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Ultrasound-Guided Modified Pectoral Nerve Block with Transversus Thoracic Muscle Plane Block: Review Article

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ABSTRACT
Background: While thoracic paravertebral nerve block (TPVB) is also frequently used for this purpose, transversus thoracic muscle plane-pectoral nerve block (TTP-PECS) is a unique and promising interfacial plane block that can give analgesia for modified radical mastectomy.
Objective: This review article about the ultrasound-guided pectoral nerve block with transversus thoracic muscle plane block.
Methods: We searched PubMed, Google Scholar, and Science Direct for relevant articles on Ultrasound-Guided Modified Pectoral Nerve Block and Transversus Thoracic Muscle Plane Block. Only the most recent or thorough study was taken into account between 2006 and 2020. Documents written in languages other than English have been ignored due to lack of translation funds. Unpublished works, oral presentations, conference abstracts, and dissertations were generally agreed upon not to qualify as scientific research.
Conclusion: Strong analgesia is provided by thoracic paravertebral block, although it is technically difficult and carries the risk of consequences such as hypotension, pneumothorax, and spinal cord injury, but there are many controversies about the most effective, safe and simple regional analgesia techniques or modalities for cancer breast surgery.
Keywords: PECS, TTP, Ultrasound**.**

INTRODUCTION

Since 2011, Blanco has described the pectoral nerves block (PECS block), an interfascial peripheral nerve block. For various breast surgeries as well as other operations involving the anterior chest wall, such as the implantation of breast expanders and subpectoral prostheses where it can be utilized to give analgesia. Pacemakers, iatrogenic pectoral muscle dissections, Port-a-caths, traumatic chest injuries and chest drains are further potential indicators. For outpatient breast procedures, PECS block may be an alternative to thoracic epidural and thoracic paravertebral blocks **[1]**.

The original block, known as the PECS I block, is an interfascial plane block in which local anesthetic is given to block the lateral and medial pectoral nerves between the pectoralis major and minor muscles (C5, 6, and 7) and provide analgesia to the anterior chest wall **[2]**.

A modified PECS I block is a PECS II block. In this case, in addition to the initial block, local anesthetic is also injected at the third rib, between the serratus anterior and pectoralis minor muscles. The long thoracic nerve (C5-C7) and intercostobrachial nerve (T2-6) were among the thoracic intercostal nerves that were supposed to be blocked. This change sought to provide analgesia to the axilla, which is necessary for axillary clearance, broad excision, lymph node excision, and many types of mastectomy procedures **[3]**.

In addition, PECS block is regarded to be a straightforward and less intrusive method because it can be done with the patient lying down, either before or after general anesthesia induction **[4]**.

Anatomy of nerves involved in PECS block:

There are three sets of nerves involved in PECS block:

A) First set of nerves
  1- Lateral pectoral nerve.
  2- Medial pectoral nerve.

B) Second set of nerves:
  1- Lateral cutaneous branches.
  2- Anteriorcutaneous branches.

C) Third set of nerves:
  1- Long thoracic nerve.
  2- Thoracodorsal nerve.

A) First set of nerves:

They involve the primary brachial plexus branches known as the pectoral nerves, which supply the pectoral muscles' motor innervation. Medial and lateral pectoral nerves are considered as the two important pectoral nerves **[5]**.

The lateral pectoral nerve (C5-C7):

The lateral pectoral nerve (LPN) travels along the lateral cord of the brachial plexus emerges. The C5, C6, and C7 spinal nerves are where it starts (Fig. 1). The larger of the two pectoral nerves is this one. The medial pectoral nerve may receive a connecting branch from the brachial plexus shortly after it splits off from the lateral cord, creating the ansa pectoralis loop. The LPN is located in a fascial plane near the pectoral branch of the thoracoacromial artery, between the pectoralis major muscle (PMM) and pectoralis minor muscle (pmm). The nerve then enters the clavicopectoral fascia inferiorly and innervates the clavicular head of the pectoralis major before being distributed to it **[2]**.

Some lateral pectoral nerve fibers pass to and

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innervate the PMM as a result of a connecting medial pectoral nerve branch that serves the PMM. Nociceptive and proprioceptive fibers are also carried by the LPN. It has fibers that supply the costoclavicular ligaments, anterior articular joints, the periosteum of the clavicle, and the shoulder joint capsule. Location of the axillary artery and vein anterior to the ansa pectoralis [6].

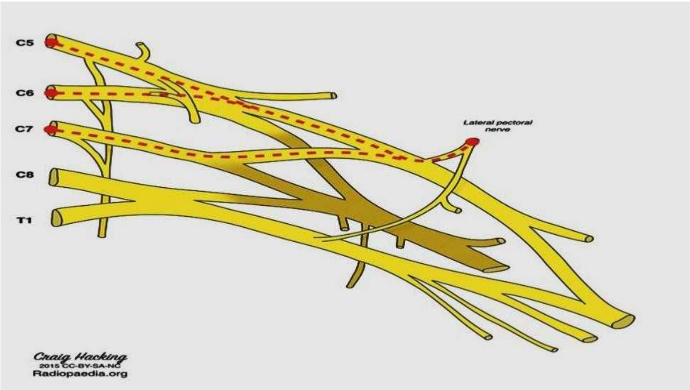

Fig. (1): Lateral pectoral nerve [5]

The medial pectoral nerve:

The medial pectoral nerve (MPN) is derived from the medial chord of the brachial plexus. It comes from the spinal neurons C8-T1 (Fig. 2). The axillary artery is the MPN's primary point of origin. After obtaining a communicating branch from the lateral pectoral nerve (the ansa pectoralis), it curves anteriorly to lie between the axillary artery and vein. From there, it penetrates the PMM and splits into several branches that nourish the muscle. The muscle is punctured by two or three branches, which then wrap around its lower border and terminate in the costal head of the pectoralis major. Most commonly in association with the intercostobrachial nerve, it provides sensory innervation that supplies the ventral side of the arm and the chest wall close to the axilla [6].

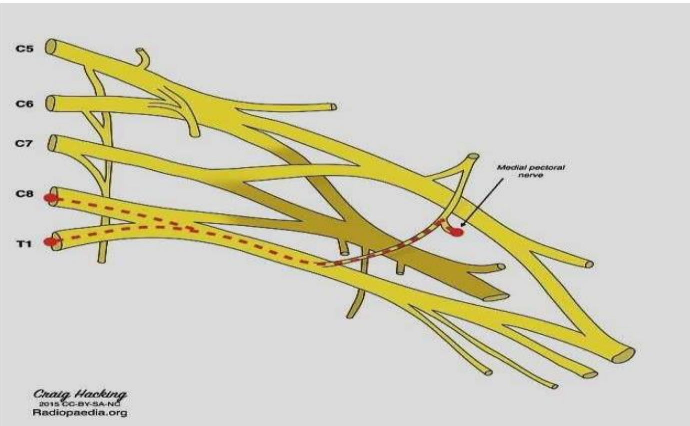

Fig. (2): Medial pectoral nerve [5]

B) Second set of nerves:

They involve the T2 intercostobrachial nerve as well as the anterior divisions of the T2 through T6 intercostal nerves. The intercostal muscles are located between them [5]. Vessel, artery, nerve, and the intercostal vein and artery, which are arranged from superior to inferior (VAN), the intercostal nerves follow the subcostal groove. They consist of lateral and anterior cutaneous branches [7].

The lateral cutaneous branches:

The lateral cutaneous branches pierce the external intercostal and serratus anterior muscles at midaxillary line and take an inferomedial course to reach the border of the pectoral muscles where it divides into anterior and posterior terminal branches, except the lateral cutaneous branch of the second intercostal nerve because it does not divide and is namedthe intercostobrachial nerve (T2). The anterior and posterior terminal branches of the lateral cutaneous branches supply the skin of the lateral breast. The anterior intercostal nerves innervate the lateral two thirds of the anterior thoracic wall branches [8, 9].

Anterior cutaneous branches:

The anterior cutaneous branches split into the fascia and intercostal muscles in the parasternal line, then the medial and lateral branches. They feed the medial section of the anterior thoracic wall after puncturing the internal intercostal muscle and PMM in front of the internal mammary artery, including the medial side of the breast. The lateral terminal branch follows an inferolateral path and divides into further terminal branches that terminate at the skin of the breast or at the areolar edge, while the medial branch crosses the lateral boundary of the sternum [7].

***C)* Third set of nerves:**

- They involve the thoracodorsal and long thoracic nerves.
- **The long thoracic nerve:**

The ventral rami of the C5, C6, and C7 roots give rise to it. It nourishes the serratus anterior muscle and behind the other brachial plexuses and enters the axilla. Winging scapula may develop as a result of axillary clearances or extensive mastectomies, especially when the arm is elevated forward. To create the pocket required for breast expanders, the serratus muscle and pectoralis muscles are separated during surgery [6].

- **The thoracodorsal nerve:**

It emerges from the posterior cord, which is made up of the divisions at the back of the three brachial plexus trunks. The latissimus dorsi muscle at the rear of the axilla is innervated by it and travels down the thoracodorsal artery. When performing latissimus dorsi flaps for breast reconstructions, it is essential because of how deeply it is buried. The key components and anatomy of the nerves involved in PECS block are shown in **(fig. 3*)*** [5].

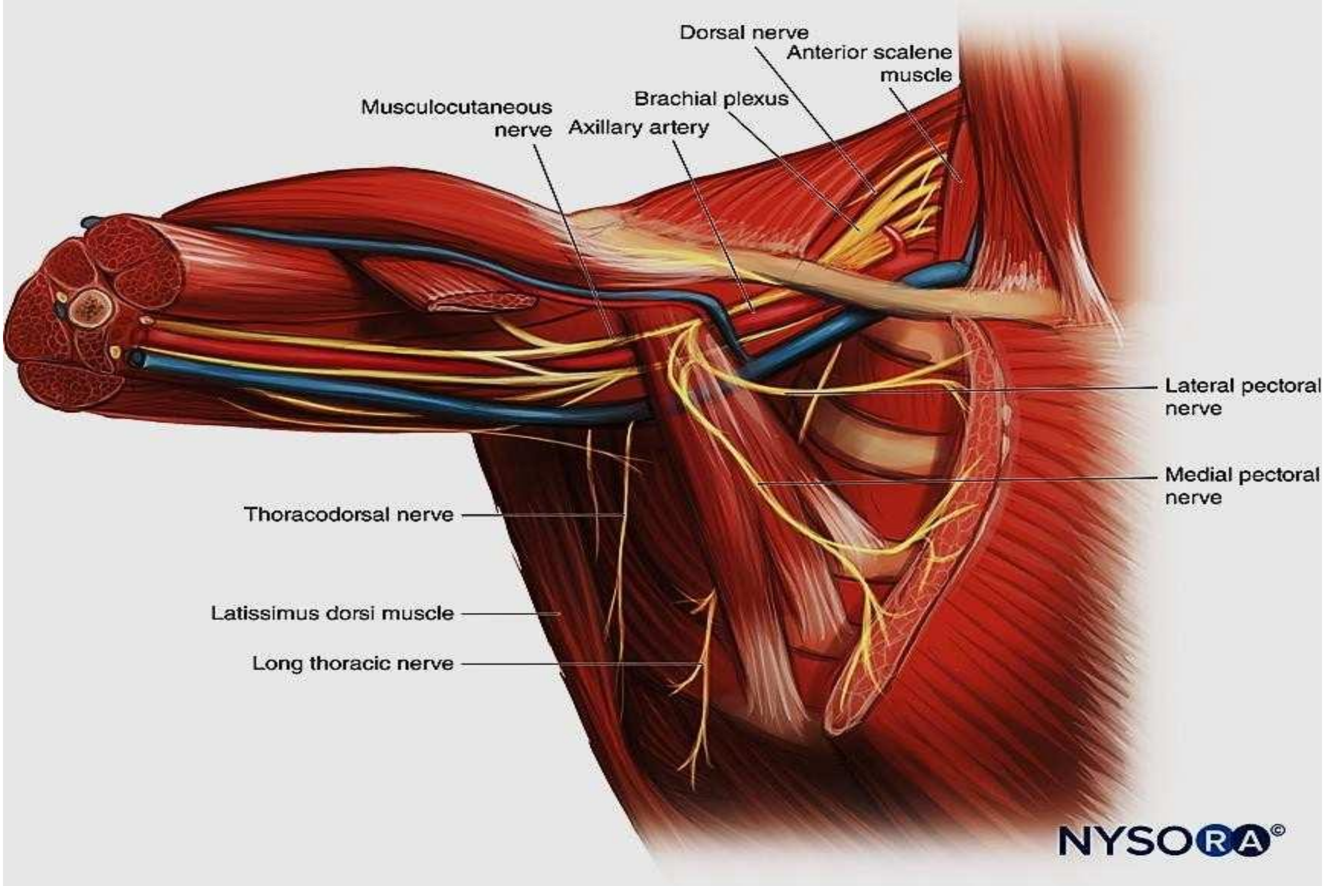

Fig. (3): Nerves and structures included in PECS block [5]

Technique of PECS block: Blanco [2] developed a procedure similar to a coracoid-level infraclavicular brachial plexus block process employing a superior-lateral needle insertion and a linear, high-frequency 10–12 megahertz (MHz) probe. **Perez *et al.*** [10] described putting the ultrasonic probe inferior to a medial to lateral needle into the lateral portion of the clavicle and transverse to the sternal axis. The pleura and blood vessels, as well as not restricting the needle's route through the coracoid process, were said to be avoided. This technique reduces damage to bone and vascular structures [11].

Once the infraclavicular and axillary regions have been cleaned, the probe is placed beneath the lateral third of the clavicle for the PECS I block (Fig. 4). Subcutaneous tissue, the axillary artery, the pectoralis major and minor muscles, the axillary vein, and the pleura should all be recognized after the proper anatomical structures have been recognized under US guidance. The thoracoacromial artery and the lateral pectoral nerve should also be located between the PMM and pmm (Fig.5). 2% lignocaine is injected into the skin puncture site before the block is administered with a 20-gauge Tuohy needle. The tissue plane between the PMM and pmm was reached with the needle, and 10 mL of 0.5% bupivacaine was deposited with frequent aspiration [12].

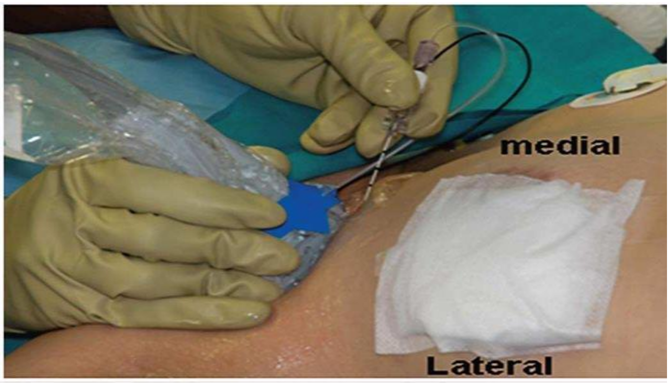

Fig. (4): Image of the probe position and needle direction from medial to lateral during PECS I block [10].

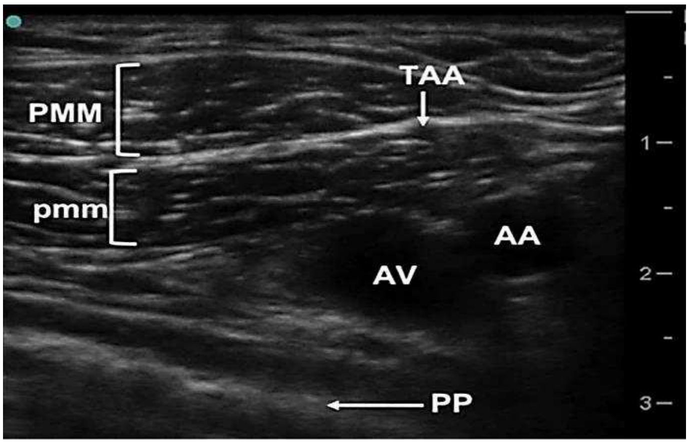

Fig. (5): Ultrasound visualization for PECS I block.

The pectoralis major muscle (PMM), pectoralis minor muscle (pmm), thoracoacromial artery (TAA), axillary artery (AA), axillary vein (AV), and parietal pleura (PP) are identified [13].

Where the lateral boundary of the pmm is located, at the level of the second, third, and fourth ribs present, is the target level for the PECS II block. The third rib and the lateral border of the pmm are visible after positioning the probe under the lateral third of the clavicle and moving it laterally and distally. The serratus anterior muscle (SAM), which is located at the third rib and covers the second, third, and fourth ribs, is also seen between the ribs and deep to this muscle. 2% lignocaine will be injected into the skin puncture site. In order to disseminate the injectate to the axilla, 20 mL will be deposited with numerous aspirations at the level of the third rib between the pmm and the SAM. The needle is then progressed in-plane from medially to laterally [14]. For a continuous block, it's possible to leave a catheter in the interpectoral layer. Levobupivacaine injections (0.125% at 5 ml/h) have been described, despite the fact that no trials describing appropriate dose have been carried out [15]. Because ultrasound (US) aids in direct imaging of anatomical structures, it improves the accuracy of the PECS block and causes less harm to surrounding structures. It identifies potential differences in the MPN and LPN's genesis, evolution, relationship, and ancillary structures. In order to prevent harm to these structures when performing the PECS block, it determines their relationship to crucial structures like the parietal pleura and thoracoacromial artery [6].

Advantages of PECS block: Since it is not connected to sympathetic block, it varies from thoracic epidural and paravertebral blocks. It appears to be a straightforward, simple to use, and quickly acting block that can be applied either before or after general anesthetic induction[16].

Disadvantages of PECS block: Accidental intravascular injection caused by local anesthetic injection into the thoracoacromial artery's pectoral branch or puncture of the axillary fascia are difficulties that can be prevented by properly visualizing the anatomy, especially the thoracoacromial artery [6]. Although the pleura is deep to the SAM in the PECS II block, pleural puncture is still achievable there, and because it is close to the target injection site, careful needle viewing should be performed [5].

Transversus thoracis muscle plane block

The transversus thoracis muscle plane block is a freshly developed type of local anesthetic (TTP block) relieves pain in the anterior chest wall. The TTP block, is a single-shot nerve block that injects local anesthetic into the transversus thoracis and internal intercostal muscles muscle plane. It was discovered that the TTP block covers the T2-T6 intercostal nerves. Since the anterior branches of these intercostal nerves dominate the sensory innervation of the internal mammary region, this novel approach might be able to provide analgesia during surgery on the anterior chest wall. Later, during the investigation **Ueshima *et al.*** [17] showed that efficient bilateral breast cancer resections may be performed without the need for general anesthesia when the TTP block was combined with bilateral PECS II blocks of the pectoral nerves.

The transversus thoracis muscle arises from three points: the sternal ends of ribs 4–7, the inferior third of the body's rear surface, the xiphoid process's posterior surface, and of the sternum. On either side of the sternum, 4-5 slips are formed by its fibers as they diverge and travel superolaterally. Specifically, the muscle slips are sequentially inserted into the costal cartilages of ribs 2 through 6, respectively [18].

Innervation

The second through fifth thoracic intercostal nerves supply nerve fibers to the transversus thoracis. Spine's anterior rami of nerves T2-T6 make up these nerves [19].

Technique of TTP Block: According to Ueshima's instructions, 15 cc of 0.25% bupivacaine was injected into the transversus thoracis muscle between the fourth and fifth ribs at the sternum using a high frequency linear probe (6-13 MHz) and between the internal intercostal [17].

Ultrasound guidance for peripheral nerve blockade: Using Doppler sonography, blood flow during a supraclavicular brachial plexus block could be identified in 1978, marking the first documented instance of ultrasound (US) being used in peripheral block of nerves. Using ultrasonography to aid in the imaging of a supraclavicular brachial plexus block was originally reported and made possible in 1994, despite the fact that the first technology did not permit direct nerve visualization. Since then, regional anesthesia via US has become more and more popular, and US is also utilized for a range of peripheral nerve blocks [20].

Basic physics of ultrasound: An ultrasound transducer uses sound waves with frequencies between 2 and 15 megahertz (MHz) to transmit and receive images. Piezoelectric crystal sheets are present inside the transducer. The crystals oscillate when an electrical current is applied, which allows electrical energy to be transformed into US waves. Depending on the kind of tissue, the US waves move through tissues at a different speed. After that, a screen with the image presented in black and white tones appears [21].

Components of US machine: Most ultrasound machines have the following components in common:

1. **A transmitter:** that generates sound waves "echo" in brief bursts.
2. **A transducer:** that converts electrical energy to

sound energy.

3. **A receiver:** that detects signals returning to the transducer.
4. **A display:** that displays the signal on the screen [22].

Types of electronic transducers: Most transducers fall into one of three categories:

1. Linear array transducers: The width of image is equal to the length of transducer head. It works at frequency >5 MHz **(5-20 MHz)**, and it is used to image superficial musculoskeletal structures, nerves and vessels.

2. **Curved array transducers:** The transducer face has a curvature to it. It is very likely to roll on its scanning surface, which will change how the US beam, which enables us to "look around the corner," is directed. It functions between 1 and 5 MHz. Used most effectively to photograph deep-lying structures, such as obstetric and abdominal tissues [23].

3. Phased array transducers: From a small transducer contact area, they offer a large field of vision. To produce a "Echocardiography" image of the heart or a trans-cranial structure, they can easily fit between the ribs or underneath the rib cage. [23].

System set-up:

1. **Transducer selection:** should be selected depending on the required resolution and the depth of penetration.
2. **Depth:** With more deep structures appear smaller but a wider anatomical area can be revealed.
3. **Focus:** to optimize image, the area to be scanned should be within the focal area of US beam.
4. **Gain:** By varying the quantity when there is a mixture of white, black, and gray on the screen, altering the gain of the image may make it easier for the operator to discern between different structures.
5. **Color Doppler:** aids in differentiating moving objects as well as blood vessels from peripheral nerves, which are typically hypoechoic and might be mistaken for blood vessels. When necessary, it can be used to determine the blood flow direction [22].
6. **Probe selection:** When deciding on the transducer frequency, image resolution and beam penetration should be balanced. Higher transducer frequencies boost resolution but have poor tissue penetration. Lower transducer frequencies have lower resolution even though they can reach deeper into the tissues [24].

A high-frequency **(6–13 MHz)** surface features like the brachial plexus in the supraclavicular fossa or the inter-scalene groove can be visualized with an ultrasonic transducer. A transducer with a lower frequency **(5–10MHz)** is ideal for structures that are slightly deeper, such as the brachial plexus in the infraclavicular fossa, while a low-frequency transducer from **(2–5 MHz)** is used to image more deep structures such as the sciatic nerve and the lumbar paravertebral region [21].

Axis of Intervention:

Whether approaching from above or below, the block needle can be seen in either direction. The needle enters the skin at the side of the probe during the in-plane approach. While moving near the target, the needle crosses the US plane and the entire shaft is seen. The needle enters the skin away from the probe (away from the plane of sound) while using the out-of-plane technique. Only the needle tip is visible with this method; the rest of the needle is off-screen. Although both approaches are changeable, the in-plane method may be chosen because it reveals a larger needle artifact that is simpler to track [25].

Needle Visibility:

The needle's gauge and angle of incidence are the main determinants of needle visibility according to US. The angle that the US waves make with the surface of the building is known as the angle of incidence. The image will be better because more US waves will be reflected back to the transducer and fewer would be scattered away, the angle should be perpendicular or nearly perpendicular. The operator can improve the target image by tilting or rotating the probe to alter the angle of incidence [26].

Echogenicity of the tissues: When all of the waves are reflected by a tissue structure, they look white or hyperechoic on the display, like bone, and when none are, like blood vessels, they appear black or anechoic. Collagen and connective tissue, which surround hypoechoic nerves and muscles, give the appearance of a stippled or starry sky [27].

- Isoechoic: The structure is of the same brightness or echogenicity as the surrounding tissues.
- Hyperechoic: The structure is bright e.g. bone and fascia.
- Hypoechoic: The structure is dark but not completely black.
- Anechoic: The structure appears completely black e.g. CSF and blood [28].

Advantages of ultrasound:

- Ability to visualize and identify the target nerves and their relationship to surrounding structures (e.g. arteries, lung, veins and other nerves).
- Identify the patient variability (e.g. size, shape, anatomical variations).
- Determine depth, angle, and pathway of the needle to the target nerve.
- Real-time visualization of the technique and guidance of the needle tothe target.
- Visualization of the spread of local anesthetic (encircling nerve) andplacement of a catheter.
- Allow the procedure to be carried out on anesthetized patients safely (e.g. children) and

even to repeat it if ineffective.

- Portability and safety (no ionizing radiation) [29, 30].
- When compared to peripheral nerve stimulation (PNS), peripheral nerve blockade (PNB) using ultrasound guidance has been demonstrated to require less time to perform, more rapid onset, long duration of anesthesia, decrease the risk of vascular puncture, improve the quality of sensory block, decrease dosing for many blocks, decrease the risk of local anesthetic systemic toxicity and consequently increase patient safety [31].
- Enable the differentiation of complicated neurovascular distinctions seen within the brachial plexus, as well as the identification of nerves with relatively small diameters.
- Permit proactive examination of the patient's anatomy for neurovascular changes or abnormalities in order to enhance patient safety by avoiding block problems.
- Compared to a PNS-landmark approach, combining PNS and US was proven to boost success rates and lower complication rates [32].

Disadvantages of ultrasound:

- The difficulty of US waves to pass through bone is the main limitation of US imaging. This creates an auditory shadow that makes it impossible to see the buildings beneath it.
- Air greatly reduces the US waves and obstructs visibility, particularly near the intestinal loops or lung.
- With the potential for intravascular and intraneuronal injection, the majority of regularly used needles are not sufficiently visible by US imaging [33].
- Regional pattern recognition is hampered by anatomical differences of peripheral nerves.
- Challenges that new users of ultrasound encounter when learning the nomenclature, cross-sectional anatomy, suitable local anesthetic dissemination, various probe operating mechanics, and routine needle tip visualization [34].
- Images may seem hazy to a novice user, and it may be challenging to recognize the intricate neurovascular anatomy.
- Interpretation may also be distorted by inexperience due to a failure to notice typical on-screen artifacts produced by picture processing. As opposed to a clear motor response end-point induced by nerve stimulation [27].
- Due to the same hyperechoic, or echotexture, distinguishing neural tissue and its epineurium from connective tissue or tendons may be challenging [35].
- There are many reasons why ultrasonography guidance for peripheral nerve blockade (PNB) is becoming more and more common. The capacity of ultrasonography to directly observe peripheral nerves and tissue planes in real time may be its main utility [35].

CONCLUSION

Strong analgesia is provided by thoracic paravertebral block, although it is technically difficult and carries the risk of consequences such as hypotension, pneumothorax, and spinal cord injury, but there are many controversies about the most effective, safe and simple regional analgesia techniques or modalities for cancer breast surgery.

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