Ultrasound-Guided Interfascial Plane Blocks

Subjects: Anesthesiology

Contributor: Marek Szamborski, Jarosław Janc, Joanna Rosińczuk, Jędrzej Jerzy Janc, Patrycja Leśnik, Lidia Łysenko

Ultrasound-guided interfascial plane blocks performed on the anterior and lateral thoracic wall have become an important adjuvant method to general anesthesia and an independent method of local anesthesia and pain management.

Keywords: pectoral nerve plane block ; serratus anterior plane block ; transversus thoracic muscle plane block

1. Introduction

Ultrasound-guided interfascial blocks of the anterior and lateral thoracic wall are safe and relatively easy to perform. Therefore, they are widely used in emergency medicine, oncologic surgery, general surgery, thoracic surgery, cardiac surgery, orthopedics, cardiology, nephrology, oncology, palliative medicine, and pain medicine [1][2].

2. Local Thoracic Plain Blocks—Review of Techniques

2.1. Pectoral Nerve Block

Pectoral nerve block type I (PECS I) involves the medial and lateral thoracic nerves. This method was first described in 2011 by Blanco [3]. The anesthetic is deposited in the space between the pectoralis major and pectoralis minor muscles at the level of the third rib in the anterior axillary line, blocking the lateral and medial pectoral nerves. This provides anesthesia to the upper lateral quadrant of the thoracic wall. Initially, this method was dedicated to low-invasive breast procedures.

Pectoral nerve block type II (PECS II) is an improvement of the PECS I block, described by Blanco [4]. In addition to the medial and lateral thoracic nerves, PECS II includes the long thoracic nerve, thoraco-dorsal nerve, and lateral cutaneous branches of the intercostal nerves Th2–Th6. The anesthetic is deposited into two spaces: the space between the pectoralis minor and pectoralis major muscles, and the pectoralis minor and serratus anterior muscles at the level of the third rib in the midaxillary line. This provides anesthesia to the upper lateral quadrant of the thoracic wall and the axillary fossa region. The technique was originally used for painful reconstructive breast procedures and radical axillary lymph node resection anesthesia.

Technique: The classic approach to performing PECS I and PECS II blocks is to localize the anatomic structures using a linear ultrasound transducer (with a standard frequency range of 5–12 MHz). The patient is supine, with their arms along the body and the head slightly rotated in the direction opposite to the blockade performed. The head is placed parallel to the clavicle and in the midclavicular line. After locating the vessels in the midclavicular line below the clavicle, the ultrasound transducer is inferiorly and laterally moved until the third rib is visualized. The sonoanatomical image identifies the pectoralis major, pectoralis minor, and serratus muscles, with the fascial spaces between them. The characteristic sonoanatomical landmark is the thoracic branch of the thoracoacromial artery running in the space between the pectoral minor and major muscles. The medial distribution of anesthetic for PECS I blocks allows for anesthesia of the anterior cutaneous branches of the intercostal nerves; in turn, lateral distribution may involve the lateral cutaneous branches of the intercostal nerves. In PECS II, the medial distribution increases the extent of the lateral thoracic wall block mainly supplied by the long thoracic nerve and dorsal thoracic nerve, involving the axillary fossa, subclavian region, and deltoid muscle.

Application: The PECS I and PECS II blocks are used in a wide range of procedures, such as implantation of vascular catheters, intravenous ports, punctures, continuous drainage of pleural cavity (mainly PECS I); mastectomy; minimally invasive aortic valve replacement; thoracoscopy; minithoracotomy; rib fractures; postmastectomy pain syndrome; neoplastic pain; and pacemaker/cardioverter implantation (mainly PECS II) [5][6][7][8].

Mini-review: In recent years, there has been a significant spread of PECS blockade use. Its ease and universality of use have contributed to the expansion of available applications in thoracic surgery, e.g., in analgesic treatment after cardiac

surgery of mitral/tricuspid valve replacement [9]. In addition, randomized trials are increasingly describing a potency comparable to that of paravertebral block (PVB), which is used for oncological and thorax surgery [10]. The safety of use associated with the limitation of general anesthesia drugs has opened up opportunities for using PECS II in obstetrics and gynecology [11]. An increasing number of patients with significant contraindications to general anesthesia have the opportunity to qualify for extensive vascular procedures using PECS II block [12]. The PECS II block is constantly modified to individual needs. Tuglar et al. [13] described a significant modification of the blockade called PECS-zero for breast surgery in an obese patient. Its new modifications result in greater comfort for the patient and the operator, being helpful for vascular access port implantation using cephalic vein venesection [14].

2.2. Serratus Anterior Plane Block

The Serratus anterior plane block (SAP) was developed in 2013 by Blanco et al. [15] during the analysis of adjacent structures at the PECS II block. This method significantly extends the possibility of analgesia in the lateral and inferior-lateral regions of the thoracic wall. SAP blocks includes the lateral cutaneous branches of intercostal nerves, located below the serratus anterior muscle within the region of Th3–Th9. The superficial variant of the block also includes the long thoracic and thoraco-dorsal nerve. Local anesthetics are administered in the fourth and fifth rib regions into the fascial space between the serratus anterior muscle and the latissimus dorsi muscle (superficial variant) or under the anterior alveolar muscle (deep variant). The needle insertion site is located between the midaxillary and posterior axillary lines.

Technique: The anatomical structures are localized using a linear ultrasound transducer (with a standard frequency range of 5–12 MHz). The patient is supine with an arm abducted at least 90° on the block side. After locating the vessels in the midclavicular line just below the clavicle, the ultrasound transducer is laterally moved and rotated by 90°, positioned along the vertical axis of the thorax to reach the lateral sectors of intercostal IV and V in the midaxillary line. When identifying the major and minor pectoralis muscles, ribs, with their neurovascular bundles, are moved over the latissimus dorsi and serratus anterior muscle. Directing the needle “on the rib” facilitates the correct deposition of local analgesics. Depending on the selected variant of the SAP anesthesia, the drug is administered above or below the serratus anterior muscle. The extent of anesthesia depends on the volume of anesthetic deposited [16].

Application: The SAP block is used in mini-thoracotomies and classical thoracotomies; thoracoscopy; minimally invasive cardiac surgeries (aortic valve replacement); electrophysiological implantations, for example, subcutaneous implantable cardioverter-defibrillators (SICD); pain management after a rib injury; or implantation of tunneled permanent catheters [17][18][19][20][21].

Mini-review: The SAP block is often used in combined anesthesia in thorax and cardiac surgery [22][23]. In addition to providing significant hemodynamic stability and reduced opioid consumption, it also has a very good analgesic effect [24][25]. A novelty is using the SAP block as an element of analgesia for epigastric procedures [26][27].

2.3. Transversus Thoracic Muscle Plane Block

The transversus thoracic muscle plane block (TTP) involves depositing an anesthetic in the space between the transversus thoracis muscle and intercostal muscles. The extent of anesthesia corresponds to the medial part of the sternum, depending on which side of the block is performed, along with the medial part of the thoracic wall. The blockade includes the anterior ends of the intercostal nerve branches. The method was described in 2005 as a parasternal block and is performed without ultrasound guidance. This technique is used to reduce the requirement for analgesics after sternotomy following cardiac surgery [28]. In a TTP block, the nerve structures mentioned above in the range of Th2–Th6 are anesthetized [29].

Technique: A linear ultrasound transducer (with a standard frequency range of 5–12 MHz) is placed parallel to the sternum in the parasternal line, sonoanatomically identifying the space between the second and fourth ribs. The needle is cranially directed, starting from the lower intercostal region. Due to the rich vascularization, injury to the venous perforators and intercostal veins, which run down the internal thoracic vein, should be avoided. The needle is successively passed through the pectoralis major and the external and internal intercostal muscles, reaching the surface of the transverse muscle, where the local anesthetic is deposited. Damage to the internal mammary artery, which gives off smaller branches in this area, should be avoided [29]. The closeness of the vascular structures, pleura, and pericardium makes this anesthesia challenging to achieve.

Application: The TTP block is especially useful in: sternotomy procedures; penetrating injuries of the sternal region; analgesic supplementation of the medial quadrants during breast surgery; subcutaneous implantation of cardiac defibrillators; and the treatment of pain syndromes, such as Tietze syndrome [30][31].

Mini-review: The transversus thoracis muscle is variable in many people and can be difficult to visualize with ultrasound. After coronary artery bypass grafting, patients can have tissue disruption in the transversus thoracis plane because of the internal mammary artery harvest, creating difficulties in transversus thoracis muscle identification. Subsequent reports have confirmed the high effectiveness of the block in the treatment of pain syndromes within the sternum region [32][33][34].

2.4. Pectoral Interfascial Plane Block

The pectoral interfascial plane (PIF) block is performed in the parasternal space between the pectoralis major and the internal intercostal muscles. The technique is very similar to the TTP block. The anesthesia covers the anterior ends of the intercostal nerve branches, relieving pain in the parasternal region and the sternal area on the block side [35][36].

Technique: Analogous to the TTP block, the linear ultrasound transducer (with a standard frequency range of 5–12 MHz) is positioned parallel to the sternum in the parasternal line, exposing the space between the pectoralis major and the intercostal muscles; anesthetic should be deposited in the layer between these muscles [37].

Application: The PIF block can be used to achieve analgesia after blunt chest trauma; in mechanical resuscitation; during breast and sternotomy procedures; in cases of Tietze syndrome [30][38].

Mini-review: PIF blocks are still mainly used in cardiac surgery and traumatology of sternal injuries. Due to the complicated technique and potential complications during its performance, the blockade technique has been modified, using safe anesthetics to perform it. Subsequent reports have confirmed the high effectiveness of the block in the treatment of pain syndromes within the sternum region [32][33][34].

2.5. Intercostal Nerve Block

The intercostal nerve block (ICNB) is most commonly performed as a pain management method and has little relevance in surgical procedures. This block involves targeted anesthetic delivery to the intercostal nerve region; the extent of anesthesia covers a specific intercostal space.

Technique: A linear ultrasound transducer (with a standard frequency range of 5–12 MHz) is placed in the near sagittal axis (parallel to the long axis of the rib), starting from the posterior axillary line. The intercostal space slightly differs in its content depending on the ultrasound transducer position—medial or lateral to the rib angle. Lateral to the rib angle, the vessels and nerves run between the internal intercostal muscle and the deepest groove of the upper rib. The vessels and nerves are located in the space between the internal intercostal membrane and the pleura, which is to the right of the rib angle. The analgesic is directly deposited over the pleura near the inferior margin of the rib.

Application: ICNB blocks can achieve adjuvant analgesia after traumatic rib fractures, and in thoracotomy; maintenance of pleural drainage; neuralgia caused, for example, by herpes zoster; cancer metastases; pain relief after extensive epigastric procedures; splenectomy; cholecystectomy; and nephrectomy [21][39].

Mini-review: ICNB, as a quick and simple procedure, is an alternative method to continuous epidural anesthesia in analgesic care [40]. In addition, the modification of the execution of the technique by changing the location of the anesthetic infiltration was described [13]. The analgesic effect of ICNB has also been observed in its application to urological treatments, which is quite surprising [41]. The safety of ICBN allows it to be used in patients for anesthesia in high-risk surgical procedures without the need for intubation [42].

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