia. Recently, several case reports involving the use of bilateral and/or continuous ESP blocks for adult and pediatric cardiac patients have been published.[53,57,58] Krishna et al[54] published a prospective, randomized controlled trial (RCT) of bilateral single-shot ESP blocks versus pharmacological management with IV acetaminophen and tramadol within a cardiac surgical population. They report statistically significant decrease in postoperative pain scores and increase in length of pain relief.[54] Macaire et al[52] reported decreased use of intraoperative sufentanil and postoperative morphine when comparing patients with and without continuous ESP blocks undergoing cardiac surgery. When compared to thoracic epidural analgesia in cardiac surgical patients, ESP blocks had similar postoperative pain scores.[51] Currently, a comparison of ESP versus paravertebral blocks has not been published. As a regional technique, an ESP block provides analgesia by LA spread through a myofascial plane into the neural foramen. In comparison, a paravertebral block directly enters and injects LA into the paravertebral space. Allowing for LA diffusion versus direct needle entry into the paravertebral space may limit the possibility of recognized complications of paravertebral blocks such as injury to pleura, vascular, and neurological structures. The posterior deposit at the costotransverse foramen during an ESP block decreases the likelihood of inadvertent migration of LA into the epidural space providing an alternative to other regional techniques.

ESP Block LA Spread

Variations among cadaver studies have been found regarding injectate spread into the ventral rami after magnetic resonance imaging (MRI) and dissection assessment, but all studies report significant distribution along the craniocaudal plane and the lateral cutaneous branches of the intercostal nerves.[57,58] Both Forero et al[46] and Adhikary et al[49] report radiological confirmation of notable craniocaudal spread with a single ESP injection. Schwartzmann et al[59] have assessed the spread of injectate from an ESP block within a live patient via MRI and reported distribution along the ventral rami although cadaveric studies remain inconclusive.[60]

Complications

There have been no reported complications with this block. Like other fascial plane blocks, theoretical complications include infection, hematoma from vascular injury, and LAST. The relative safety and theoretically low risk among an anticoagulated surgical patient population opens the possibility of improving postoperative pain management, although guidelines have yet to be released.[60] The compressibility of the erector spinae muscle region would facilitate hemostasis if a vascular structure was damaged. Further investigation will be required to identify potential complications from the ESP block.

LAs USED FOR FASCIAL PLANE CHEST WALL BLOCKS

Bupivacaine and ropivacaine are the most commonly used LAs reported in the literature with concentrations varying from 0.0625% to 0.5% and volumes injected ranging between 10 and 40 mL depending on the site of injection (Supplemental Digital Content 1, Table 1, http://links.lww.com/AA/D17). Fascial plane blocks are considered "volume blocks," and our group's approach is to use the highest volume of either ropivacaine or bupivacaine based on the patient's maximum allowed milligram dose. An overview of reported doses and anesthetics used for PECS I/II, SAP, and ESP blocks is provided in Supplemental Digital Content 1, Table 1, http://links.lww.com/AA/D17.

Use of many adjuvants to prolong block duration including opioids, α2-adrenoceptor agonists, and steroids has been described. Majority of studies and case reports or series involving the fascial plane blocks included in this review describe treatment for acute postsurgical pain and do not utilize adjuvants, but rather continuous catheter-based delivery analgesia to achieve prolonged block duration. We identified one series by Zocca et al[34] who used methylprednisolone in a patient with postmastectomy pain syndrome for a SAP block (chronic pain setting).

Dexamethasone has also been shown to prolong duration of LA action with peripheral nerve blocks as well as transversus abdominis plane (TAP) block.[61,62]

Although opioids such as morphine, fentanyl, and hydromorphone are frequently used as adjuvants to neuroaxial LAs, their effect has not been demonstrated with peripheral nerve blocks. Buprenorphine has shown good efficacy as an adjuvant to peripheral nerve blocks, but its use has not been described for the fascial plane blocks covered in this review.[63,64] Clonidine, an α2-adrenoceptor agonist, is also effective in prolonging block duration when used with long-acting LAs.[65] Its use has not been described with the fascial plane blocks described in this review, but it has been shown to prolong duration and improve efficacy of bilateral transversus abdominis plane blocks after a cesarean delivery.[66] Another α2-adrenoceptor agonist, dexmedetomidine, has been shown to increase quality and duration of analgesia when combined with LAs for peripheral nerve blocks.[67–69] Increased risk of side effects including sedation, bradycardia, and hypotension may pose a limitation to a more widespread use of the α2-adrenoceptor agonists.[65] This limitation may be overcome by further study of efficacy and safety aimed at identifying appropriate dosing regimens maximizing efficacy and minimizing the side effect profile.

Liposomal bupivacaine (Exparel; Pacira Pharmaceuticals, Inc, San Diego, CA) is a preservative-free aqueous suspension of multivesicular liposomes containing bupivacaine. Recommended maximum dose is 266 mg (20 mL).[70] Coadministration with LA other than bupivacaine hydrogen chloride (HCl) is not recommended due to concerns for immediate release and resultant toxicity. The Food and Drug Administration (FDA) suggests that coadministration with bupivacaine is acceptable as long as the ratio of milligram dose of bupivacaine HCl to liposomal bupivacaine does not exceed 1:2.[70]

We frequently use liposomal bupivacaine for PECS I/II, PIF, TTMP, and SAP blocks, but avoid it for the ESP block, because of the proximity of the plane to the neuroaxis and the evolving understanding of the block's mechanism of action as well as lack of safety data for that specific indication. Two case reports involving breast surgery cases were published describing its use with ESP block without reported complications.[71]

There is a lack of strong evidence that liposomal bupivacaine can provide analgesia up to 72 hours. Study results reporting 72 hours duration are limited by reporting cumulative data being driven by the analgesic effects primarily observed in the first 24–48 hours.[70,72,73] More studies are needed to better understand potential beneficial effects that liposomal bupivacaine might offer as compared to the current standard of care as well as the use of continuous catheter delivery-based analgesia (Supplemental Digital Content 1, Table 1, http://links.lww.com/AA/D17).

CONCLUSIONS

Knowledge and skills in regional analgesia have become very important for a cardiothoracic anesthesiologist in today's era of minimally invasive cardiac surgery and strive toward faster functional recovery and discharge. Future research should focus on establishing dosing regimens for specific fascial plane blocks in cardiac surgery, efficacy, safety, and mechanisms of novel blocks such as ESP and PIF, as well as safety of liposomal bupivacaine and other adjuncts for latter indications.

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