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The efficacy of ultrasound-guided rhomboid intercostal block versus serratus plane block in patients undergoing modified radical mastectomy

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Abstract
Postoperative pain is a notable issue that arises following undergoing modified radical mastectomy (MRM). The probable reasons for perioperative myofascial pain are the excision of the pectoralis major fascia and the stretching of the pectoralis muscles to enhance surgical accessibility. After a radical mastectomy with axillary involvement, perioperative discomfort may additionally impact the thoracodorsal, pectoral, and long thoracic nerves in along with the branches of the intercostal nerves. Consequently, several analgesic treatments have been suggested to alleviate immediate postoperative pain. These procedures include intercostal blocks, infiltrating with local anaesthesia, erector spinae plane blocking (ESP), serratus plane block (SAB blocking), paravertebral block, and rhomboid intercostal blocking (RIB). The superiority of one over the others remains unclear. The SAB approach is a novel method for pain relief that offers effective postoperative analgesia for individuals receiving MRM. The ultrasound guided rhomboid intercostal block (US-RIB) is a recently developed method for administering a facial block. Recent clinical trials have shown that RIB is a good treatment for reducing postoperative pain among individuals with breast cancer following MRM surgery.

Keywords: Serrates, superiority, facial

Introduction
Modified radical mastectomy (MRM) is the established surgical procedure for treating breast cancer, typically accompanied by significant acute postoperative pain. Ensuring sufficient pain treatment after surgery is crucial for enhancing functional results, accelerating recovery, and reducing the duration of hospitalization [1]. The duration of postoperative pain can extend beyond 3 to 6 months following surgeries and may progress into chronic pain, occurring in around 20% to 30% of cases [2-5]. Chronic pain can have detrimental impacts on individuals, leading to a decline in their overall quality of life and potentially contributing to long-term reliance on opioid medication. Hence, it is important to take measures to prevent chronic pain in these individuals. Effective solutions for managing immediate postoperative pain play a crucial role in this context [2-6].
Regional anesthetic treatments offer effective postoperative pain control and might result in a lower occurrence of chronic pain [7]. Several analgesic treatments have been suggested to alleviate immediate postoperative pain, such as intercostal block, infiltrating with local anesthesia, paravertebral block, SPB, and RIB [8-12].

Post mastectomy pain
Acute pain arises as a result of tissue damage linked to surgical procedures and is expected to diminish as the body heals. The usual duration for this process is often around 3 months, at during which the discomfort becomes chronic or persistent **[13].** Pain is a complex phenomenon that encompasses various dimensions and is unique to each individual patient. Pain experience variations are determined by biological reaction, psychological condition, and social setting [14, 15].
The cause of acute postoperative pain is influenced by multiple factors. Surgical operations result in tissue damage. The occurrence of a surgical injuries elicits a wide range of reactions within the pain matrix, that include the sensitization of pain pathways in both the peripheral and central nervous systems, as well as the experience of anxiety, worry, and frustration.

While pain typically diminishes in the majority of individuals within the initial days following surgery, Some individuals undergo a consistent or increasing pattern in pain severity and the extent of pain relief medication needed [16].

Pathophysiology

1. Nerve injury: The nerves that are most frequently susceptible to damage after breast cancer surgeries are the intercosto-brachial nerves (ICBN), lateral and medial pectoral nerves, the thoracic intercostal nerves, the thora-codorsal nerve, and the long thoracic nerve [17].

2. Phantom pain: Similar to other forms of amputations, the removal of tissues from the breast is prone to the occurrence of phantom pain and sensations. The lesser occurrence of breast discomfort contrasted to phantom limb pain may be attributed to the reason that breasts aren't involved kinesthetic sensory stimuli in the same manner as limbs engage [18].

3. Perioperative radiation: The use of radiation may result in nerve injury, causing long-lasting peripheral neuropathy. The use of radiation might potentially result in unavoidably damage to adjacent nerves, including the brachial plexus, encompassing both the proximal and distal branches. The initiation and degree of pain caused by radiation might be directly related to the cumulative dosage administered [19].

4. Perioperative chemotherapy: The etiology of chemotherapy-induced peripheral neuropathy resulting from frequently utilized antineoplastic drugs is complex and involves multiple factors. The activation of glial cells by platinum-based medications like oxaliplatin and cisplatin leads to the production of pro-inflammatory cytokines by surrounding immune cells. This, in turn, can produce nociceptor sensitization and peripheral neurons hyperexcitability due to changes in the activity of sodium and potassium ion channels [20].

Risk factors

- **Age:** A lower age is linked to a greater pain burden index and a correlation between younger age and enduring pain. This discovery could be attributed to the reason that younger individuals typically have more aggressive, estrogen-receptor negative illness or higher tumor grade, necessitating more extensive operations or additional medications [4, 21, 22].
- **Body Mass index (BMI):** Obese patients undergoing surgery may face challenges during axillary dissection because of their enormous breasts, which increases their chance of experiencing more extensive tissue and nerve injury. Individuals with an elevated BMI are at a greater risk of experiencing perioperative problems, including poor healing of wounds and increasing blood loss [5, 23, 24].
- **Psychological:** Numerous studies have demonstrated a strong link between the onset of chronic pain and elevated levels of preoperative anxiety. Additionally, there is a notable and separate relationship between PMPS and somatization, symptoms of depression, and sleep disruption [25].
- **Surgical type:** Both breast-conserving surgeries (BCS), with or without dissecting of lymph node, and radical mastectomy haven't regularly been found to be associated with the development of PMPS [4, 26].
- **Axillary lymph node dissection (ALND):** is a surgical procedure that aids in the determination of the stage and treatment of cancer of the breast. In many investigations, ALND has been identified as a risk factor for the occurrence of PMPS, as opposed to sentinel lymph node biopsies.

Treatments

The treatment of acute pain following breast surgeries should adopt a multimodal strategy, incorporating both pharmacological and non-pharmacological therapies. The engagement of a multidisciplinary team comprising an oncologist, pain-management specialist, psychologist, physiotherapist, and palliative care specialist. Moreover, it is imperative to establish a thorough and customized pain management strategy prior to surgeries. This plan should encompass educating the patient about the potential consequences of the procedure, the characteristics and progression of their symptoms, as well as the various treatment alternatives that are accessible [29].

- **Non-pharmacological therapies:** should be consistently incorporated into the pain management plan. Furthermore, it is important for individuals to understand that non-pharmacological therapies constitute just a single component of the overall therapy strategy. Certain patients may have a preference for non-pharmacological methods over pharmacological ones, in order to mitigate the potential dangers associated with drug side effects or expenses [30].
- **Physical treatment:** The commencement of physical therapy (PT) has consistently demonstrated its advantages for individuals undergoing recovery from breast cancer surgeries. Engaging in range of motion exercises and active stretching can enhance the strength and functionality of the upper extremities. These exercises also help to preserve the movement of the glenohumeral and scapular joints and facilitate the activation of neuromuscular activity. The ultimate objective is to reduce any dysfunction that may arise [31].
- **Psychological therapies:** including cognitive behavioral therapy (CBT), have been found to have positive benefits on anxiety, sadness, and mood disturbance, which are major variables in the progression of persistent pain [32].
- **Pharmacological therapy:** Several medications have shown efficiency in managing neuropathic pain and are useful for individuals with chronic neuropathic pain following breast cancer surgeries. Prescribers might utilize various criteria to aid in the selection of the most suitable drug, as well as alternative options for second or third-line treatment [33-35].

Interventional therapy

1) Nerve blocks

The intercostal nerves provide innervation to both the chest wall and the parietal pleura. The anterolateral chest wall receives sensory innervation from the lateral cutaneous and anterior cutaneous branches of the T2–T6 nerves, as well as the thoracic nerves, pectoral nerves, long and supraclavicular nerves. The intercostal nerves pass from the inter-vertebral foramen and reach the paravertebral space

(PVS) [36].

- **The paravertebral block:** includes the administration of anesthetic into the space surrounding the vertebrae. This space is bordered by the parietal pleura on the front and sides, the costotransverse ligaments at the back, and the vertebrae and intervertebral foramina medially, the ribs form the upper and lower boundaries of this region. The administration of local anaesthesia near the thoracic vertebrae, specifically targeting the area where the spinal nerves arise from the inter-vertebral foramen, will result in unilateral, somatic, segmental, and sympathetic anaesthesia. This includes the posterior ramus in several thoracic dermatomes [37].
- **Intercostal Nerve Block:** The intercostal nerve is located below the intercostal vein and artery within a neurovascular bundle. Their trajectories within the thorax traverse the space between the parietal pleura and both the external and internal intercostal muscles. At the midaxillary line, the nerves split into two branches: a ventral branch and a dorsal branch [38].
- **The Erector Spinae Plane Block:** involves the administration of a local anaesthetic to block both the ventral and dorsal rami of the thoracic and abdominal spinal nerves. This outcomes in a sensory blockage of multiple dermatomes in the posterior, anterior, and lateral thoracic and abdominal walls. The administered product spreads both upwards and downwards, causing this effect [39].
- **The pectoralis nerve block:** involves the pectoral nerve, intercostal nerves 3-6, inter costobrachial nerve, and long thoracic nerve. The Pecs I block involves the administration of anesthesia to both the lateral and the medial pectoral nerves [37].
- **Serratus Anterior Plane Blocks (SAPB):** The desired outcome is attained by obstructing the nerves in the axillary fossa, specifically the intercosto-brachial nerve, the long thoracic nerve, the cutaneous intercostal nerve (T3-T9), and the thoracodorsal nerve. These nerves are situated in the space between the serratus anterior muscle and latissimus dorsi muscle, as well as between the posterior and midaxillary lines [40].

Neuromodulation

The application of neuromodulation has experienced a surge in popularity due to the rising incidence of neuropathic pain diagnoses and a shift towards reducing the usage of chronic opioid medications. One cautious method for managing PMPS with neuromodulation involves employing a trans-cutaneous electrical nerve stimulation (TENS) unit [41].

Ultrasound guide

Sound is a form of mechanical wave which propagates across a medium in a straight line and in a longitudinal manner. When sound propagates throughout a medium, the molecules of this medium undergo alternating compression and rarefaction. Sound propagation isn't possible in a vacuum due to the absence of a medium. This is because sound waves are mechanical energy which relies on the transmission of vibrations between molecules. It should be emphasized that the molecules don't experience any movement when the sound wave traverses them; rather, they oscillate in a back-and-forth manner, creating regions of rarefaction and compression inside the medium [42].

The several modalities of ultrasonography employed in medical imaging [43]

1. A-Mode (Amplitude Modulation): A-mode represents the most basic form of ultrasonic imaging. A solitary transducer sweeps across the body, capturing echoes that are then displayed on a screen, indicating their respective depths [43].

2. B-Mode (brightness mode, 2D mode): B-mode ultrasonography utilizes a linear array of transducers to scan a plane throughout the body's tissues, resulting in a two-dimensional image displayed on a screen [43].

3. In M-mode (motion mode): a series of B-mode scans are performed in quick succession, allowing for the visualization and measurement of motion. This is achieved by observing the movement of organ borders that generate reflections as they change position in relation to the probe [43].

4. The Doppler mode: is utilized for the purpose of measuring and displaying the flow of blood [43].

There are three regularly utilized Doppler techniques [44]

Continuous Wave Doppler

It employs dual crystals to both transmit and receive the signal concurrently. The device is capable of precisely measuring the rapid movement of blood throughout the entire area being examined.

Pulsed Wave Doppler

It sporadically receives and sends the signals utilizing a single crystal, enabling a meticulous evaluation of the flow over time at an exact depth or location on the image.

Color Flow Doppler

The signal is a pulsed wave with a specified color value, that is overlaid on a 2D image.

Methods for visualizing nerves and needles (Needle imaging)

Comparison between Long Axis and Short Axis

The term "axis" in ultrasonic-guided regional anaesthesia refers to the perspective of a structure (such as a nerve or vessel) in regard to the ultrasound beam. A long-axis view is a visual representation that extends along the entire length of the nerve, whereas a short-axis view is a visual representation that cuts through the diameter of the nerve. When performing ultrasonic-guided regional anaesthesia, our goal is to typically achieve a short-axis view of the nerve [45].

Comparison between In-Plane and Out-of-Plane

In the context of US-guided regional anaesthesia, the term "plane" refers to the position of the needle in relation to the ultrasonic beam. The majority of nerve blocks are executed using an in-plane technique. When executed accurately, in-plane techniques enable the complete visualization of the whole needle, including both the shaft and tip. This enables the user to position the needle point with maximum assurance and security. For a considerable period, out-of-plane needle techniques were employed when paresthesia or nerve stimulation was utilized to find nerves [45] **.**Although it seems straightforward, inserting a needle out of plane can be challenging. An important drawback of this method is that the needle will be seen as a hyperechoic or luminous point on the ultrasound display, potentially indicating either the tip or the shaft of the needle [45] .The out-of-plane needle approach involves tracking the movement of the needle tip as it is introduced into the tissue (Figure 1) [45].

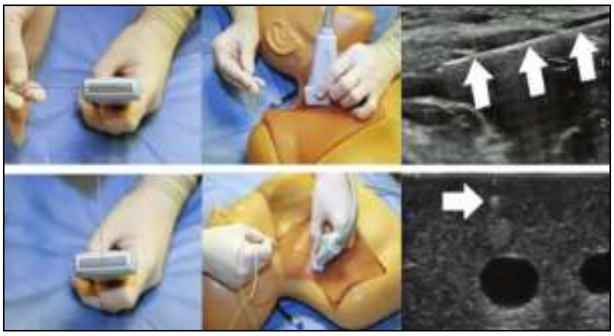

Fig 1: In plane and out of plane technique

Advantages of ultrasound in regional anesthesia [46]:

1. Live visual representation of neural structures
2. The direct observation of nearby structures (such as blood vessels and bones) makes it easier to identify nerves.
3. Ensure accurate positioning of the needle.
4. Observation of the direct and localized diffusion of the anesthesia.
5. There is a reduced likelihood of injecting into the neurons or blood vessels.
6. Reduced occurrences of complications, such as pleural puncture.
7. The block takes effect quickly and requires a lower amount of local anaesthesia.
8. Minimization of pain at the site of fracture with the use of nerve stimulation.
9. Compensation for anatomical variance using various methods that are not reliant on certain landmarks.

Serratus anterior plane block

The anatomical region in question, as defined by Blanco *et al*. in 2013, is situated between the the serratus anterior and latissimus dorsi muscles. It lies on the mid-axillary line at the level of the 5th rib, and its pain-relieving properties are focused on the lateral thoracic region [47-49].

Anatomy and Physiology

The serratus anterior muscle arises from the front side of the first 7 or 10 ribs and attaches to the medial border of the scapula. The structure comprises 7 to 10 serrated tendinous projections which arise from each rib and is supplied with nerves by the long thoracic nerve. This muscle is bounded by both superficial and deep potential spaces. The superficial plane is created at the 5th rib level by the anterior part of the serratus anterior muscle and the posterior part of the latissimus dorsi muscle [48]. The lateral cutaneous branches of the thoracic intercostal nerve go via the external and internal intercostals, and serratus anterior muscles at the midaxillary line, providing innervation to the muscles of the lateral thorax [50]. Hence, these branches of the intercostal nerves traverse the two aforementioned potential areas. Injecting a local anaesthesia into these areas will cause it to diffuse across the side of the chest, leading to abnormal sensations in the T2 through T9 areas of the skin on the front and sides of the chest. (Figure 2) [50].

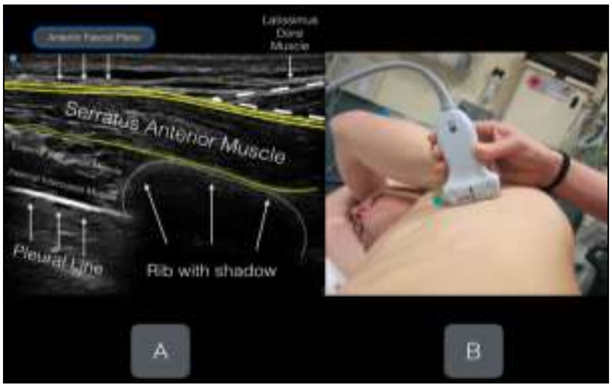

Fig 2: Anatomical location of serratus anterior plane block (SAPB) [50]

Clinical application

SAPB is regarded as a thoracic epidural and vertebral technique due to its straightforward and precise procedure and its ability to provide correct pain relief. This technique reduces the need for opioids prior to and following surgeries, as well as prevents variations in blood pressure, nerve damage, and other negative effects. It is seen as a substitute for para-neural blockage [51].

Breast surgery: SAPB significantly decreases postoperative pain levels following breast and thoracic procedures [52]. SAPB not just suppresses the immediate pain experienced following breast cancer surgeries, but also serves to prevent and alleviate long-term chronic pain resulting from the procedure. The SPB is a more precise method for targeting the web of nerves that supply the front part of the chest wall, which includes the breast. This approach is safer and simpler compared to neuraxial procedures [53].

SAPB Technique

Position a high-frequency linear transducer on the individual's midaxillary line in the transverse plane, namely at the level of the 5th rib. Ensure that the indicator of the transducer is facing towards the left of the operator. The local anesthesia is administered in front of the rib and beneath the serratus anterior muscle for the deep SAPB. It is important to constantly keep the whole needle in sight during the treatment, and caution should be exercised to prevent any contact with blood vessels when moving through the soft tissue. After the needle tip is seen in the correct position, a small amount of 1 to 3 mL of local anesthesia ought to be injected to verify the insertion, separate the fascial layers using fluid, and create the potential gap. Following the incision of the fascial plane, it is recommended to provide a greater quantity of diluted local anesthesia, such as 30 to 40 mL of 0.25% bupivacaine, in a progressive manner. Subsequently, the needle is extracted, and the injection site is then shielded with either adhesive dressing or sterile gauze [54].

Contraindications [54]

1- Absolute contraindications: The insertion of an SPB has very few contraindications, which include patient refusing, allergies to local anaesthesia, and a localized infections [54].

2. Relative contraindications: refer to situations where ultrasonography is not recommended due to anatomical abnormalities that make it challenging to identify landmarks. Examples include surgical emphysema, implantation of intercostal drains, and previous surgeries at the insertion location [54].

Complications [55]

1. Pneumothorax
2. Perforation of blood vessels
3. Injury to the nerves
4. Insufficient or ineffective blockage
5. Toxicity from local anesthetics
6. Contamination

Rhomboid Intercostal Block (RIB)

The RIB, which stands for interfacial plane block for chest wall analgesia, was proposed in 2016 as a potential substitute for thoracic epidurals and paravertebral blocks [56]. Subsequent examples have provided evidence of the effectiveness of RIB for pain relief following thoracic operations and mastectomies. The administration of local anesthetic into a specific area on the back of the chest wall, known as the triangle of auscultation (TOA), has been shown to be beneficial [56].

The TOA is situated next to the lower medial border of the scapula. The upper boundary of the area is defined by the trapezius muscle, the lower boundary by the latissimus dorsi muscle, and the outside boundary by the vertebral border of the scapula. The base of the triangle is comprised of the inferior section of the rhomboid major, the lateral region of the erector spinae muscle, and the serratus anterior muscle. These structures are situated over both the 6th and 7th ribs, along with their external and internal intercostal muscles. The tissue plane separating the intercostal muscles from the floor of the TOA extends [57]:

1. The structure is situated beneath the scapula and serratus anterior muscle, and it travels along the midaxillary line wherein the lateral cutaneous branch of every intercostal nerve penetrates both the external and internal intercostal muscles.
2. The erector spinae muscle is located medially, and it extends towards the thoracic transverse processes. At this point, the dorsal rami of the thoracic intercostal nerves arise between the tips of neighboring transverse processes and enter the erector spinae muscles. These nerves nourish both the muscles and the skin that covers them [57].

Cadaveric examination utilizing 25 cc of methylene blue contrast dye reveals [58]:

1. The dye spreads in a caudad and cephalad direction.
2. The tissue plane from T2-T8 levels exhibits intense staining.
3. There is staining present around the side branches of the intercostal nerves T3-T8.
4. The extension reaches the posterior major rami at the midline.
5. The clavipectoral fascia extends laterally within the axilla, reaching as low as the T9 along the lower attachment of the serratus muscle, and as high as the T2 alongside the serratus anterior muscle.

A single individual who had multiple fractures in their ribs received a 25 ml dose of bupivacaine 0.25% using this method. The individual experienced alleviation from symptoms, with the anesthetic covering the dermatomes from T2 to T9 on the entire front half of the chest, just medially to the midline, extending from the axilla to T9. On the back half of the chest, the anesthetic covered the dermatomes from T2 to T9, stopping just inside the spinous processes. This outcome implies that rhomboied intercostal blocking could be beneficial in delivering pain relief for both the front and back hemithorax [58]. Figure 3

Fig 3: Ultrasound image of rhomboid intercostal block shows the spread of local anesthetic between the rhomboid and intercostal muscles [59]

In conclusion, both Rhomboied intercostal block and Serratus anterior plane block were effective as intraoperative analgesia in modified radical mastectomy patients. But RIB had better analgesic efficacy compared to SPB as evidenced by less intravenous opioid usage and delayed time to first analgesic request.

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