Review Article

Thoracic paravertebral block

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Abstract
Thoracic paravertebral (TPV) nerve block produces ipsilateral, segmental, somatic, and sympathetic nerve blockade in contiguous thoracic dermatomes.
Keywords: TPV, serratus, anterior block

Introduction
The technique was first described in 1905 by Sellheim and reintroduced into clinical practice by Eason and Wyatt in 1978.[1] Since then, it has become increasingly popular for treating acute and chronic pain of thorax, abdomen, and pelvis. It can be used unilaterally or bilaterally, with a single injection technique or *via* a catheter

Anteriorly, the TPV space is confined either by the parietal pleura (T2 to T10/T11) or the diaphragm (T10/T11 to T12). The endothoracic fascia is part of the anterior border. It is a layer of loose, mesh-like connective tissue of approximately 250-μm thickness that lies directly posterior to the pleura and attaches it to the thoracic wall. Medially, the endothoracic fascia merges with the prevertebral fascia.[2-3] Cranially, the high thoracic TPV space lies in close proximity to the adipose tissue of the brachial plexus, phrenic nerve, and cervical sympathetic trunk, which may have consequences for local anesthetic spread.

Caudally, the boundary of the TPV space is subject to debate. Although some cadaver studies showed that the caudal end of the T12 TPV space is effectively sealed off by the origin of the psoas major muscle, other studies observed spread of injectate to the lumbar plexus and the celiac ganglion through the medial and lateral arcuate ligaments of the diaphragm.[4]

Contents of the TPV Space
The TPV space is filled with adipose tissue that contains the intercostal nerve, artery and vein, and the sympathetic trunk. Unlike at the intercostal location, the neurovascular structures are not yet arranged in a standard position. The intercostal nerve comes into the TPV space from medial and gradually assumes a position along the inferior edge of the rib toward lateral. The posterior intercostal artery and vein both enter the TPV space from anteromedial. The artery usually lies in the inferior half of the TPV space, only approaching the inferior border of the rib at 6 to 7 cm from the midline. It is quite tortuous, particularly in elderly persons and at high thoracic levels.[5]

Ultrasound-guided Techniques:
- **Transversal Intercostal Approach, Lateral to Medial, In-plane[6]**

The transducer is placed transversally at 8 cm lateral to the midline in the sagittal plane. After identification of the rib and the pleura, the transducer is rotated to an oblique transversal position along the long axis of the rib and tilted until the intercostal muscles are visualized. The needle is introduced in-plane at the lateral side of the probe and advanced into the space between the internal and innermost intercostal muscles. This technique technically constitutes an intercostal block and relies on spread of local anesthetic fluid toward the

contiguous TPV space medially and from there to adjacent ipsilateral TPV spaces.

- **Transversal Technique at the Transverse Process, Lateral to Medial, In-plane**[7]
  The reflection of the transverse process is a commonly used landmark to determine the target for injection. The needle is inserted in-plane from lateral to medial and advanced until it enters the triangular area in-between the parietal pleura (anterior) and the internal intercostal membrane and intercostal muscles (posterior). The final position of the needle tip is in the transition zone from intercostal to TPV space, just ventrolateral to the tip of the transverse process.
- **Transversal Technique at the Transverse Process, Out-of-plane**[8]
  After identification of the transverse process, the pleura, and the internal intercostal membrane, the needle is inserted out-of plane 1 cm caudal to the ultrasound transducer and advanced in a straight sagittal plane with slight caudocranial angulation until the tip is visualized in a position between the internal intercostal membrane and the pleura.
- **Sagittal Technique at the Rib, In-plane**[9]
  At 5 cm lateral to the midline, the transducer is placed sagitally over the ribs. The needle is inserted in-plane at the inferior side of the transducer and advanced in a cephalad direction. It is guided toward a location in-between the internal intercostal membrane and the pleura.

Oblique Sagittal Technique at the Transverse Process, Lateral to Medial, In-plane

The transducer is positioned at approx.-imately 3 to 4 cm lateral of the midline between two transverse processes in an oblique sagittal position with a slight amount of angulation from craniomedial to caudolateral. After identification of the parietal pleura and the SCTL, the needle is inserted at the caudal border of the transducer and advanced using an in-plane technique into the TPV space. An anterior displacement of the pleura upon injection confirms correct needle placement.

- **Sagittal Technique at the Transverse Process, In-plane**
  The transducer is placed approximately 2.5 cm lateral to the midline in a sagittal orientation. The midpoint of the transducer is aligned in-between two adjacent trans-verse processes, thereby placing the target TPV space at the center of the ultrasound image.[11] Alternatively, the transducer can be moved cranially to place the TPV space at the caudal border of the ultrasound image.[18] With the latter modification, the needle is inserted at a steeper angle, thereby reducing the length of the needle pathway. The needle is inserted in-plane at the lower border of the transducer and advanced in a straight sagittal direction to cranial and anterior. It is also possible to insert the needle at the cranial border of the transducer and advance in a caudal direction. Entering the TPV space through the SCTL may lead to a loss of resistance, but visualization of an anterior displace-ment of the pleura upon injection confirms correct needle placement.
- **Sagittal Technique at the Trans-verse Process, Out-of-plane**
  The transducer is placed sagitally over a transverse process, placing it at the center of the ultrasound image.[10] Alternatively, the space in-between two adjacent transverse processes may be positioned at the center.[*] The needle is inserted using an out-of-plane technique and advanced until the central transverse process is contacted, or else the cranial of the two, with no or minimal angulation in the sagittal plane or the transversal plane. Subsequently, the needle is walked off the transverse process into the TPV space and advanced 1 to 1.5 cm beyond the transverse process without further visualizing the needle tip on ultrasound. Entering of the needle tip into the TPV space can result in a loss of resistance to normal saline and by visualizing anterior displacement of the pleura upon injection

Considerations Regarding the Choice of Ultrasound-guided Approach

The field of ultrasound-guided regional anesthesia is moving fast. For TPV blockade, this has resulted in at least nine

different ultrasound-guided approaches that have been described in the past 5 yr and are part of this review article. Quite possibly, this number will increase with growing clinical experience leading to modifications to these approaches. However, some approaches will lose relevance for exactly the same reason. From this review, it is already apparent that some experts have adapted their technique over time.[12,19] As there are currently no comparative studies, the choice between approaches involves personally weighing a number of factors relating to the ease, success, and safety of block performance. In the following section, these factors are discussed in context of the categorie

Serratus anterior plane block

with a linear ultrasound transducer (10–12 MHz). The patient is placed in the supine position and the probe is placed over the mid-clavicular region of the thoracic cage in a sagittal plane. Ribs are inferiorly and laterally, until identification of the fifth rib in the midaxillary line. The latissimus dorsi (superficial and posterior), teres major (superior), and serratus muscles (deep and inferior) are then easily identifiable by ultrasound overlying the fifth rib. As an extra reference point, usage of the thoracodorsal artery; this aids in the identification of the plane superficial to the serratus muscle. The needle is introduced in-plane with respect to the ultrasound probe from supero-anterior to postero-inferior.[10]

Complications

Rebound pain is possible since the analgesia provided by bupivacaine typically lasts around six hours. Local anesthetic systemic toxicity (LAST) is a potential complication of regional anesthesia. For this reason, dilute anesthetic is used, and a maximum dose of 2 mg/kg of bupivacaine is the recommenddation. Pneumothorax is a potential complication but would entail catastrophic error since the fascial planes targeted in this block are superficial to the ribs, and the pleural line can be visualized clearly on ultrasound. If a pneumothorax is suspected, ultrasound can help to confirm lung sliding immediately after the procedure. Nerve injury is unlikely given the needle is not steered directly at nerves, but instead towards the plane through which the nerves run[10]

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