Regional Anesthesia for Breast Surgery

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Fig. #1. After mastectomy *cosmetic rehabilitation* of the lady patient can be done. It can utilize micro-vascular grafting of autologous skin, muscle and fat free-flaps harvested from, e.g. the lower abdomen. The abdominal harvest procedure with closure, effectively becomes a bonus "tummy-tuck". Nipples can be recreated. The other side healthy breast can also be reduced to create a matching pair of breasts.

1. INTRODUCTION

Breast surgery is not trivial for a lady. Beyond being physically injurious, and being often associated with life threatening diagnoses, it is destructive to her human beauty image. All patients deserve best medical care and best relief of suffering. The excuse for physicians to not treat any patient's pain and suffering as optimally as possible, does not exist, and more so for breast surgery patients.

Regional anesthesia for breast surgery is unique and interesting, and has many advantages when used instead of general anesthesia or with general anesthesia. Persistent Post-surgical Pain (PPP) in the breast region following breast cancer region can occur in 50% of woman who have under-gone breast cancer surgery[1]. PPP can be devastating for the woman. Regional anesthesia is considered an optimal analgesia therapy to prevent chronic post-surgical pain syndromes. A study by Chiu comparing two regional anesthesia techniques resulted in only an 8% incidence of persistent post-surgical pain (PPP) at 12 months after surgery[2]. The nerve anatomy of the breast region is very complex due to the presence of a "dermatomal sandwich". This refers to a wide range of dermatomal roots supplying the tissues, and also a discontinuity of dermatomal nerve roots supplying adjacent tissues in the breast region. The nerve root range extends from the C4 to the T7 nerve roots. This requires multiple different nerve blocks for full breast region anesthesia, for large breast surgeries.

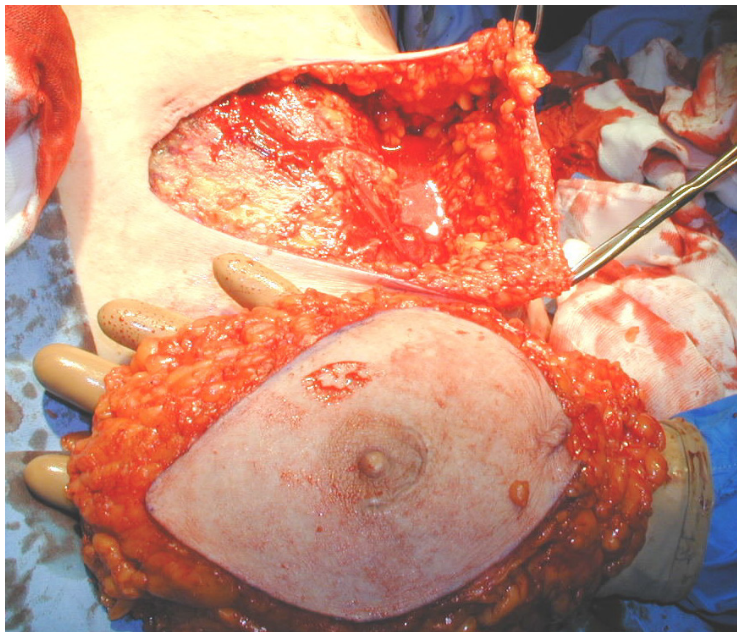

Fig. #2. Breast surgery is not trivial surgery for a lady.

There is currently great interest in the use of regional anesthesia for breast surgery because;

1. Breast cancer is the most common cancer in woman, with 1 in 8 USA woman experiencing it within a life time[3].
2. 1.7 million breast cancers are diagnosed annually in the world[4].
3. Nearly all breast cancer sufferers will undergo surgery.
4. Regional anesthesia offers an alternate to general anesthesia in some cases.
5. Regional anesthesia, even if combined with general anesthesia, still offers profound post-surgical analgesia with reduction in opiate doses.

6. When combined with general anesthesia, regional anesthesia allows for light general anesthesia, with a great reduction in opiate use, and a near elimination of post-surgical sedation, nausea and respiratory depression from large opiates doses.
7. Post-surgical nausea is uniquely common to breast surgery, and any therapy that reduces opiate usage will assist moderating the nausea problem.

Regional anesthesia used with breast cancer surgery has not been shown to improve cancer related outcomes with certainty, although there is some suggestion of that[5]. Conversely there is no suggestion that use of regional anesthesia is detrimental to cancer related outcomes. Future, better and larger prospective studies might prove the regional anesthesia does improve malignancy outcomes in breast surgery.

The nerve block of greatest interest for unilateral breast surgery, is the paravertebral nerve block[6]. Klein noted that the paravertebral nerve blocks for breast surgery decreased opiate usage, improved analgesia and reduced nausea. The paravertebral nerve block is however limited in duration and is optimally utilized when the block and analgesia is maintained with continuous infusion of local anesthetic[7],[8]. Because of the lack of experts in regional anesthesia to perform paravertebral blocks, there is much interest in the newer fascial plane blocks as they may be more easily learned by non-expert practitioners of regional anesthesia.

2. ANATOMY FOR BREAST-SURGERY ANESTHESIA

SECTION INDEX;

2.1. The dermatomal nerve sandwich, and each layer's nerve-root supply.
2.2. The Axilla
2.3. The pectoral muscles, and their nerve supply.
2.4. The intercostal nerve

2.1. THE DERMATOMAL SANDWICH, AND EACH LAYER'S NERVE-ROOT SUPPLY.

The anterior breast region consists of *a dermatomal sandwich*. If one slices deep into a breast with a scalpel, the blade will pass through three sandwich layers. The first sandwich layer is the overlying skin. The skin of the breast region starts over the clavicle and the neurotome extends caudad for 2 to 5 cm. That skin segment has a cervical nerve root supply from C4 and C5. The breast skin immediately caudad to that, jumps to a nerve root supply from roots T2 to T7 with the T4 root enervating the nipple. The breast tissue itself is also part of the first sandwich layer. The mammary tissue has a thoracic segmental nerve supply of T3 to T6. The underlying pectoral muscles form the second sandwich layer. The pectoral muscles have a cervical segmental supply of C5 to T1. The cephalad part of pectoralis major has a C5 nerve supply and the most caudad part the T1 end of the nerve supply. The deeper lying pectoralis minor muscle, attached to the 3rd to 5th ribs, has a C5 to T1 nerve supply but mostly from C7and C8. The pectoral muscles form the middle layer of the "dermatomal sandwich". Finally, deep to the pectoral muscles, the chest wall formed of ribs and intercostal muscles has a thoracic segmental nerve supply again of T2 to T6 and represent the third layer of the dermatomal sandwich. The pectoral muscles are thus the cervical segmental sandwich filler between two thoracic segmental slices. As mammary (breast) tissue can vary between individuals very much in mass, the overlying skin that could be involved in surgery incisions in expansive surgery could extend from immediately below the clavicle with its C5 nerve supply down to T7. There is no single nerve block injection, that is simple and safe, and that can provide anesthesia from C5 to T7 for comprehensive mastectomy surgery involving all the tissues from the skin to the ribs. Typically, multiple injections are needed at different sites. When breast reconstruction uses autologous tissues from far beyond the breast region, even greater regional anesthesia challenges exist.

Fig. #3. Awake and comfortable breast surgery under nerve block is possible for the simple surgeries confined to the breast region. Note the paravertebral catheter injection-port lying on the pillow.

Furthermore, the blood supplying arteries of the breast may carry in their own nerve supplies. The groups of arterial blood supply are from (a) the axillary artery, (b) The internal thoracic artery, and (c) the 2nd to 4th intercostal arteries. Occasionally when these arteries are cauterized during awake surgery under local anesthetic, the patient may feel a modest discomfort from sympathetic mediated pain via nerve fibers carried on the artery. It seems it is especially the penetrating arteries from the internal thoracic artery that may do this. Usually some supplementary intravenous analgesia and sedation, and or direct local anesthetic application by the surgeon makes it possible to proceed with the surgery.

2.2. ANATOMY OF THE AXILLA;

The axilla may be dissected at surgery, for removal of breast tissue remnants in the axilla (tail of Spence), and or for excision of lymph nodes draining the breast.

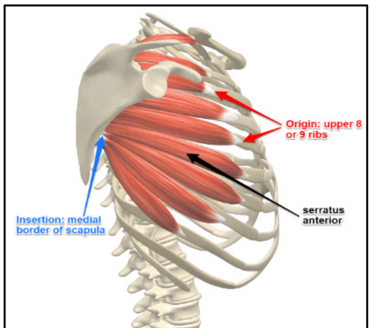

Fig. #4. Serratus anterior muscle.

The axilla is a pyramidal 3-sided space pointing upwards to the lateral edge of the first rib and middle of the clavicle under-surface. The wide base of the axilla pyramid is formed of hairy skin and is seen when the arm is abducted. The axilla lies between the humerus to lateral, the pectoral muscles to antero-medial, the subscapularis muscles lying against the scapula to upper-posterior, the latissimus dorsi muscle lying to lower posterior side. Direct to medial lie the upper 5 ribs covered by the serratus anterior muscle. Serratus anterior finds first attachment to the 2nd to 9th ribs at near the midclavicular, and then runs around the rib-cage towards

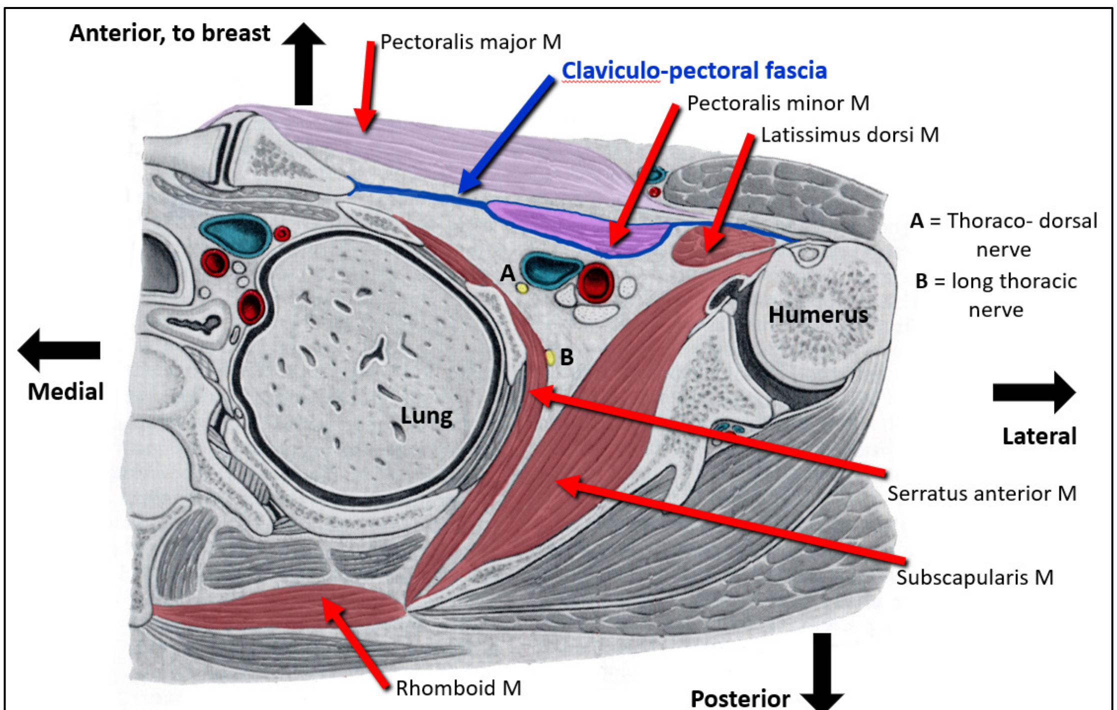

Fig. #5. The axilla in sectional view.

posterior to attach to the medial side of the scapula, holding it close to the chest. direct to medial. The long thoracic nerve, is a branch of the cervical part of the brachial plexus and runs down the medial side of the axilla over serratus anterior in the mid axillary line.

The clavipectoral fascia runs down from medial attachment to the first rib, and cephalad attachment to the clavicle and coracoid process. It encases the pectoralis minor muscle making the muscle part of the anterior wall of the axilla neurovascular compartment. It is very substantive cephalad to the pectoralis minor muscle, and flimsy and lax caudad to the pectoralis muscle. See figure no. 7. It tends

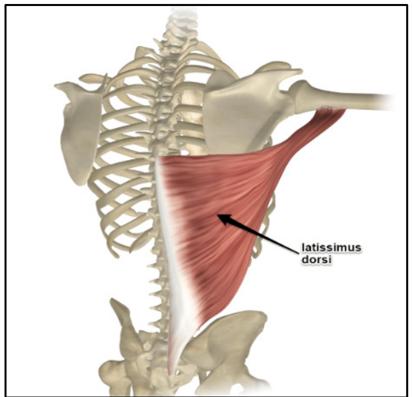

Fig. #6. Latissimus dorsi muscle.

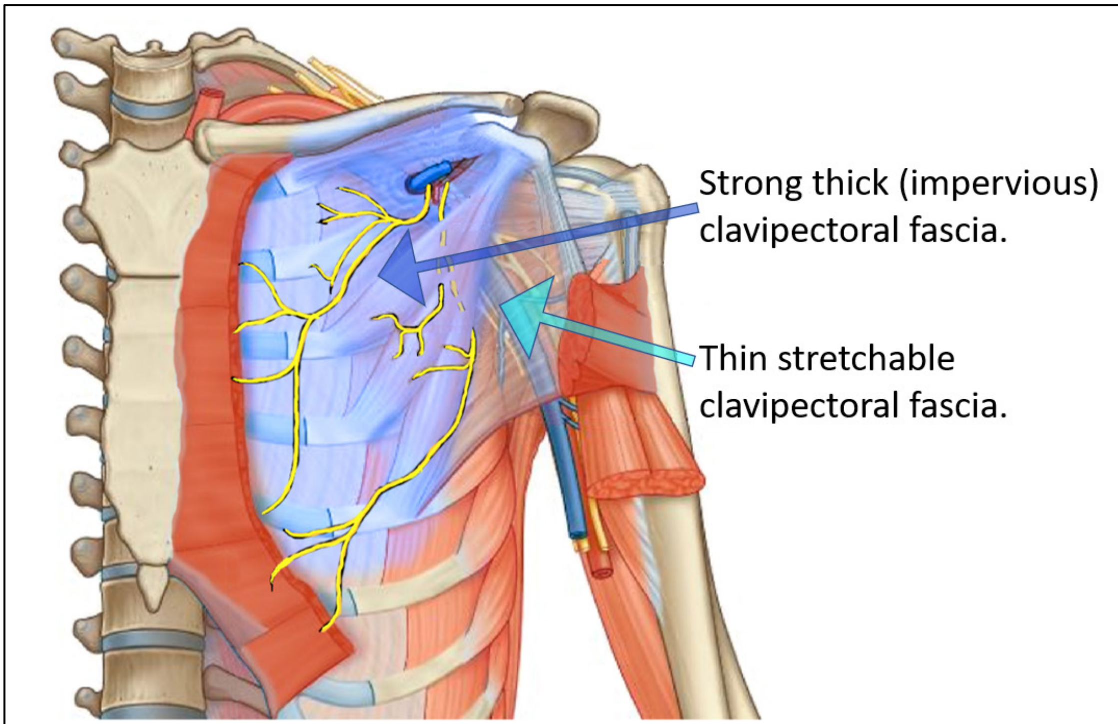

Fig. #7. The clavipectoral fascia is thick and impervious in one part, and thin and stretchable in the other part. This fascia lies posterior to the pectoral muscles.

to separate the upper axilla and its neurovascular content from the anterior lying pectoral region except where the pectoral nerves and thoraco-acromial artery penetrate it.

Drug injected deep to pectoralis minor muscle, but within its clavipectoral fascial encasing seems to not spread to the brachial plexus lying deep to the fascia as no arm blocks ever result. That drug injected deep to the pectoralis minor muscle does however seem to achieve good spread over the clavipectoral fascia to fully block both pectoral nerves as they penetrate the clavipectoral fascia from posterior. In 2 to 6% of woman there is breast tissue that extends into the axilla, called the tail of Spence.

The axilla tissues have the following sensory supplies. See figures no. 5 and 7;

- Anterior wall; pectoral muscles supplied by the pectoral nerves which are branches of the cords of the brachial plexus.
- Posterior axilla wall; subscapularis muscle lying on the anterior surface of the scapula, and supplied by the subscapular nerve, which is a branch of the posterior cord of the brachial plexus. The far posterior edge of the medial wall of the axilla is formed by the latissimus dorsi muscle supplied by the thoracic dorsal nerve that runs from cephalad to caudad over the serratus anterior muscle, and about 2 cm posterior to the long thoracic nerve.
- Medial wall; ribs covered by serratus anterior muscle. Serratus is supplied by the long thoracic nerve that runs on the muscle from cephalad to caudad in a mid-axillary position.
- Base of the axilla; the skin forming the base is supplied by the intercostobrachial nerve with nerve roots T1-2.

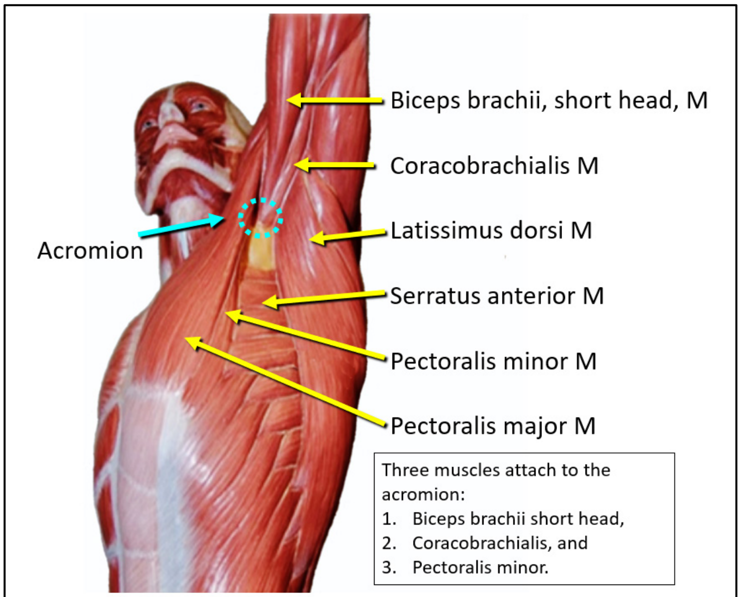

Fig. #8. View of the axilla with the arm abducted. The muscles forming the axilla

2.3. The pectoral muscles and their nerve supply[9],[10],[11],[12].

These two muscles lie immediately deep to the mammary tissues. Pectoralis major is resected with radical mastectomy, inducing severe pain. Its tendon attaches to the proximal humerus to adduct it. Its surface fascia is dissected of with a *modified* radical mastectomy inducing some pain.

The pectoralis minor muscle lies deep to the pectoralis major muscle and its tendon attaches to the coracoid process to stabilize the shoulder girdle. It is much smaller than pectoralis major. The pectoral nerves are both branches of the brachial plexus with dominant cervical nerve root origins.

The regional anesthesia challenge as that these pectoral nerves need separate supplementary nerve blocks to help a T4 epidural or a T4 centered paravertebral block provide total anesthesia of the breast region to make an awake radical mastectomy possible, or alternatively to provide 100% analgesia after general anesthesia and surgery.

Both pectoral nerves derive from the cords of the brachial plexus. They separate from the brachial plexus and axillary artery complex where the thoraco-acromial artery penetrates the thick clavi-pectoral fascia. The two pectoral nerves are joined by loop called and Ansa. Drug injected deep to the pectoralis minor muscle and onto the medial pectoral nerve may track easily along that Ansa, towards the lateral pectoral nerve. The lateral pectoral nerve passes between the two pectoral muscles to supply the cephalad 80% of the pectoralis major muscle. The medial pectoral nerve sends one branch into the pectoralis minor muscle to supply it, and another branch around the pectoralis minor muscle caudad edge through to supply it. That branch supplies the rest of the pectoralis muscle, and also the caudad 20% of the pectoralis major muscle. That caudad edge of the pectoralis major muscle is the muscle part most often injured with nearly all mastectomies, even if they are muscle sparing.

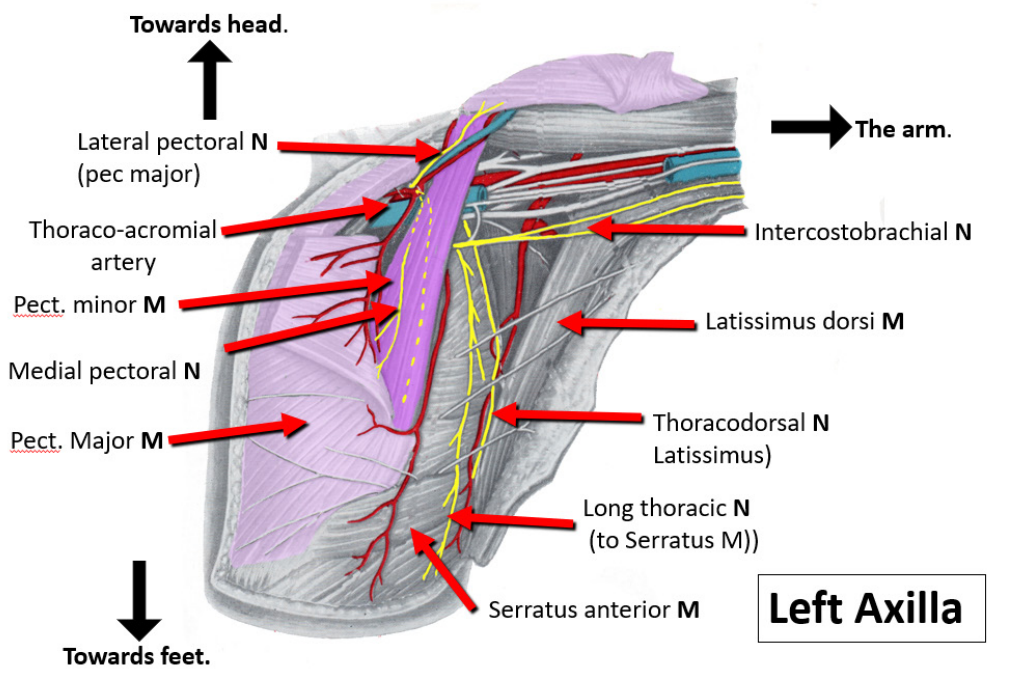

Fig. #9. The left axilla, viewed from anterior, with the pectoralis major muscle resected to expose more of the axilla and the pectoralis minor muscle.

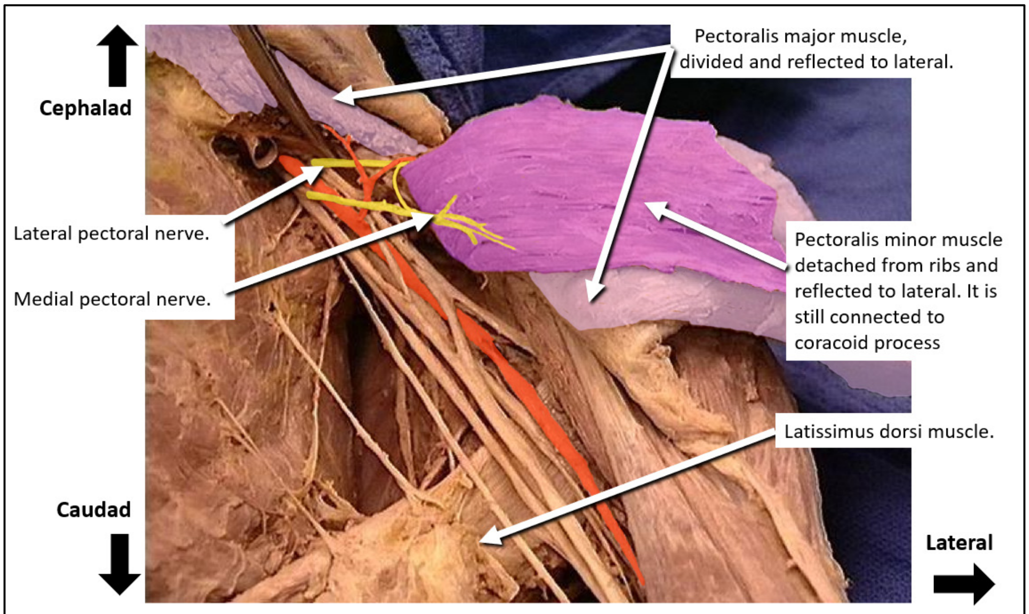

Fig. #10. Dissect ion of the LEFT axilla showing the pectoral nerves.

2.4. The intercostal nerve.

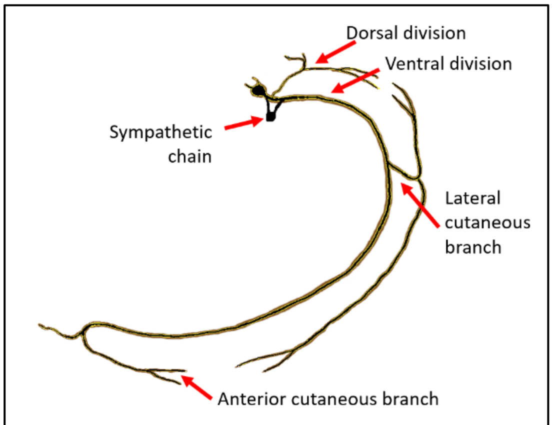

Fig. #11. The components of the intercostal nerves.

Each intercostal nerve, has four key components. They can all be ultimately blocked by a single small injection within the *paravertebral space*. See figure number 10. The first component are the connections to the sympathetic chain. Paravertebral Injected drug usually will fully block the chain at that level as well as the branches to it. The next three intercostal nerve components end supplying three skin areas. Those three components are with skin sensory functions are; (i) the dorsal division, (ii) the lateral cutaneous nerves and the (iii) anterior cutaneous nerve.

It is probable that a nerve block technique variant, that clinically fails to block the anterior cutaneous nerves, has clinically only blocked the lateral cutaneous branch of the intercostal nerve and not the actual intercostal nerve. See figure number 11. This is a classification of how an intercostal nerve can be blocked partially or fully.

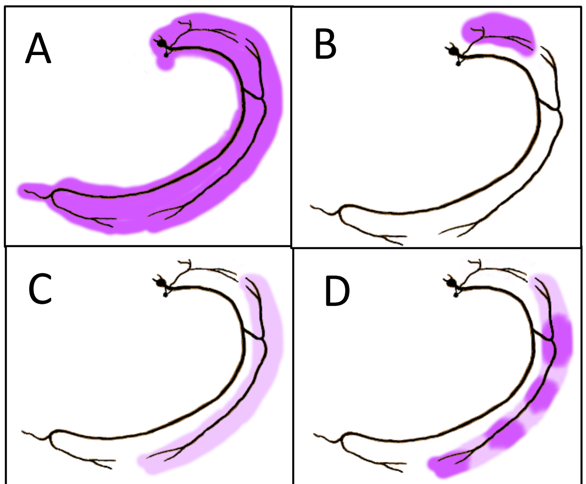

Fig. #12. The possible variant ways that local anesthetic injected in different places could block the components of the intercostal nerve.

In variant block "A", FULL BLOCK, the drug was injected into the paravertebral space and all four, above described, intercostal nerve components were blocked with <u>full</u> strength drug. In block "B", COMPONENT BLOCK, the drug was injected in full strength, into the dorsal division passing within a muscle interspace, but separated from the main portions of the intercostal nerve. Only that one nerve component, the dorsal division, was blocked. In block component "C", DIFFUSION DEPENDENT BLOCK, the drug was injected within a tissue plane removed from the nerve, but allowing drug to diffuse onto the lateral cutaneous branch of the intercostal nerve. It clinically covers a very large portion of the intercostal nerve, but misses the sympathetic chain block, and the very most midline parts of the skin anterior and posterior (dorsal division and anterior cutaneous nerve. Also, the block although analgesic in some degree, is not dense enough for awake surgery within the blocked segments. The drug became diluted on its path of diffusion across fascial planes. Drug that flows freely as a liquid, tends to retain its maximum concentration. Drug that diffuses across fascia to reach its target nerve become diluted by interstitial fluids. In block "D", PATCHY BLOCK, it is similar to block "C" except the block is patchy because drug redistribution after injection is erratic. Some patients will have a highly satisfactory result if the block is appropriate for the tissues injured, but some patients in the group will fail to achieve benefits sufficient to justify doing the block. That is very different to specific drug-on-nerve blocks where results are virtual 100% similar to all individuals.

3. TYPES OF BREAST SURGERY.

There is an immense range of breast surgeries, in terms of magnitude, and anatomical extent. It is essential the anesthesia provider fully know what the planned surgery entails, in order to select the most appropriate regional anesthesia techniques. This is especially so, if awake surgery is planned. Awake surgery means surgery without general anesthesia.

Types of breast surgery;

1) **Very minor surgery**;
   - Simple hallow breast lump excision under local infiltration anesthesia only. Awake surgery is easily possible.
   - Deep challenging breast lump excision. General anesthesia can be used, with local anesthetic infiltration done at the end, for post-surgical analgesia.
2) **Partial or simple mastectomy**. A quadrant or large segment of the breast is removed with preservation of all or most of the skin, and preservation of the pectoral muscles. The mastectomy can be then;
   a. With no axilla dissection, or
   b. With axilla exploration.
3) **Full mastectomy**, with large portion of skin removal. This will entail dissection down onto the pectoralis major muscle and removal of its anterior myomesium.
   a. With no axilla dissection for notes planned, but 6% of woman will have tail of Spence breast tissue extend into the axilla.
   b. With planned axilla surgical exploration.
4) **Radical mastectomy**. This entails removal of all of the breast tissue, with the nipples and all redundant skin over the breast tissue so as to close the skin wound without skin flaps developing. It typically includes a clearance of all fat and lymph nodes with in the axilla. Both pectoral muscles are excised and the ribs lie exposed prior to skin closure.
5) **Modified radical mastectomy**. This is modern surgery. It involves all that classic radical mastectomy involves except the pectoralis major muscle is preserved.
6) **Aesthetic breast surgery**
   a. Reduction surgery. This involves mainly excision of redundant skin and shifting the areola position. No axilla or muscle incising is done.
   b. Breast augmentation. Typically, this includes insertion of synthetic material. The prosthesis will lie either;
      - Retro-mammary, but in <u>front</u> of the pectoralis major muscle, or
      - Retro-pectal, behind the pectoralis major muscle.

   Placing the prosthesis in front of the pectoralis major muscle makes the breast project more, and is the older fashion. Placing the prosthesis behind the pectoralis muscle gives a more natural look, and is the more modern standard procedure. It is however disruptive of the pectoralis major muscle causing much pain and muscle spasms after surgery. Nerve blocking the pectoral nerves adds greatly to patient post-surgical comfort.

7) **Post-mastectomy reconstructive surgery.**

There are a very wind range of techniques, in an evolving surgical field. See figure number 13.

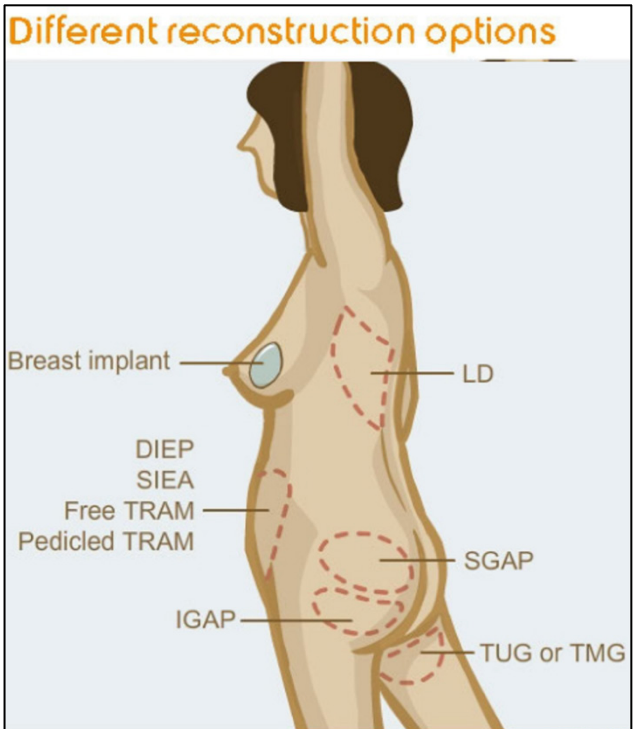

Fig. #13. The different sites for harvesting autologous tissue for breast reconstruction.

•**The DIEP flap**.

The name derives from the **D**eep **I**nferior **E**pigastric **a**rtery **P**erforator which is a central component of the graft. A portion of skin, subcutaneous fat and a feeder artery is excised from the lower abdomen and moved free to the chest to restore skin and mass to the breast after mastectomy. The rectus abdominis fascia is incised, but no muscle is removed. Micro-surgical reattachment of the blood vessels is needed. As no muscle is involved, post-surgical pain is not severe from the harvest site. The abdominal scar stretches from hip to hip. Half of the excised tissue is discarded, if only a unilateral breast repair is done. See figure number 11. As with all the abdominal flaps, the umbilicus is usually repositioned too.

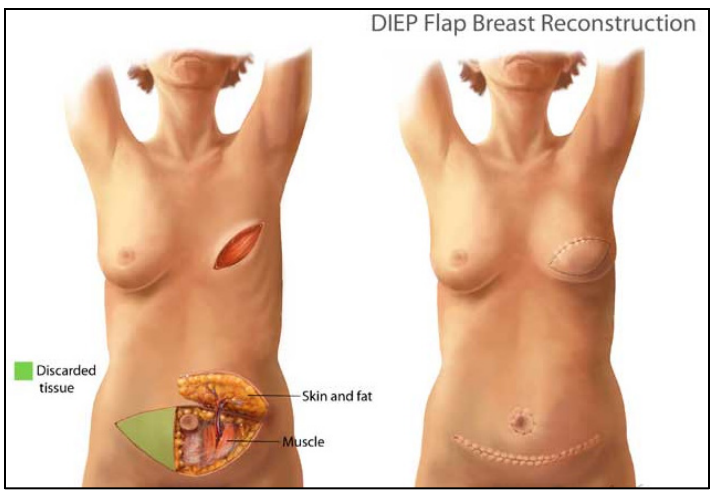

Fig. #14. A unilateral DIEP flap breast construction.

The stacked DIEP flap.

See figure number 14. This is a DIEP flap, for a unilateral breast construction where the abdominal tissues are sparse. The entire flap that is harvested from the abdomen, is used, stacking the one layer of skin and fat on top of the other side's fat portion to give more bulk to the reconstructed breast. A double vascular micro-surgical graft is done. Surgery takes 6 hours.

- **The SIEA flap.**

See figure number 13. It is similar to a DIEP flap, except that the **S**uperficial *I*nferior **E**pigastric **A**rtery and vein are harvested, and the rectus abdominis fascia is not incised. This involves digging into the rectus abdominis muscle, that that done with a DIEP flap, and is more comfortable afterwards. As a free flap micro-surgical arterial reattachment is needed. These patients must be kept warm and normotensive during anesthesia with avoidance of arterio-constrictors. It is a muscle sparing flap. The skin incision is along "the bikini line". Surgery takes 8 hours.

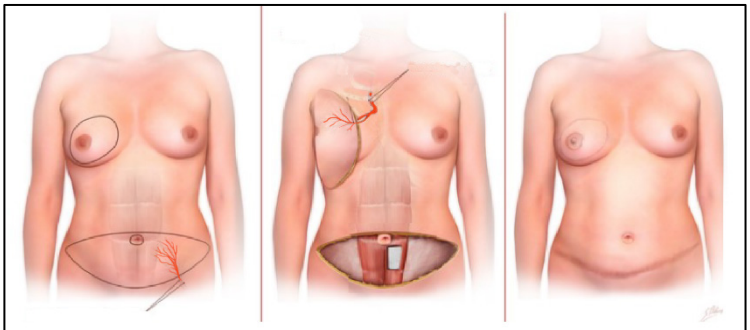

Fig. #15. The TRAM flap, which includes a muscle portion.

- **The TRAM flap.**
  See figure number 15.
  It is a free flap similar to the DIEP and SIEA flaps, except a portion of rectus abdominis muscle is removed around the artery to assist preserve the artery. The name TRAM derives from the full muscle name of **T**ransversus **R**ectus **A**bdominis **M**uscle. After the harvest the rectus abdominis muscle defect needs to be repaired, and often with mesh to prevent a hernia developing.
- **The muscle sparing TRAM flap.**
  This is TRAM flap where a less than full width and depth portion of rectus abdominis muscle is harvested. Some is left behind to facilitate rehabilitation after the surgery, and moderates the risk for an abdominal hernia developing after surgery.
- **The TUG flap.** See figure number 13.
  This is a muscle containing free flap derived from the gracilis muscle on the upper medial side of the thigh. The flap also has skin and fat. It is used when abdominal flaps cannot be harvested. Miro-surgical arterial re-anastomosis will be needed in the breast site.
- **The pedicled TRAM flap.**
  The harvested skin fat and muscle flap is kept attached to its mother blood vessels. It gets tunneled under the flesh to deliver it to the breast under reconstruction. A larger portion of muscle is used than with the free TRAM flap surgery. As with all abdominal flap donations the tissue excision across the abdomen is symmetrical, and the unused harvested half is discarded.
- **The PAP flap.**
  It is muscle sparing triangular skin and fat flap taken from the posterior thigh, close to the buttock. Its name derives form it supply artery, the **P**rofunda **A**rtery **P**erforator. Micro-surgical arterial re-anastomosis is used in the chest. Surgery lasts 5 hours.
- **IGAP flap**.
  The name derives from the harvested flap-tissue's supply artery called the **I**nferior **G**luteal **A**rtery **P**erforator. The flap is a free one, needing micro-surgery vascular reattachment at the breast to another artery. The flap is muscle sparing and uses only skin and fat excised near the buttocks crease. It is technically difficult and a time-consuming surgical procedure. The full surgery can take 12 hours. Sciatic nerve injury is possible. The buttocks can look lopsided if only a one-sided surgery is done.
- **SGAP flap.**
  The name derives from the **S**uperior **G**luteal **A**rtery **P**erforator. It is a muscle free flap of skin and fat harvested form the upper buttock, or the very top of

the thigh. This is the favored skin-fat harvest in thin woman with no belly fat. The harvested skin and fat correspond with what is socially called "the love handles". It is technically challenging and surgery takes long. Sometimes liposuction is applied to the unharvested side to preserve buttock symmetry.

- **Stacked GAP, or "Hybrid" GAP flaps.**
  This is for a unilateral breast construction where a woman cannot use her lower abdomen as donor site, and also has too little fat in the buttock region. Similar to how a stacked DIEP graft is done, so are bilateral skin and fat harvest taken and grafter one atop the other, with the excess skin discarded. Either two IGAP or two SGAP harvests can be used. The buttock will look symmetrical. Typical surgical time is 6 hours.

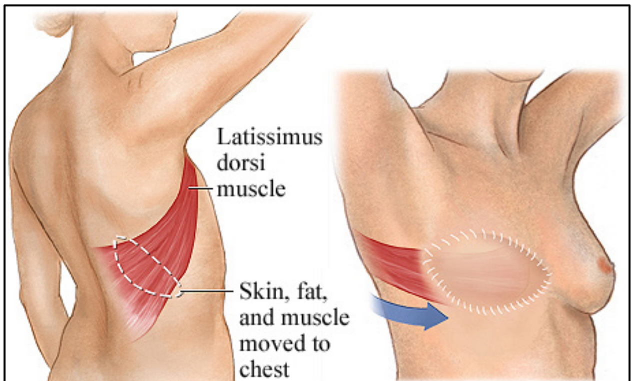

Fig. #16. The Latissimus dorsi flap

- **Latissimus dorsi flap.**
  See figure number 16. This flap contains skin, fat and muscle. It is a pedicled flap with intact arteries and veins. After dissection from the back near the lateral aspect of the scapula, the flap is tunneled to anterior into the breast region and then sutured into place. It is used when a woman is unsuitable for TRAM, DIEP, or SIEA flaps. The full procedure takes 4 hours. It is sometimes combined with a prosthetic implant.

- **The body lift perforator flap.**
  This combines the DIEP flap on the breast surface, with SGAP muscle flap under the DIEP "stacked" underneath. Both are free flaps needing micro-surgical vascular reattachment. It is called a "body lift" flap because if done bilateral, as is usual it effectively combines a tummy-tuck procedure, and buttock-trim procedure, with breast augmentation. During the surgery the patient will initially lie supine, then prone, and finally supine again and the procedures last 10 hours.
- **Fat grafting**.
  The most common method involves *lipo-suctioning* fat from the thighs, belly and buttocks. The fat is liquified and injected back into the breast region. Another technique is *lipofilling*, which also suctions fat, but via larger needle inserted through small incisions, and then injected into the beast.

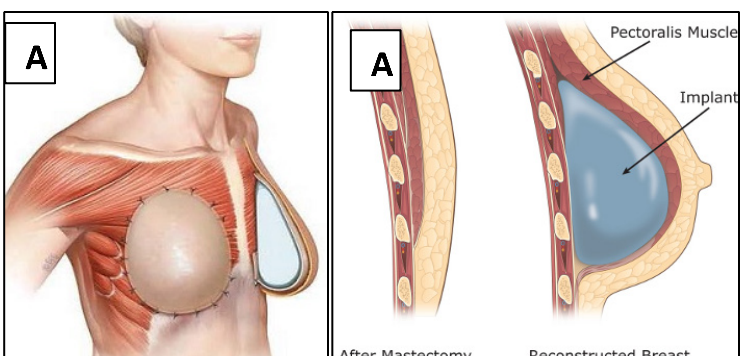

Fig. #17. Figure **A** are pre-pectoral synthetic breast prostheses. Figure **B** is retro-pectoral breast prosthesis

- **Synthetic prosthesis inserts.**
  There a variety of graft types of little relevance to anesthesia considerations. Inserts however, can be either inserted pre-pectoral or post pectoral.

4. THE STORY OF FANNY BURNEY

Fig. #18. Fanny Burney.

Fanny Burney lived in London in **1811,** when she needed a radical mastectomy, for cancer. The doctor operated her on a table in her own home's kitchen. He also operated on her, without anesthesia. There were four strong men each assigned to restrain her to the table and each to hold one limb during the surgery. The surgeon encouraged her to scream throughout the surgery. This she did, and she screamed continuously with all of her heart.

The surgeon placed a light veil across her face. Fanny requested the assistants not to hold her, and Fanny managed to restrain herself from moving during her live surgery. In her later writings she expressed pride in herself, that she had managed to not need the four strong men to help her get through the surgery. She later described vividly feeling the scalpel excise her flesh. She felt everything, yet managed to lie still. She could even distinguish the scraping feeling of the scalpel on her ribs as the pectoral muscles were cut from their rib attachments. She noted that when the surgery was completed and the light veil on her face was removed that she saw spots of blood on the ceiling, and that the surgeon's face was as pale as a white sheet. She said she felt very sorry for the surgeon. Fanny lived for 28 years after her surgery.

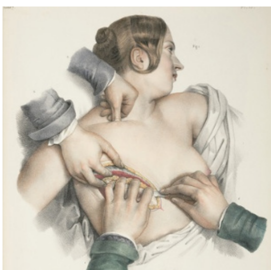

Fig #19. Surgery on awake patients was fast. Assistants pressed on arteries to reduce bleeding.

Fig. #20. Four men restrain an awake Victorian era surgery patient.

Fig #21. Mastectomy usually occurred in the lady's home.

Fig. #22. Hot irons from a coal fire were used for awake cautery. See the rope restraint on the ankles.

Following William Morton's later public demonstration of ether anesthesia in **1846** in Boston, it is hard not to consider the discovery of anesthesia as the greatest discovery in medicine ever. No modern woman ever has to endure what Fanny Burney went through.

The modern woman should at the first meeting with her family after breast surgery, be able to sit upright in bed and be smiling with a warm pink face.

5. NERVE BLOCKS FOR THE BREAST (MAMMARY) REGION

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5.1. Introduction.

This section discusses nerve blocks for the mammary tissue and its overlying skin. Breast procedures can range from percutaneous needle biopsies to radical mastectomies including removal of the pectoral muscles. The smaller procedures require the support of varying grades of sedation (with infiltration local anesthesia) to full general anesthesia.

The level of sedation used with infiltration anesthesia may range from anxiolysis (calm with open eyes) through conscious sedation (closed eyed patient able to respond to instructions) to deep sedation (patient asleep, unable to respond to verbal instructions, but moving with painful stimulation and needing intermittent airway anesthesia patency correction). The boundary between deep sedation and full anesthesia is fine, hard to diagnose, and hard to anticipate. Deep sedation is often actually general anesthesia with an uncontrolled airway.

The patient mortality when the patient is in general anesthesia and uncontrolled airway, in the care of non-anesthesiologists, is higher than the patient mortality associated with a planned general anesthetic.

Potential usable blocks for the mammary region and its skin are; (1) epidural block, (2) thoracic paravertebral block, (3) erector spinae block), and (4) serratus plane block.

If the pectoral incision is going to have its anterior fascial layer stripped or the axilla is going to be explored it is best to combine the paravertebral block with general anaesthesia and use NSAID containing multimodal therapy for post-surgical analgesia together with the block. Those added tissues have brachial plexus nerve supply. At the University of Iowa awake surgery is done that includes axilla and pectoral muscle dissection by the added selective blocking of the muscles front and back in the axilla. The pectoral nerves, the nerve to latissimus dorsi and the nerves to the subscapular muscle are selectively blocked in the infraclavicular zone.

Shine and Greengrass used thoracic paravertebral blocks to alleviate pain after the surgery of transthoracic (lateral incision) aorta aneurysm repair, as it avoided concern about use of anti-coagulation therapy with epidural catheters. It also allowed optimal distal spinal cord function testing after surgery, when there was a concern for post-surgical paraplegia[13]. Anesthesiologists also started to prefer the one side paravertebral block for surgeries limited to a one side thoracotomy approach, rather than use an epidural[14].

Boezaart and Raw described a continuous catheter technique using nerve stimulators[15]. The advantage of a catheter technique is it allows sustained analgesia beyond the immediate surgery period. This is well suited to where the surgical incisions are restricted to about 5 thoracic vertebral levels or less.

Terheggen assessed thoracic paravertebral blocks and experienced one puncture of the parietal pleura (uncomplicated) and one bilateral paravertebral block (labeled an epidural block) in a study group of only 15 patients[16]. He subsequently recommended thoracic paravertebral blocks not be used with minor beast surgery due to it being too risky. This conclusion is however questionable as the broader experience of this block is much better and these may have been the errors of inexperienced operators. They used “Eason’s” technique[17] which required walking superior of the rib-process complex.

Klein’s experience of the paravertebral block for “minor” breast surgery was encouraging[18]. Minor breast surgery means no there is no surgical interference with the pectoral muscle or the axilla. Klein used a sharp Quincke point “spinal” needle for his technique and this presently highly recommend NOT to do. Do all paravertebral blocks preferably with “blunt” Tuohy needles. Sharp needles seemingly may increase risk for intravascular injection pleural penetration and they offer no “loss of resistance” features that successful blocks can utilize.

Large surgery to the breast (mastectomy) is associated with up to 60% incidence of phantom tissue syndrome and chronic pain. Paravertebral nerve blocks done prior to surgery seems to reduce the incidence of that.

5.2. High thoracic epidural anesthesia for breast surgery.

Epidural anesthesia is feasible at any point of the vertebral column. A thoracic epidural catheter inserted in the mid-dermatome of the surgical incisions can be used as sole anesthetic or as supplement to general anesthesia. For example, a T4-5 or T3-4 inserted epidural catheter and injected with about 1.5 ml of local anesthetic per desired segmental spread is effective in typical healthy adult females. This author has used both of ropivacaine 1% 6 ml combined with general anesthesia for bilateral breast augmentation and ropivacaine 0.4% 10 ml for awake breast augmentation. The lesser concentration requires more “soak time” (waiting time for onset of surgically satisfactory anesthesia), but is associated with less risk for spillover weakness into the lower parts of the brachial plexus with hand weakness.

Generally high thoracic short segment epidural anesthesia is associated with minimal hemodynamic changes. This is seen in volunteer studies and is validated in the author’s experience. The epidural should not extend into mid-cervical zones such as C3, 4, 5 with muscle paralyzing doses lest bilateral phrenic nerve block result. Spread of the epidural to T1 and C8 will cause discernable sensory (and even motor) changes in the fingers and hand. This is harmless but the patient needs forewarning to diminish the distress this could cause.

Choosing the higher insertion site of 2 choices (e.g. T3-4 over T4-5) is generally better as epidural blocks tend to cover 1 to 2 segments lower that those above the insertion level for reasons that nerve roots exiting the spinal cord tend to descend before exiting an intervertebral foramen. Local anesthetic is absorbed into the CSF immediately under the injected epidural drug fluid sleeve, in similar fashion to that of opiates. This causes the “extra” downwards segment that is commonly blocked.

A special note is than the cardiac sympathetic accelerator autonomic nerve supply is derived from T1-T5. With an epidural blocking those segments, usually there is minimal cardiovascular consequences in the resting patient. If, however a parasympathetic stimulus (vagal) stimulus is generated a severe bradycardia can result. This is due to the lack of opposing sympathetic drive to the heart. This author has never yet experienced this in a full career of anesthesia and many T1 to T5 epidurals. The treatment would by atropine or similar drug.

5.3. Thoracic Paravertebral block for breast surgery.

Paravertebral blocks have been very popular for unilateral breast surgery and preferred over epidural blocks in a number of academic centers. A study by Pusch, of 86 women undergoing a range of breast procedures, without pectoral muscle excision, compared general anesthesia to thoracic paravertebral block (TPB)[19].

In 1998 Coveny, Greengrass, and Steele presented retrospective data on 145 breast operations involving mastectomy[20]. One hundred patients received only general anesthesia and were the comparator group. In the study group of 156 individuals who received only thoracic paravertebral blocks, awake surgery without local anesthetic supplementation was achieved in 85% of the cases. Only 9% needed conversion full general anesthesia. Considering (i) there was no supplementary blocking of the pectoral nerves, and (ii) the axilla was deeply dissected in some patients, the results are outstanding. All outcomes investigated showed best results in the paravertebral blocks group. Technical block failure was strongly seen to be lowest in the hands of the most experienced physician performing the blocks. The authors argued that thoracic paravertebral block should be the standard against which other regional anesthesia blocks for breast surgery, should be compared to.

In 2000 Klein, Greengrass, and Steele did a sixty-case prospective study on the thoracic paravertebral block in ladies undergoing breast augmentation and reconstruction[21]. The two patient groups got, the one general anesthesia, and the other, thoracic paravertebral blocks and deep propofol sedation with retained rousability. Postoperative analgesia had a trend up to 72 hours for single-shot paravertebral block group to have less pain, although statistically significant less pain only was present for the first 24 hours. Paravertebral injections consisted of injections of 4ml 0.5% bupivacaine at each of the levels T1 to T7 at 2.5 cm from midline and walking the needle caudad off the transvers process for a 1cm depth. There were no block complications or failures.

Thoracic paravertebral block is associated with improved latissimus dorsi flap oxygenation when the muscle is used in breast reconstruction surgery[22]. As the muscle gets it motor nerve supply form segments C6-8 via the long thoracic nerve there is no obvious explanation for that observation.

A retrospective study of the records of 129 woman suggested that those who had a paravertebral had less breast cancer tumor recurrences[23].

Bilateral paravertebral blocks are feasible for bilateral breast surgery and acceptable practice, but the single injection of an epidural has some merit too.

The paravertebral block has safety advantages over epidural blocks of having a very low risk for catastrophic epidural complication. The paravertebral block is technically very easy to perform, but is fraught with risk for novitiates to self-teach. It is readily learned however under a modest amount of mentored guidance. The tactile and needle holding skills of epidural injection are readily transferred to learning paravertebral blocks. Ineptitude with epidural injection however predicts for similar technical ineptitude with paravertebral blocks.

Paravertebral space is easily catheterized and this allows maintenance of the block for a period of days using local anesthetic infusions. This author has used ropivacaine infusions of 0.2% at 8 to 12 ml per hour satisfactorily.

The thoracic paravertebral blocks do not last very long. In one group using ropivacaine 0.5% injected prior to breast cancer surgery, found analgesia benefits only lasted through the surgery and for the stay in the post anesthetic care unit (PACU)[24].

For breast surgery, inject the single shot thoracic paravertebral block at T4, aligning with the nipple dermatomal nerve supply. A volume of 15 to 20 milliliters of local anesthetic will spread from T2 to T6 reliably and often to T1 and T7 as well. Catheters can be placed.

5.4. The history of the paravertebral nerve block.

This is a classic nerve block described in the first published text book of regional anesthesia by Frenchman Victor Pauchet in 1917. The technique was first used by Sellheim in 1905. and further evolved by Lawen and Kappis in 1911 and 1919 respectively. Eason's 1979 review of the block and anecdotal description of his 75 blocks experience raised interest in the block again[0]. Furthermore, Regional anesthesia spurred by increasing attempts to reduce anesthesia mortality even further as well as a growing desire to improve post-surgical pain treatment experienced a general re-birth steadily from 1980 or so onwards.

5.5. Advantages of the thoracic paravertebral block?

1. It offers selective unilateral analgesia/anaesthesia and avoidance of the high morbidity risks of neuraxial anaesthesia, particularly where anticoagulation concerns are present.

2.It seems to has less risk for paraplegia than epidural blocks.

3. It can spread to paravertebral segments above and below that of the injection level which is different to intercostal blocks= single injections or single site infusions can block multiple segments (unlike mono-segment intercostal blocks).

4. Local anesthetic infusion catheters are readily inserted to maintain the block for sustained analgesia.

5. Although bilateral paravertebral thoracic paravertebral blocks can be done, good consideration should be given to rather doing an epidural instead. An epidural is much more economic on local anesthetic drug and allows other nerve

blocks to be done for other tissues like autologous donor graft sites and the pectoral muscles. because

5.6. Mechanism of action of thoracic paravertebral blocks.

Local anesthetic is presumed to work mainly direct on the peripheral nerves immediately lateral to the intervertebral foramen. The rami communicantes to the sympathetic chain are also blocked. These are not blocked with epidural blockade and segmental sympathetic carried pain signals that climb to higher segment levels before entering the spinal cord may escape blockade. This is typically seen with abdominal surgery where the a neuraxial block may provide anesthetic of the anterior abdominal wall but not of the viscera[25]. With intrathoracic surgery it is thus logically worthwhile that paravertebral blockade of segments T2 to T4 be achieved to block pain sympathetic carried fibres form the lung and the visceral pleura, in addition to the segments blocked for the chest wall incisions.

5.7. Pharmacology of thoracic paravertebral blocks.

In this authors practice experience, single shot blocks do not last nearly as long as single shot peripheral nerve blocks, but do last longer than single shot epidural blocks.

Infusion of local anesthetics into the paravertebral space produce similar drug blood level to any other block infusion as plateau concentration depend only on infusion rate and metabolism rate. With peak blood levels after paravertebral boluses, absorption is relative fast and peaks occur earlier and at high values than that typical for e.g. that of a sciatic nerve. Therefore, full caution must be exercised when planning maximum safe-dose techniques (e.g. extensive bilateral blocks).

It can be generally expected that 15 ml injected paravertebral at one level can produce a spread of 2 segments up and down each for total of a 5-level block. This is however not very consistent. Many authors favor multiple level injections for this reason. It has also been observed both in published literature and this author's experience that paravertebral blocks are of much slower onset than that typical of a peripheral nerve block, e.g. a sciatic nerve block. This may be the reason that spread seemed inconsistent in many studies, as the assessment were done too early after injection.

The following approach is recommended.

Surgery to be done asleep (under GA). Place a catheter at the level of the center surgical dermatome. Infuse catheter afterwards, or inject a top-up local anesthetic dose at a later time, e.g. after surgery, and then remove the catheter. A top up will extend the block a few hours extra. Inject 15 to 20 ml each time.

If awake surgery is planned, it is recommended to place the catheter as above, and do supplementary single shot injections at one or two levels above the catheter level. Single shot volumes can range from 3 to 5 ml with 4 being recommended. The single shot supplements will accelerate the onset of surgical usable analgesia. Otherwise a wait in excess of 40 minutes is advised for full block development.

Local anesthetic pharmacokinetics when injected into the paravertebral space has a biphasic response[26]. The authors used a thin gauge (22G) Tuohy needle.

The first phase corresponds with that seen with intravascular injections. Adding epinephrine diminished the blood level peaks and delayed it in time. The addition of epinephrine would seem thus indicated. If the block is to be combined with general anesthesia a large volume single level injection can be done. The block will be fully developed by the end of surgery. If the block is planned to be used for awake surgery, then the block onset can be accelerated as follows: inject half the single dose volume at the center dermatome level and a quarter of the dose at each second level further up and further down. The maintenance catheter can be placed at the center injection point.

Single shot block duration is approximately 3 hours for 0.375%, 4 hours for 0.5% ropivacaine, 5 hours duration for 0.75% ropivacaine, 6 hours for 1% ropivacaine, 7 to 8 hours for 0.5% bupivacaine, and 8 to 9 hours for levobupivacaine. Inject 2.5 to 4 ml per segment level needing to be blocked. Drug spreads up and down to adjacent paravertebral spaces in a ratio of 2.25 to 2.5 ml per segment. For example, if 20 ml of drug is injected at one point, the block will cover the segment injected at and also consistently 2 block segments up and two segments downwards, at least. Injection at T6 of 10 ml drug should produce an anesthetized area spanning dermatomes T4 to T8, being five levels in total. IF the block is for post-surgical analgesia after recovery from a general anesthetic, there will be sufficient time for the five-segment block to develop. If the block is for awake surgery, block onset can be accelerated by doing a supplementary single injection at alternative levels above and below the level where the catheter was placed. Ensure total doses do not reach unsafe limits. Absorption of drug is relatively fast, and ropivacaine should be preferably used than bupivacaine if the total volume of all the nerve blocks is reaching near unsafe dose limits. Ropivacaine is the safest of the long acting drugs.

An infusion can be injected into the catheter after surgery, and generally an hourly flow of ropivacaine 0.2% running at 8 to12 ml per hour will maintain a 4 to 5 segment spread of nerve block. Occasionally, in the evening or on the first morning after surgery, a supplementary repeat main dose may be required to restore the full dermatomal **breadth** needed from the nerve block.

It must be noted, if more lateral injection points are used, as with some of the early ultrasound guided techniques, the above pharmacology will not apply. There will be less spreading of drugs and more needed to block each level and all catheters will result in very limited range blocks being sustained.

5.8. Thoracic paravertebral land-mark-based block techniques overview

Pauchet's technique.

His book documented the first block description. He used multiple injections starting from **4**cm from midline, walking inferior off the rib aiming the needle 45 degrees to medial towards the intervertebral foramen. No longer advised.

Eason's technique[27].

Use a 20G lumbar puncture needle or 16G epidural needle. Insert the needle through the skin **3** cm from the midline, directed direct to anterior. That means, the needle tip should never deviate towards lateral, nor to medial. Make contact with the bone of the rib or transverse process. Redirect the needle to cephalad in a parasagittal plane and advance beyond the bone using loss of resistance to injection of air. Cease advancement once a loss of resistance is perceived. Aspirate to exclude vascular placement and lung penetration. A catheter may be advance one cm beyond the needle tip. The author anecdotally quoted 75 case's experience. This is close to an intercostal technique that allows medial drug spread, but needle endpoint is also close to pleura. This seems to minimize the chance for spread between paravertebral spaces.

Richardson and Lonnqvist technique.

They brought their point of insertion to **2 to 3** cm from midline, used a loss of resistance technique but they supported sharp needle use still. This author opposes use of sharp needles.

Naja described the use of the nerve stimulator in children for low thoracic paravertebral blocks for inguinal hernias.

Multimodal paravertebral space identification. This author has personally technically performed over 300 paravertebral blocks utilizing a variety of techniques and has settled on the following methodology. This multimodal technique uses many modalities of end-point identification simultaneously, and accepts any clear end-point first presenting. It has been in the author's hands very reliable and very safe, and is the authors teaching standard. The multimodal technique uses a nerve stimulator set at 1.5 mAmp current, a large blunt Tuohy needle, and a loss-of-resistance to injection of 5DW and no air in the syringe. The ultrasound is very useful in guiding the needle to its point of first bone contact. The ultrasound has no use in further positioning the needle at the precise depth within the paravertebral space, nor at the precise optimum distance from the intervertebral foramen or midline. A variety of other techniques must be simultaneously and skillfully used for that final purpose. This is called the FUSION technique

5.9. Complications of thoracic paravertebral block.

1. **NEURAXIAL BLOCK**. As with all paravertebral injections drug can be delivered to the neuraxis and a spinal, epidural or subdural injection result[28]. It is likely the risk for this is increased by undue medial direction insertion of needles, and well as the hypothesized abnormal extension of dural sleeves along the nerve root due to local myelomeningocele, or other congenital abnormality. The exact risk is unknown but this author's experience and reading of the literature suggests that high grade extensive neuraxial block is very rare, but short segmental evidence of contralateral low-grade block, is common.
2. **SHORT SEGEMENT CONTRALATERAL BLOCK**. This is poorly researched, but published and multi-practitioner verbal anecdotal evidence suggests that the risk goes up with injectate volume and may approach 10% with single level injections of 20 ml of local anesthetic. This is usually entirely harmless and mostly discovered during systematic mapping of block spread. Possibly it related to diffusion of drug across serial fascial planes and barriers and this may explain the short segment extend of block and the lower grade of block achieve contralateral.

3. **NERVE INJURY**. As yet un-described, and if it occurred it would likely be of small consequence.
4. **INTRAVASCULAR INJECTION**. This is risk with all regional anesthesia and may be slightly higher here than with more peripheral limb nerve blocks.
5. **SEPSIS**.
6. **HAEMATOMA**. As yet un-described, and likely to be of small consequence if it occurs.
7. **BLOCK FAILURE**. Block failure can result from inappropriate segment blocking for the surgery. E.g. failure to block segments T2-4 with thoracotomies will result in persistent lung pain via the sympathetic system regardless of the analgesia of the chest wall incisions. Provided the segments chosen blocked. Technical failure is operator dependent and in-experience associated.

5.10. Contra-indications for the thoracic paravertebral block.

There are the standard contra-indications common to all procedures and all nerve blocks such as allergy to the intended drugs to be used, lack of patient consent and sepsis at the site in intended injection etcetera. All contra-indications can be relative and balanced risk-benefit decision must be taken involving the patient and the surgeon, sometimes.

Specific contra-indications to thoracic paravertebral block are few, rare and relative.

1. **Anti-coagulation** therapy or pathological coagulopathy. There are no science-based guidelines, nor case reports of complications attributed to abnormal coagulation. Common sense would suggest the intermediate degree of coagulation disturbance that a surgeon would consider acceptable to risk the surgery with equally be acceptable to risk the nerve block with. In fact, paravertebral block becomes relatively INDICATED where the profound analgesia of epidural is desirable but contra-indicated by suboptimal coagulation status.
2. **Anatomical abnormalities**, e.g. kyphoscoliosus. This makes successful block harder to achieve and the complications risk is increased. Experience and intelligence with adapting the needle insertion direction, however may still allow achieving successful safe nerve block.
3. **Stripping of the pleura surgically**. If the posterior pleura adjacent to the paravertebral space being targeted was previous removed, do not do the block. If the pleura is to be removed at the surgery to follow, do not do the block. The paravertebral block may be futile as the local anesthetic will escape into the thoracic cavity.
4. **Lack of experience and skilled training** in the technique, and regional anesthesia generally.

5.11. Thoracic paravertebral block nerve block procedural steps.

1. **Step #1. Identify the level(s) to be blocked**. Count the dorsal thoracic spines and mark the level(s) to be blocked. Prior ultrasound location of the bony transverse-rib structures and the spinous processes, with marking them on the skin, prior to needle insertion is very helpful.

2. **Step #2 infiltrate with local anesthetic, in awake patients.** It is not necessary to anesthetize all the way to the transverse process usually.
3. **Step #3. Place the needle onto bone**. Insert the needle through the dorsal skin **2.5 cm** from midline. Successively insert the needle deeper probing systematically in a cephalad-caudad parasagittal arc until the transverse process is located.
4. **Step #4. Advance the needle CAUDAD off the bone** staying in a parasagittal plane (deviating neither to medial nor to lateral).
5. **Step #5. Stop advancing, when ANY one of the following FIVE endpoints is reached.**
   I. Loss of resistance to injection of 5% DW is felt. It is subtle and less obvious than with an epidural.
   II. A feel of a "pop" after the needle passes through a costo-transverse ligament or other fascia. A pop is not consistently observed as the ligaments are not continuous in medial to lateral plane. The "pop" is usually subtle. If the "pop" feeling is obvious has a "snapping" character, it is more likely the needle was felt penetrating the posterior parietal pleura.
   III. Reaching a distance of 1.25 cm beyond last bony contact. NEVER advance further. All pneumothoraxes are associated with more deeply inserted needles. The block will work.
   IV. Evidence of intercostal muscle twitching. As the breast and the pectoral muscles conceal the intercostals muscle in the chest it is helpful to have an assistant place a hand against the chest in the axilla to feel for intercostals twitching. In the abdomen the abdominal wall muscle will be seen to twitch, in the corresponding thoracic dermatomal distribution. Use a current of 2 mAmp, and there is no reason to test the needle position with lower currents.
   V. Report from the patient that they feel a tapping paresthesia anteriorly, e.g. in the breast or nipple. Any degree of sedation of the patient will hinder this end-point being reported.

6. **Step #5. Exclude pleural penetration by placing a saline drop onto the open hub** of the Tuohy needle. Responses
   I. No drop movement = extremely unlikely pleural.
   II. The drop moves in and out with respiration. This is common. It is extremely unlikely that the needle is within the pleural cavity.
   III. The drops sucks into the hub slowly, as do repeated hanging drops. The chance of the needle tip being intra-pleural is 50%.
      - Management; If there was no preceding "pop", and the Paravertebral space was identified within 1 cm of the last bony contact, or by nerve stimulation (motor or sensory) then trust the needle position. Pass a catheter. If catheter advances with any small resistance then the needle position is perfect in the Paravertebral space. If the catheter advances with zero resistance upon first exit from the needle, then regard the needle is intrapleural and redo the block with modification of needle direction.

IV. Drops placed in hub suck in vigorously means definite pleural puncture has occurred. IMMEDIATELY remove the needle to stop air entrainment via the needle. Redo the block.

7. **FLUOROSCOPY AND CONTRAST**

This is only recommended if lytic blocks are planned. Use contrast injection to confirm the correct fluid spread. Also, chronic pain-based injections usually target a specific vertebral level. Fluoroscopy helps diagnose the precise level.

When a paravertebral block is being done just for perioperative analgesia such precision of vertebral level determination is not necessary. Any injection this is within a range of three levels that includes the targeted one, will all result in perfect clinical analgesia. Therefore, fluoroscopy and contrast injection are not needed with perioperative analgesia paravertebral blocks. If Fluoroscopy was used it would create costs without benefits. It would also cause undue delay in performing the procedure. There is no need not use for fluoroscopy in perioperative regional anesthesia.

5.12. Thoracic paravertebral block technique tips.

The lung (visceral pleura) is never penetrated by cautious advancement of a blunt Tuohy needle, even if the needle has broached the pleural cavity. Penetration of the lung's visceral pleura, is even more likely as the lung tends to get pushed back by the blunt needle. Penetration of the actual lung could cause air leakage and a growing pneumothorax. This author has never seen that nor heard of that occurrence. This author has seen entrainment pneumothoraxes occur when pleural penetration did occur and an open needle was allowed to entrain air for a few minutes before needle retraction. The resultant pneumothoraxes were very small and absorbed without drainage in single hours. A radiologically visible pneumothorax can form after as little as 60 seconds of air entrainment via a 16 G Tuohy needle. In this author's long experience with trainees, pleural penetration occurred in 5% of trainee cases. In all those cases where the needle was withdrawn immediately, radiologically visible pneumothorax never developed.

A pleural needle placement must be suspected when 1 or more of THESE three signs occur; (1) A snapping "pop" is felt as the needle advances, (2) Fluid drops placed in the hub of the needle are sucked in vigorously, or (3) the catheter feeds in with no resistance at all, especially with no resistance to the first centimeter of advancement.

The "normal" paravertebral catheter always offers very slight or modest resistance to advancement upon exiting the needle. If there is doubt and it seems the paravertebral catheter fed in too easily, the block is best redone.

Accordingly, it is essential to perform this block with great sensitivity of touch, as the endpoints are often subtle. It is also important to absolutely accept the first of the five end-points reached. It does not matter to block success which is the first one recognized. Resist advancing the needle to try for second different endpoint.

This block may be performed on anaesthetized patients, and it is helpful to avoid muscle paralysis, in order to allow use of a nerve stimulator in seek intercostal muscle twitching.

Directing the needle caudad of the bone rib-transvers-process pair is the best choice as it enters where the Paravertebral space is at its deepest. That also means the distance to pleura is longest.

There is currently no gold standard nor a common ultrasound guide technique for paravertebral blocks. It is also a fact that simply adding an ultrasound transducer to a technique does not automatically make the nerve blocker, easier, better, safer, or faster. On every continent, a number of teachers promote a personal variant block technique. They nearly all have severe limitations

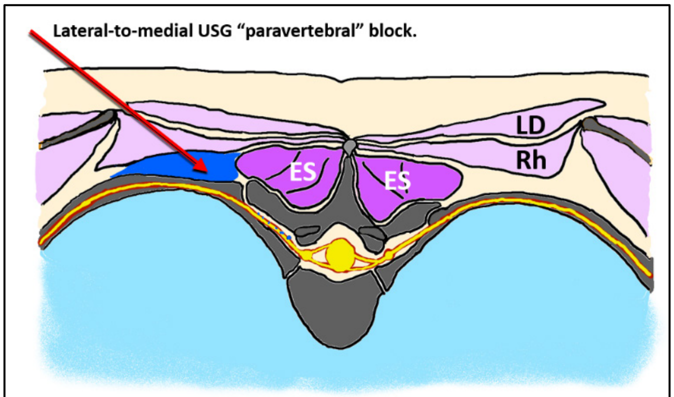


Fig. #23. Lateral to medial ultrasound guided paravertebral block.

The one big challenge is that ultrasonography cannot display the relatively small nerves of the paravertebral space. So thus, the object of ultrasonography is to indicate the ***space*** occupied by the nerves. This brings the second challenge to the fore. All the relevant bony surfaces and fascial surfaces slope at big angles different to the orientation to the skin, as well as to each other. A structure is only optimally imaged if sonographic waves can impinge on it perfectly vertical so as to reflect directly back to the transducer. Adjusting the transducer angle to the skin to optimize one deeper structures sono-image will make other relevant structure less visible.

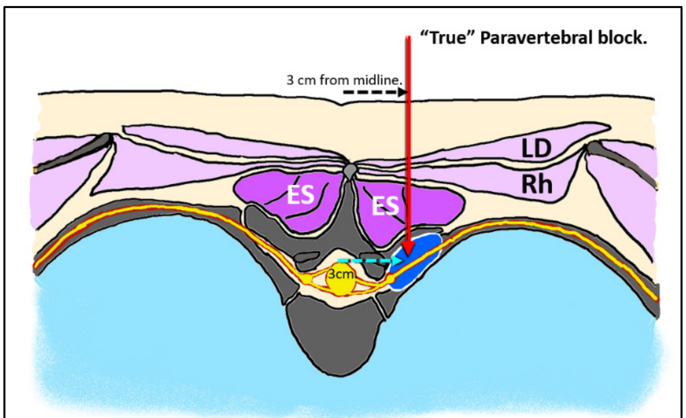
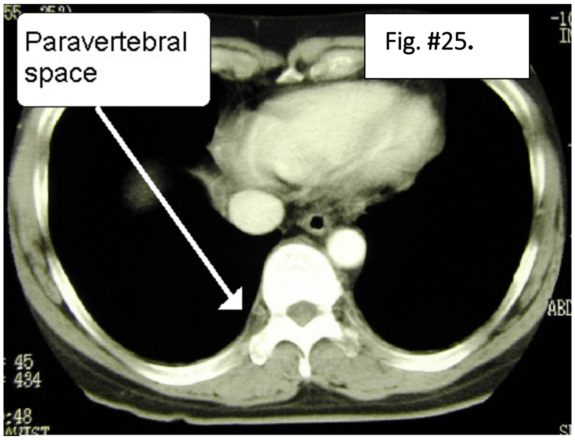


Fig. #24. "True" paravertebral block, injection point.

The ultrasound guided techniques can be classified as follows:

- **Transverse off-plane FUSION landmark technique**- Recommended as the 2nd best technique.
- **Transverse off-plane K1 technique**- Third best technique.
- **Transverse in-plane K3 technique**. This is a dangerous technique and not a paravertebral block, but a very medial intercostal block. It absolutely requires multiple injections.
- **Paramedian oblique parasagittal in-plane K3** technique. Far too complex for average practitioners. This is not a recommended technique.
- **Parasagittal in-plane technique.** Difficult, dangerous, inconsistent. This is not a recommended technique.
- **Parasagittal off-plane FUSION technique.** This a simultaneous controlled movement of both the needle and transducer as the needle advances. It is readily mastered by natural technical skill learners, with advanced 3-D spatial perceptions, and in-depth anatomy knowledge and experience. They can

master the block with three cases of experience. It is the 1st best technique. All other qualified anesthesia providers can also learn this technique but it will take about 20 cases of experience under the tutelage a consistent single teacher



See figure number no. 25. It shows the chest in a CT cross section view. The target paravertebral space is shown. Observe that the paravertebral space has a depth of about 2.5 to 3cm, and its breadth is about 1.5 cm in adults. The paravertebral space is located immediately to lateral of the intervertebral foramen from were ta intercostal nerve emerges. A rib forms both the cephalad and caudad boundaries of the paravertebral space. Pleura lies both deeper (towards anterior) to the paravertebral space, as well as lateral to it.

See figure number 26. It is a CT transverse sectional view through a thoracic paravertebral space. It shows the ideal position for the needle tip to end at. That positon is exactly in the middle of the paravertebral space in all axes.

The pleura lies 1 to 2 cm deeper if the needle were to continue advancing. The pleura however only lies 1 cm towards lateral were the needle to have been directed to lateral of the ideal 2.5cm distance from midline. The epidural space and vertebral canal lies 2 cm to medial and is inaccesible by this direction of needle insertion. Ultrasound guided techniques that utilize a lateral to medial shallow approach can easily enter the epidural space.

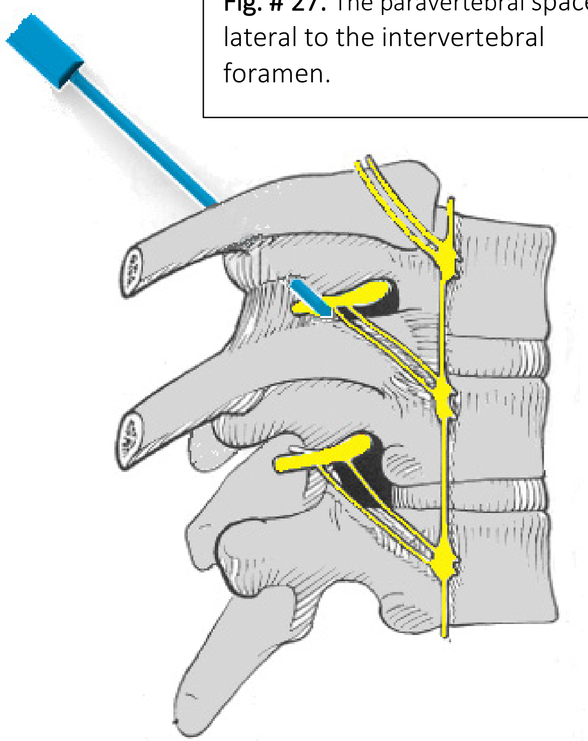
Never use any paravertebral block technique that has a needle direction from lateral to medial. If the needle imaging is imperfect, and a needle tip cut-off occurs within the sonogram it becomes possible to advance the unseen needle tip into the vertebral canal, or the spinal cord. It is also impossible with the lateral to medial approaches to determine if the needle tip is precisely 2.5 cm from the midline, in the optimal position.

The paramedian in-plane techniques cannot sufficiently define the deep structures if it is held perfectly vertical in a prone patient. Conceptually the transducer could be placed on a skin drawn line that is precisely 2.5cm from midline, and aiming directly towards anterior. If then any side tilting is done with the transducer to improve deep tissue imaging, it will no longer be capable of keeping the needle track all the way at 2.5cm from the midline.

Thus, the recommended techniques are fusion techniques. A line is marked on the skin 2.5 cm lateral to the spinal midline. The ultrasound is used in an off-plane fashion to identify the two boney structures of transverse process and rib jointly. The bony structures position is marked on the skin. The needle is inserted through the 2.5cm line over the bony structures marking. The transducer may then either be held in the transverse or in the parasagittal position, adjacent to the needle already 1.5 cm deep inserted in the flesh. From this time the transducer may be side tilted so as to image the needle-tip off-plane, as it advances towards the transverse-process-rib structure. Once the needle tip is placed against bone the ultrasound is abandoned. The Tuohy needle is then advanced using tactile feeling, loss-of-resistance, and nerve stimulation. Needle advancement ceases when one of five end points is reached. Often 2 or three end-points are reach simultaneously;

The catheter passing test. This test does not have to be done if it is only intended to inject a single shot block at this point, and at least one other block end point has been satisfactorily reached. If a catheter needs to be passed, do observe the degree of resistance that it offers as it leaves the needle.

Fig. # 27. The paravertebral space lateral to the intervertebral foramen.

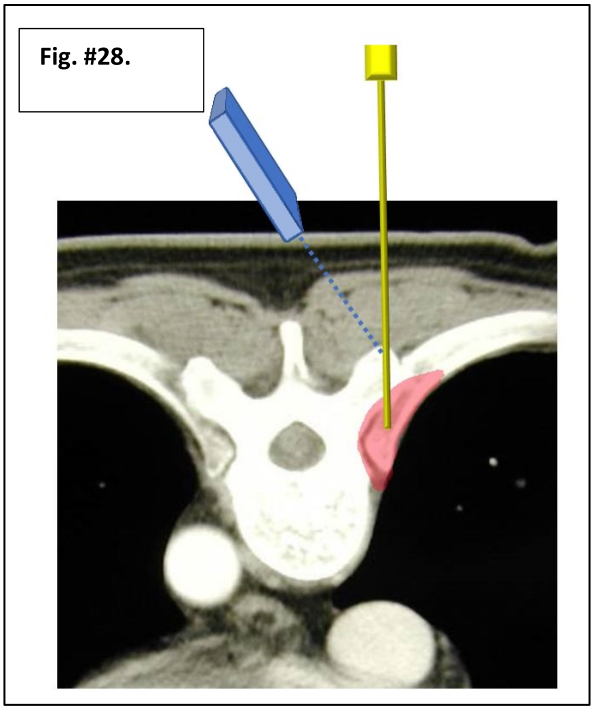


See figure number 27.

It shows a lateral view of the thoracic vertebral with transverse processes and ribs. The intercostal ribs are seen exiting the intervertebral foramina to enter the paravertebral space. Also see the nerve connections between the intercostal nerves and the sympathetic chain on the sides of the vertebral bodies.

Next observe the nerve block needle inserted from posterior and passing immediately below a transverse process, and penetrating the costo-transverse ligament to enter the paravertebral space.

Do not rotate the Tuohy needle bend so as to direct the catheter to medial, nor to lateral. Let the Tuohy needle end orifice face either to cephalad or to caudad, when advancing the catheter. Also advance the catheter only 1cm. Advancing the catheter for a length in excess of 1 cm, e.g. 4 cm, can result in the tip entering the intervertebral foramen and increasing the epidural spread of the drug.



See figure number 28. It shows at CT sectional view of a thoracic paravertebral space, highlighted in pink. A needle has been passed into the paravertebral space 1cm beyond the last point of bone contact. The needle tip is opposite the intervertebral foramen and dead center in the paravertebral space.

The ultrasound transducer is held parasagittal, and oblique to the nerve block needle on its medial side. The transducer is "looking" at the transverse process, and was used to guide the needle downwards as the needle was inserted. The ultrasound was also used to locate the axial position of the transverse process before the needle was inserted into skin.

A needle "walked off", cephalad to the lateral bone structures reaches pleura within 2 mm of the last bone contact. See figure number 29. A needle walked caudad off the bone pair, and at 2.5 cm lateral from the midline, reaches the pleura at about 20mm after last bone contact. That is the safest needle tip position.

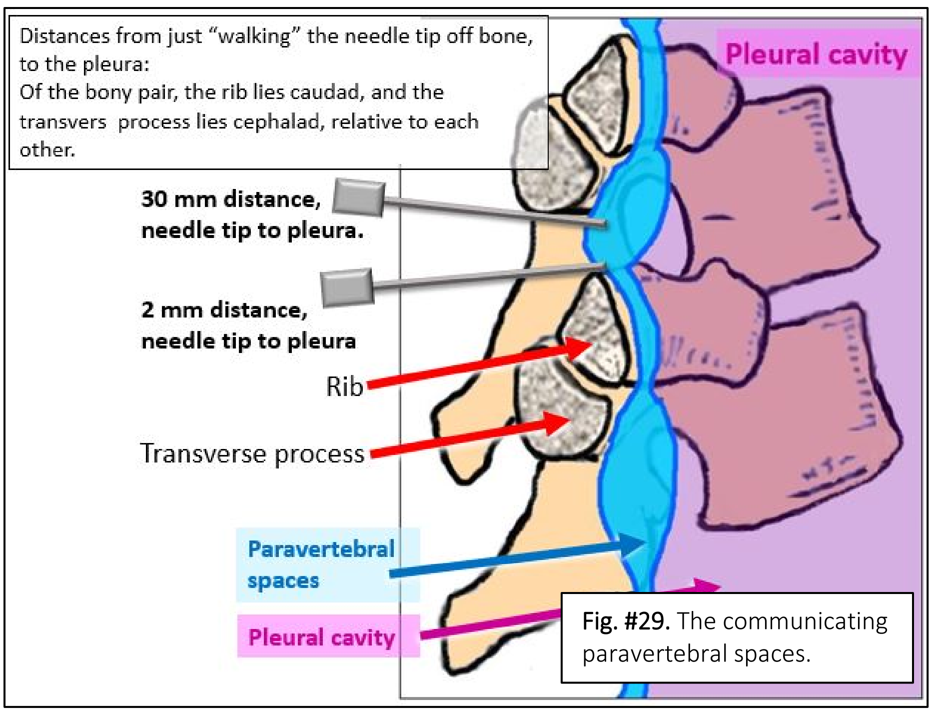


Fig. #29. The communicating paravertebral spaces.

Note also; if a needle has to be aimed so shallow towards caudad, that walks "off" the rib-transverse-process bone pair without entering the paravertebral space and touches the next bone pair towards caudad. Then 1 cm more caudad and advance it to anterior again. The goal is to rather walk-off the bone pair with a needle that is near perpendicular to skin when it enters the paravertebral space. This way the paravertebral space can be entered in the optimum position for injecting, and at the most far point from pleura.

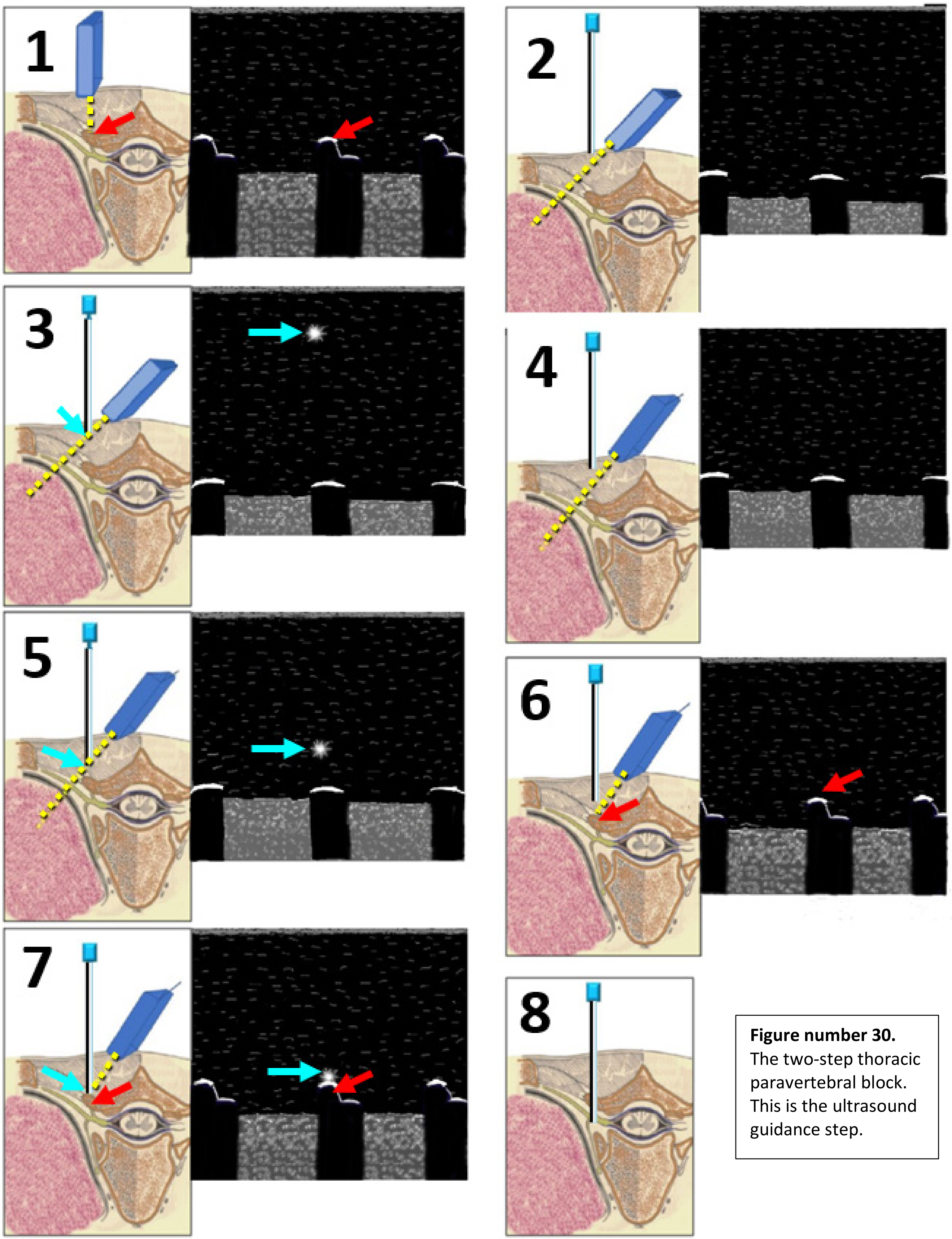


Figure number 30. The two-step thoracic paravertebral block. This is the ultrasound guidance step.

Accompanying description for figure number 30 of the FUSION "Two-step" ultrasound guided thoracic paravertebral block. This is the "Step-one"

IMAGE 1, OF FIGURE NUMBER 30;

- Mark an axial line on the back, precisely 2.5 cm from the midline. (3 cm in lowest thoracic 4 levels)
- Place the transducer on the back on the 2.5 cm line, parallel to the coronal plane, at the target vertebral level for paravertebral block.
- Position the transducer so the target transverse process is dead center in the sonogram.
- Mark that position on the skin, with transverse line from the center of the transducer.

IMAGE 2, OF FIGURE NUMBER 28;

- Insert the nerve block needle into skin at the point where the transverse and the axial lines intersect.
- Shift the transducer to the mid-line, tilting it back, looking very shallow. Ribs will be seen.
- Advance the needle deeper towards the angled ultrasound image plane, seeking an off-plane needle image.

IMAGE NUMBER 3, OF FIGURE NUMBER 30.

- The needle has reached the image place of the transducer and appears as spot-shaped tiny tissue distortion in the sonogram.

IMAGE NUMBER 4, OF FIGURE NUMBER 30.

- With the needle steady, readjust the transducer angle of tilt so that it looks slightly deeper than the prior position of block needle tip.
- The needle spot image in the sonogram becomes lost.
- Then hold the ultrasound transducer steady and advance the needle again.
- Keep aiming the needle direct to anterior, and do not deviate to medal, to lateral to caudad or to cephalad.

IMAGE NUMBER 5, OF FIGURE NUMBER 30.

- Now with the transducer steady, advance the needle tip again and back into the sonogram view.
- Important do not advance the needle any further, once the needle tip is confidently within sonographic view, as with all off-plane techniques.

IMAGE NUMBER 6, OF FIGURE NUMBER 30.

- The transducer will after a few readjustments of its tilt-angle, will see the transvser5s process tip, recognized by it most prominent part being closer to skin than its partner rib.

IMAGE NUMBER 7, OF FIGURE NUMBER 30.

- The needle should be felt to touch the transverse process. If the technique was carried out skillfully and with precision, the moment of bone contact touch should be visible on the sonogram.

IMAGE NUMBER 8, OF FIGURE NUMBER 30.

- The ultrasound, has served its purpose. Step one is complete. Place the transducer to the side.
- Start step-two of the FUSION block. "Walk" the nerve block needle caudad, off the bone structures, and direct towards anterior to enter the thoracic paravertebral space.

Utilize tactile signs, Loss Of Resistance (LOR), and a nerve stimulator to determine the distance to advance the needle. Stop at the first end-point recognized, of the five stopping signs

5.13. Detailed description of the ultrasound-guided thoracic-paravertebral-block-needle placement onto the vertebrae transverse process. ("Two-step" technique)

This technique is described as the "two-step" technique, in that unlike all the other currently described USG technique it alone emphasizes the depth and distance endpoints for optimal paravertebral drug injection embraced in classic landmark techniques. All the other USG techniques, have needle-tip endpoints that are too lateral, and also allow for the needle to unknowingly be directed INTO the intervertebral foramen. Only the focused targeting of specific depth and distance endpoints produces reliable, safe and constant paravertebral blocks that can generate multiple level blocks from single injections. The following technique fuses ultrasound guidance of the needle with a classic landmark technique, hence the name "FUSION" thoracic paravertebral block.

Position the patient either fully prone and flat, or more preferably, sitting leaning slightly forward resting their hands on a second support table. Identify the vertebral levels and side to be blocked. The resting inferior angle of the scapula corresponds with the level of the dorsal process of T6. The T1 vertebral process is immediately caudad to the cervical vertebra prominens. If the 12th rib is identifiable below the lateral chest cage, its inferior edge can be palpated and a line along it points back to the dorsal process of the 12th thoracic vertebral dorsal process.

Next mark on the skin, the midline over the dorsal processes. Then precisely measure off a distance of 2.5 cm towards lateral from that mid-line. Draw a line parallel to the first that is consistently 2,5 cm from the midline. Any closer position will place a needle too close to the intervertebral foramen, but a deviation of ½ centimeter more towards lateral is harmless, and acceptable. That is, the ideal distance is 2.5 to 3 cm, with 2.5cm being most ideal.

Now, use a linear ultrasound transducer that ideally is25 to 40 mm wide and with frequencies as slow as 8 MHz. Widest is best. Place the transducer over the 2.5 cm line, parallel to it, and pointing direct to anterior. Slide the transducer side to side, that is along the body long axis in a parasagittal axis. Seek to see the transverse process. Do not tilt the transducer at all towards medial, or towards lateral. The imaging plane must be 2.5 cm from midline, as indicated by the skin marked line. Aline the bony structure of the transvers process rib cluster with the center of the image. Those structures will not form optimum images, but with understanding and modest experience, the structures will be identifiable. Then, mark on the skin a transverse line aligned with the center of the transducer. Remove the transducer and complete drawing the transverse line so that it intersects with the parasagittal 2.5 cm line. Mark each level to be blocked similarly, and number them per the vertebral body that the intersection represents. Always assume the markings are one level incorrect and nerve block one more vertebral level up and down than what the surgery requires.

Ensure the skin markings are well marked and clear. Do the necessary sterile preparation for the injections. Use sedation and analgesia as indicated, and utilize physiological monitoring with oxygen therapy as is customary.

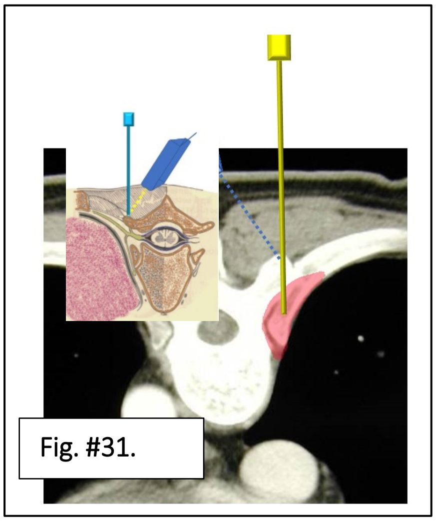


Fig. #31.

Use a 17G or 16G Tuohy needle, even if single shot injections alone are to be performed. The needles big advantages are that they are blunt and contribute to good tactile feeling of the tissues it is passed through. Connect a nerve stimulator and set the current to 1.2 to 2 mAmp, and a fast twitch. Insert the needle through the skin at a line intersection point. Advance about 2 cm direct towards anterior, and the transverse process. Next pick up the sterile ultrasound transducer

The transducer can now be held medial to the needle in a parasagittal oblique position. Seek the tip of the advancing Touhy needle. See figure number 31. As the needle is moved adjust the image plane so that it is just deeper than the needle tip. Then advance the needle until it enters image again. Then readjust the image plane to be a bit deeper, yet again. The degree of obliqueness, or the angle it by which the transducer is tilted away from perpendicular will depend on how deep the needle tip is. At one point the needle will touch the transverse process and rib pair.

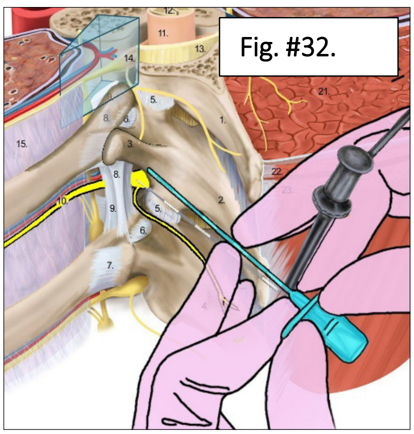


Fig. #32.

The needle's trajectory may at any time be adjusted to aim more to cephalad or more to caudad in order to meet with the target bones. Always however, keep the needle in the parasagittal plane that is 2.5 cm from midline. The needle's trajectory may not be adjusted to more medial or to more lateral.

After the needle-tip is touching bone, put the transducer aside. Connect the nerve stimulator. Attach the loss of resistance syringe containing 5% dextrose water. See figure number 30. Hold the needle in the fashion illustrated. Walk the needle caudad off the bone structure of the paired rib and transverse process. Test the loss of resistance intermittently. Instruct the patient to inform you if they feel any sensation movements or tingling in the abdomen at front. If possible, have someone experienced observe the abdominal wall at front for movements.

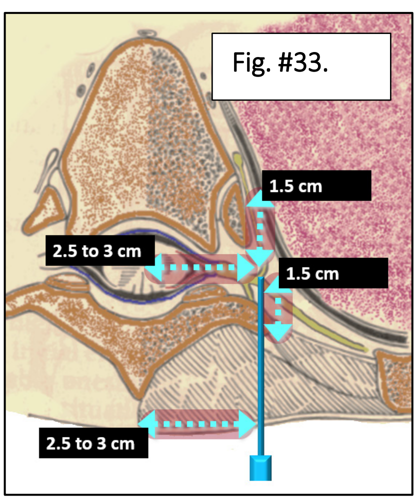


Fig. #33.

Cease advancing the needle when any of the five endpoints is first reached, namely: (i) the needle tip is 1.5 cm beyond the last point of bone contact, (ii) the patient reports a dermatomal sensation in the distribution the nerve root being stimulated, (iii) a subtle loss-of-resistance is felt to have happened, (iv) motor twitching can be seen on the abdomen, and (v) a "pop" feeling is felt as the needle penetrates the costo-transverse ligament..

See figure number 33. Its shows that a needle inserted in a direct posterior-to-anterior plane not exceeding a distance of 1.5 cm beyond first point of bone contact, and also keeping the distance of 2.5 cm from midline is perfectly centered in the paravertebral space.

Then do the hanging drop test. Follow that, all being well, with insertion of the nerve block catheter, or injection of local anesthetic, using standard safety measures.

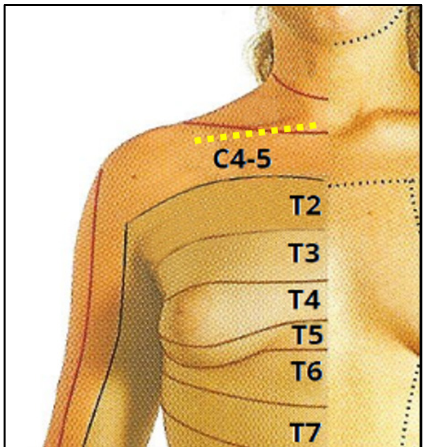


Fig #34. Skin infiltration line for breast C4-5 dermatomes.

NERVE BLOCK OF THE C4+5 SUPRACLAVICULAR NERVES.

These nerves supply the skin over the clavicle for about 3-5 cm caudad to the clavicle. A pendulous breast may even pull these dermatomes a bit more caudad as well. If surgical incisions are to encroach on this area, or if subcutaneous tissue are going to be dissected into this region, it is necessary to block these nerves as well. They are easily blocked by doing a linear subcutaneous field block over the clavicle. Use a sharp Quincke point 90 mm 20G spinal needle to do the skin infiltration. Inject 5 to 10 ml of 0.5% ropivacaine (or equivalent potency of an alternative local anesthetic drug). See figure number 34.

6. NERVE BLOCKS FOR THE AXILLA

It is common for the axilla to be surgically explored for metastatic lymph nodes, often using radio isotope guidance. The axilla exploration may be combined with a modest size breast excision or be part of a radical mastectomy. *There is no selective single simple nerve block for the axilla.*

The skin at the base of the axilla, where the incision is, needs to be densely anesthetized for awake surgery. The deeper tissues can be anesthetized less densely. These factors influence the regional anesthesia techniques. The floor of the axilla is supplied with sensation by the intercostobrachial nerve, which typically takes root origin from T2. There is however anatomical variation, and root origins can include axons from T1 to T3. Not uncommonly the pectoral nerve may take branches partially or fully from the intercostobrachial nerve.

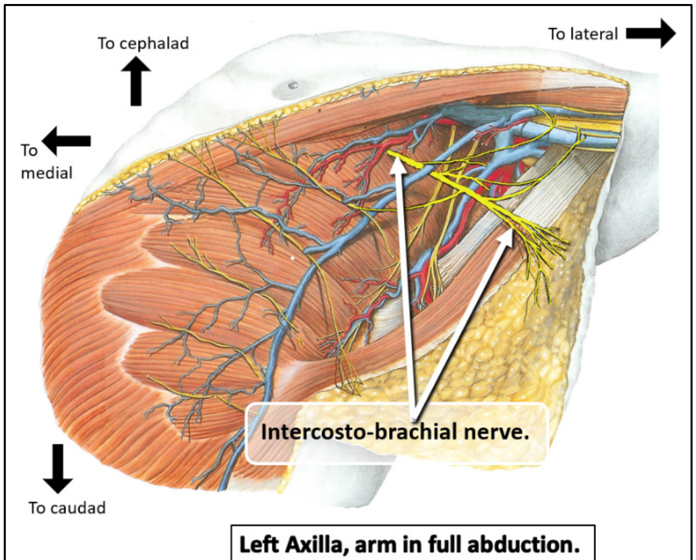


Fig. #35. The intercosto-brachial nerve, with the left arm fully abducted.

6.1. NERVE BLOCK OF THE INTERCOSTO-BRACHIAL NERVE

See figure number 35. The intercosto-brachial nerve is the most important nerve providing sensation to the skin of the base of the axilla. Block of the nerve is not well described in the scientific literature. One published ultrasound-guided technique to block the intercosto-brachial nerve selectively is described[29]. In this study the chosen end point for injection was superficial to the second rib on the anterior axilla line, above the serratus anterior muscle but deep to the pectoralis minor muscle. The nerve was not seen. The injection is thus a blind anatomically-speculative injection. With this technique, in 16 studied subjects, the long thoracic nerve was not blocked, as no one developed a winged scapula. The block seemed generally effective, but the study end points related to chronic pain and did not clarify the surgical efficacy of the block.

This author, has experience of blocking this nerve, with slightly different and preferred technique to the one above. The nerve was been blocked and successfully used for awake cases of modest size breast excision and exploration of the axilla.

Blocking of the thoracic nerve roots T1 to T4 by epidural block, will also achieve intercosto-brachial nerve block.

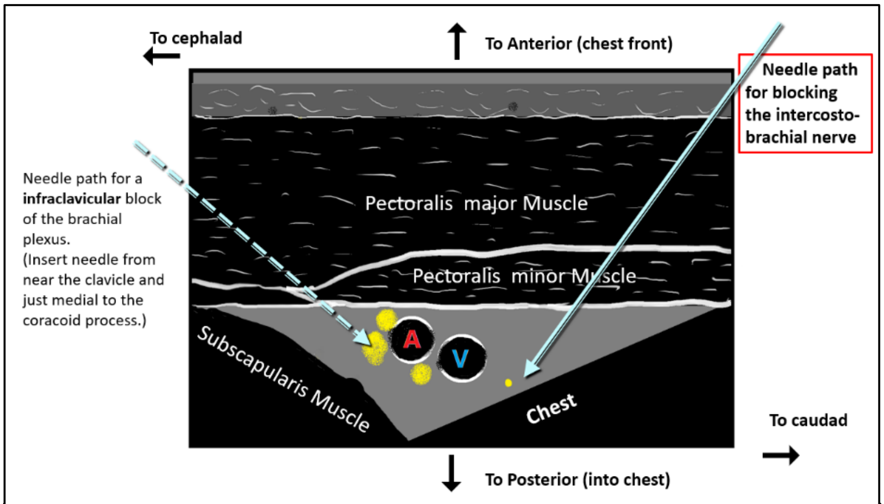


Fig. #36. Sonogram drawing: Ultrasound guided intercosto-brachial nerve block from interior in the infraclavicular position.

In patients who already have gotten a single-shot true paravertebral nerve block at T4, dosed to spread from T3 to T6 paravertebral block, do a supplementary single paravertebral injection at T2 with 4 ml of local anesthetic. That will guarantee a good intercostobrachial nerve block.

An ultrasound guided (USG) intercosto-brachial nerve block can be done in the axilla. The USG intercostobrachial nerve block is not clinically associated with an unwanted nerve block of the arm.

TECHNIQUE: Place a linear ultrasound transducer held in the parasagittal plane and immediately medial to the coracoid process, as is typically used for infraclavicular block of the brachial plexus cords. This is known in European as a "lateral infraclavicular block" injection. See figure number 37.

Obtain an infraclavicular brachial plexus view. Have the cephalad side to left of image. See figure number 34, then adjust the transducer position, by sliding slightly caudad and tilting to the side to "look" more caudad. This will shift the axillary artery, vein and the plexus nerves cephalad (to left) in the image and bring the target area into view. The target area is the space in between the axillary vein and the chest wall. The intercosto-brachial nerve itself, is too small and deep to ever see with an ultrasound. The chest wall usually looks like a dark and undetailed mass deep and right in the image.

Insert an 80 to 90 mm nerve block needle in-plane from the **caudad** side of the transducer. See figure number 37, and the red arrow. Aim at the space in between the axillary vein and the chest wall. Avoid having the needle touch the chest or the axillary vein. The injection does not have to be exactly between the chest wall and the vein and may be done 1 cm caudad to that point. This typically in the 3 to 5 o'clock relative to the axillary vein. This increases the distance between the drug and the brachial plexus surrounding the axillary artery. Inject 6 to 10 ml of 0.75% ropivacaine. This block is been used as part of group of nerve blocks, in patients selected for awake breast and axilla surgery.

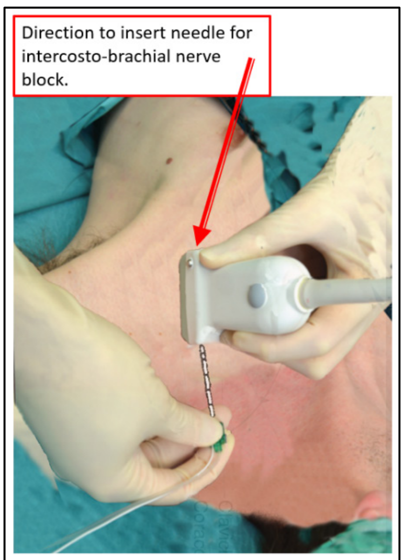


Fig. #37. The infraclavicular block approach to the cords of the brachial plexus. Note: The needle for the intercosto-brachial nerve must inserted as the red arrow is inserted, from caudad.

6.2. NERVE BLOCK OF AXILLA POSTERIOR WALL.

Any form of C5,6, 7 nerve-root blocks in the neck, will effectively block all sensation of the walls of the axilla, however at the cost of substantial muscle weakness of the shoulder, and the hands. It would not block the skin of the base of the axilla. For example, any brachial-plexus block in the interscalene, supraclavicular, and infraclavicular positions blocks all the muscles forming the walls of the axilla for axilla surgery, at the cost of shoulder and arm muscle weakness.

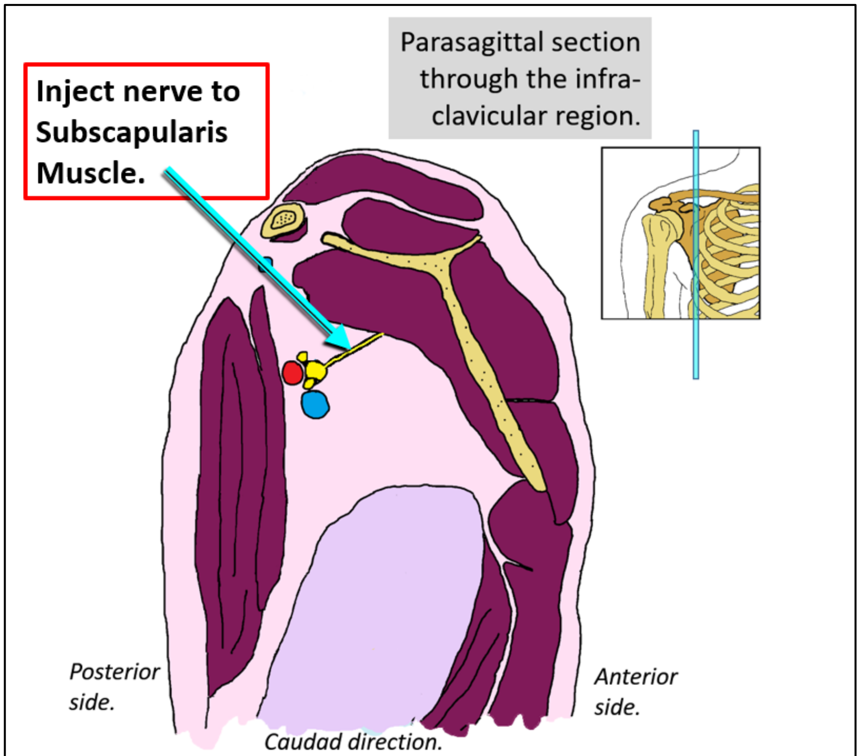


Fig. #38. Nerve to subscapularis muscle, from the posterior cord.

For a patient undergoing breast surgery muscle weakness of the arm would seem a severe unnecessary inconvenience. It is therefore desirable to attempt to provide selective surgical anaesthesia to the muscle walls of the axilla without arm-shoulder muscle weakness. There is very little scientific publication of selective techniques for this purpose.

This author can share clinical experiences of blocking the axilla. *Firstly*, the deeper axilla tissues and muscle walls do not need maximum grade of nerve blockade to patient comfort. Like many deeper tissues subjected to only traction, bruising, and inflammation, total analgesia can be achieved with half strength local anesthetic drug. This is unlike skin and bone and muscle that is cut by cautery, where high grade sensory blockaded is needed for awake surgery. *Secondly,* the injected local anesthetic can be relatively preferentially directed to the brachial plexus branches of the axilla posterior wall muscles. The sparing of the blocking the plexus cords and thus sparing of the motor function of the shoulder and arm can be achieved. This is done as follows:

BLIND TECHNIQUE WITH NERVE STIMULATOR GUIDANCE;

INSERT a 90 mm stimulating nerve block needle from immediately anterior to the lateral side of the clavicle and immediately medial to the coracoid bone. See figures numbers 38 and 39. This is at the apex of the coraco-clavicular trough. Direct the needle strictly in a parasagittal plane, i.e. not to medial and not to lateral. Also, direct the needle to caudad, and about 45 degrees to posterior of the coronal plane. The needle can be freely adjusted slightly more to anterior or slightly more to posterior, in small increments

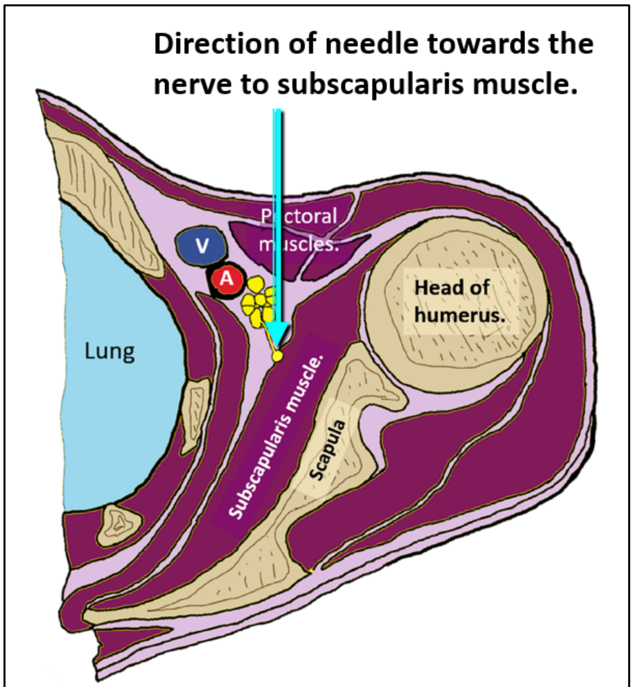


Fig. #39. Horizontal sectional view of the axilla.

within this parasagittal plane until the target muscle twitches are found using nerve stimulator.

Seek to locate the posterior cord (triceps, deltoid, finger extensors and brachioradialis twitches). Then readjust the needle-tip position to explore a millimeter or two further to posterior of the posterior cord. There is no need to advance the needle much deeper than the needle-depth at which the posterior cord was first located. An appropriate end point is when it is observed that there is twitching of the latissimus dorsi muscle (feel at the back of the axilla with the patient's arm abducted, or feel internal rotation of the shoulder from subscapularis muscle twitching. There must be no twitching of triceps, deltoid or fingers. Precision location is not necessary and a correct twitch on a nerve stimulator current of 0.6 mAmp is satisfactory. Inject 10 ml of 0.375% ropivacaine (or equivalent potency concentration of another local anesthetic drug).

VISUAL TECHNIQUE, USING ULTRASOUND GUIDANCE.

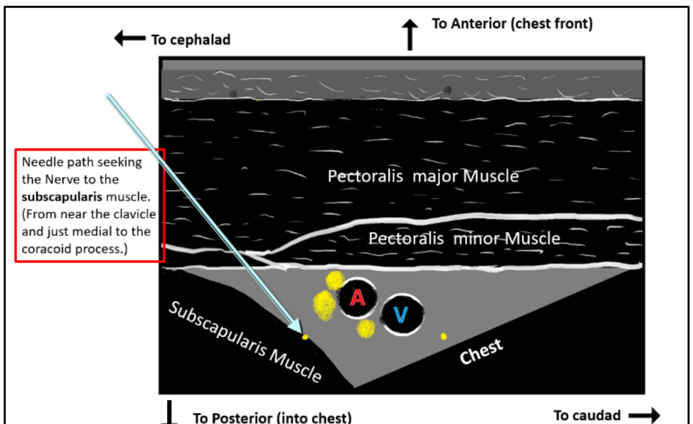


Fig. #40. Insert stimulating needle and probe the dark mass to 7 to 8 o'clock, (postero-cephalad) from the posterior cord) until a subscapularis twitch is located.

Place the transducer in the coraco-clavicular trough as if to do an USG infraclavicular block. Locate the posterior cord at the 9 o'clock position from the axillary artery with needle tip, using simultaneous nerve stimulation. See figure number 40. Set the current to 0.6 mAmp. Next, explore the dark region deep and posterior to the posterior cord, with the needle tip. A twitch of the subscapular muscle inducing internal rotation of the shoulder is the optimal end point. A latissimus dorsi twitch from stimulation of the thoraco- dorsal nerve, when used as an injection end point, has also been seen to provide satisfactory anesthesia of the posterior wall of the axilla for surgery. Inject 10 ml of 0.375% ropivacaine (or equivalent potency of an alternative local anesthetic drug).

7. OTHER NEW AND OLD INTERCOSTAL NERVES BLOCKS.

SECTION INDEX:

8.1 Erector spinae block.
8.2. Rhomboid intercostal block.
8.3. Thoracolumbar Interfascial Plane Block. (TLIP block)
8.4. Serratus anterior block.
8.5. The Intra-pleural block.

8.1. Erector Spinae Plain block (ESP).

The Erector spinae block **(ESP)** is a chance discovered nerve block that has only ever done with ultrasound guidance. When done in the higher thoracic zones, at T3, T4 or T5, the ESP has found some popularity with breast surgery. It is technically remarkably simple and safe. It is in effect, a “poor man’s” paravertebral block of the intercostal nerves injected on the posterior side[30]. Injecting at the T4 -T5 level, a typical dermatomal spread is about T3 to T7. The block provides reasonably satisfactory, but not perfect, analgesia when combined with good multimodal analgesia after simple mastectomy[31]. Avoidance of general anesthesia for very minor breast surgery has been achieved in single case reports[32]. In that case, sedation consisted of duel infusions of propofol and remifentanil to induce deep sedation with the patient being unresponsive to verbal input. Twenty milliliters of 0.5% ropivacaine was used and the block took 40 minutes to develop.

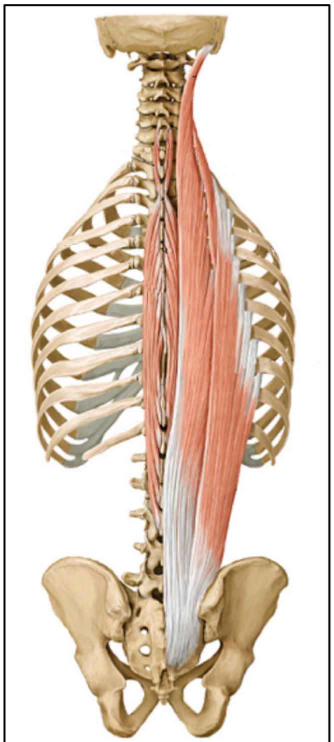


Fig #41. The erector spinae muscle.

Although the block could conceptually also be used for lower abdominal wall incisions, as in harvesting autologous grafts for breast repair it has not yet found popularity for that indication. There are a number of publications describing using the ESP with breast surgery[33],[34],[35]

The erector spinae muscle is a very long collection of muscle bundles that run the length of the spinal column from the base of the skull to the sacrum[36]. See figure number 41. The muscle attaches to the posterior surface of the vertebral lamina, spinous processes, transverse processes, and the posterior surfaces of the most medial sections of the posterior rib segments. A long list of nerve block variations has been described for injection local anesthetic superficial to, or deep to the muscle. The drug then spreads onwards to reach some intercostal nerves mostly.

Hernandez proposed that the erector spinae block drug likely spreads into the paravertebral space via the medial side of the costotransverse ligaments that have minimal fibrous structure at that point[37]. He also highlights the facts that the intercostal nerve block achieved by the erector spinae block is not very consistent nor very dense. That could be due the drug not free-flowing in full strength onto the intercostal nerves in the paravertebral space. The drug rather diffuses across

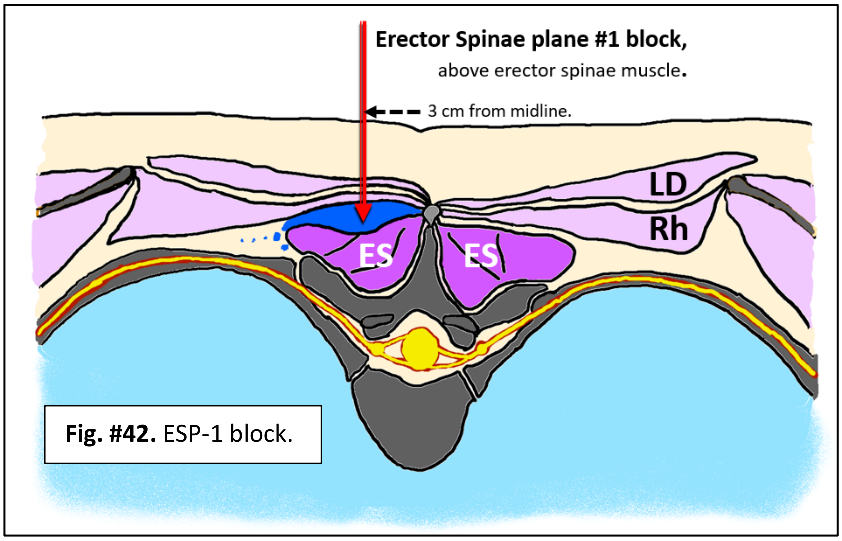


Fig. #42. ESP-1 block.

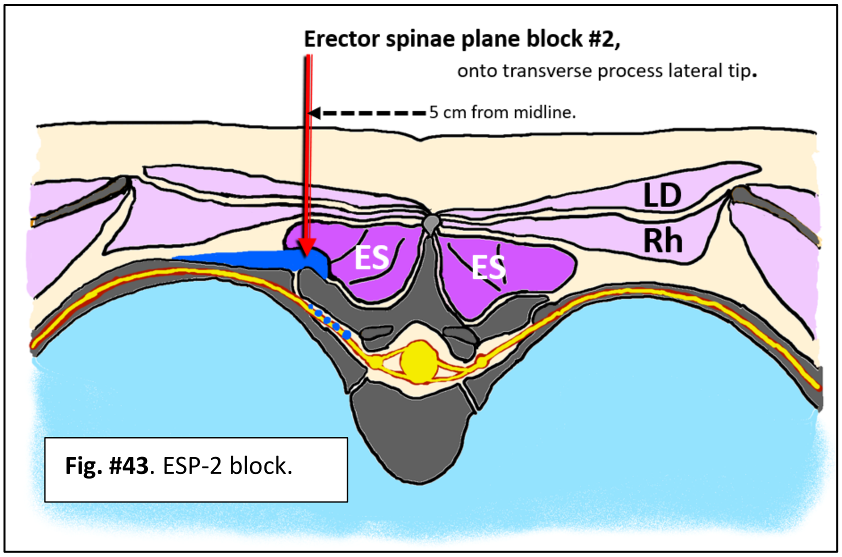


Fig. #43. ESP-2 block.

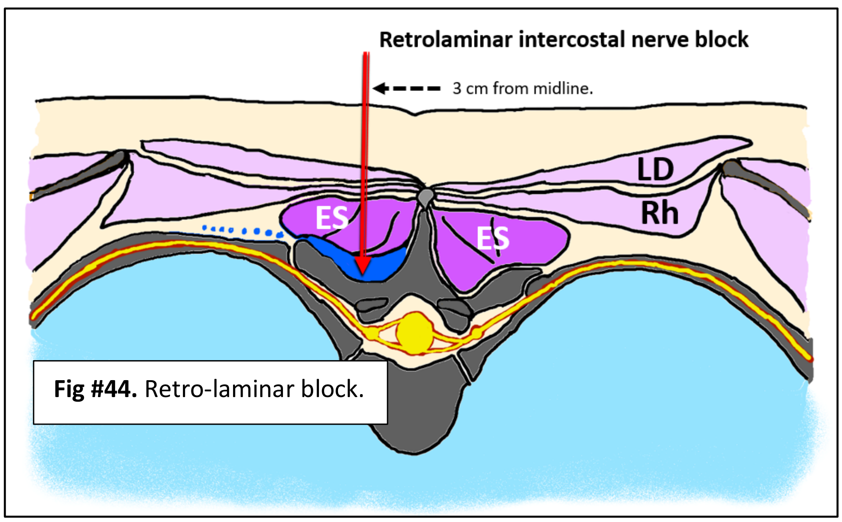


Fig #44. Retro-laminar block.

membrane and fascia barriers becoming more diluted by interstitial fluid. That would explain why sometimes patients report analgesia from an ESP block in the absence of clinical signs of nerve block in the corresponding dermatomes. Acute pain is transmitted by A-delta and c fibres, which being very thin, which are readily blocked by very dilute local anesthetic solutions. The thicker well myelinated A-Beta fibres within the intercostal nerves, that communicate the skin testing signals of touch and temperature sensation would not be blocked by dilute solutions. This fact explains the observed discrepancy between achievement of analgesia without loss of sensation often observed with this ESP block.

The blocks are;

1. **ESPB1** injected about 3cm from midline, between the rhomboid major muscle and the erector spinae muscle, in the mid-upper thoracic region. This block has been found to have no clinical merit. See figure number 42.
2. **ESPB2** is injected about 5 cm from midline, deep to the Erector spinae muscle, in between the erector spinae muscle and the external intercostal muscle. See figure number 43.
3. The **retrolaminar block**, injected about 1.5 to 2cm from midline immediately superficial to thoracic vertebra lamina[38]. See figure number 44. One retrolaminar block study done on sacrificed

animals assessed the influence of drug volume on drug spread, and used color marked drug to detect drug spread on dissection[39]. Voscopoulos found using the retrolaminar block that all of 20 rib fracture patients who received the block achieved at least 50% pain reduction, if large volumes of local anesthetic, 20 ml, was used[40]. He proposed the block worked by means of the liquid drug diffusing into the paravertebral space. When compared to a paravertebral block both managed with infusions the paravertebral gave superior analgesia for the first 24 hours after surgery[41]. Clearly, if a translaminar block is used for analgesia purposes, that is, not for awake surgery indications, its reduced efficacy and potency compared to a paravertebral block is offset by its easiness to inject and improved safety.

Successful single case reports exist of the erector spinae block injected at the T5 level in small size ladies having simple mastectomy and sentinel node removal suggest efficacy[42]. The dermatomal spread of the local anesthetic was T2-8 in a 43 kg BMI=18 lady, and T3-7 in another 155cm (5ft 2in) tall lady after injection of 20 ml 0.375% ropivacaine. Ueshima reported in 2019 two ladies who underwent mastectomies, having received T4 erector spinae blocks and general anesthesia[43].

Ueshima argues that it can be anticipated that the retrolaminar block will be more efficacious, that is spreading further in axial directions, than either erector spinae plane block[44].

Leyva in 2019 report a pilot study on 5 patients who had undergone median sternotomies for cardiac surgery[45]. Catheters were inserted bilateral at T4, deep to erector spinae muscles and over the transverse processes. Bilateral injections were made with 20 ml 0.25% bupivacaine with epinephrine, and the blocks were sustained with infusions of 0.125% bupivacaine run at 8ml/h on each side. In virtually all the cases the entire postoperative care was free of need for opiates. In two cases top-up nerve block boluses were needed and were successful. It seems that in cases where patients receive prophylactic anticoagulation therapy, and the surgical pain is within thoracic dermatomes, the ESP block may be an alternative to the thoracic epidural.

Whether the ESP block is superior or inferior to thoracic paravertebral blocks for reliability, safety, and efficacy will require appropriate future research. Regarding the use of the ESP for neurologically complex breast surgery, the ESP seems deserving of continuing presently, to be being scientifically evaluated against best paravertebral blocks, to cover the thoracic dermatomes related to breast surgery.

TECHNIQUE of the ESP Block:

The injection point is consistent, but the needle can approach equally for lateral, from caudad or from cephalad[46]. There is no significant benefit or novelty in the describing of variant patient positions and needle insertion directions, as long as the fluid drug is deposited onto the **superficial (posterior) tip of the target**

Fig. #45. Erector spinae block injected at T5. 20 ml 0.5% ropivacaine was used. This is the skin area with detectable sensation changes.

lateral process. Ueshima achieved a bilateral block by inserting the block needle from lateral onto the T4 transvers process tip on one side, for the first injection, and then after ultrasound transducer position adjustment, advanced the needle further to perform an identical injection on the opposite side transverse process tip[47].

The erector spinae block can be performed in the low thoracic region and the high thoracic region. The ESP block has not been evaluated in the lumbar region, where transverse processes are rudimentary in development and a less reliable block endpoint. The ESP block is thus usable for both (i) the autologous graft donor sites with breast reconstructions, and (ii) the breast surgical site.

LIMITATIONS of the erector spinae block, compared to properly performed paravertebral block. See figure number 45.

- The erector spinae block is inconsistent. Whilst in studies group median outcome scores are positive for efficacy, there is high fraction of patient with failed analgesia[48]. This well explained by the fact that the drug has to spread following fascial boundaries, as well as diffuse across barriers.
- The erector spinae block is not very dense. This is because the drug is not injected onto the nerves, and by the time drug has diffused onto nerves it is much more dilute and the block less dense than what could have been expected for the drug concentration used[48].
- The erector spinae block is not drug efficient. Use large drug volumes, like 23 ml 0.25% bupivacaine per side, or 30 ml of 0.25% levobupivacaine[31, 49]. These large drug volumes force the use of diluted local anesthetic to start with which further “softens” the resulting clinical block. In addition, this feature limits the use of supplementary blocks for other nerves like the pectoral nerves.
- The skin dermatomes noted as blocked, do not correlate with the clinical appearance of deep tissue analgesia[48]. Obviously, the drug can flow or diffuse indifferent degrees towards different sites and for different depths and distances. The lack of control of that block aspect is remedied by injecting large and excessive volumes like 20 to 40 milliliters.

8.2. RHOMBOID INTERCOSTAL BLOCK.

The block was conceptualized by Elsharkawy[50]. Tulgar described experience with this block, used on a patient under anesthesia, who was to have a modified radical mastectomy and axilla clearance[51]. Forty milliliters of 0.25% bupivacaine drug was injected in between the fifth rib and under the overlying rhomboid muscle from posterior. The injection point was aligned with the medial edge of the scapula, which was pulled lateral by pulling the ipsilateral arm forward and across the chest. The needle passed through trapezius and the rhomboid muscle to teach the ribs and intercostal muscles. Drug was injected against a rib, but under rhomboid muscle.

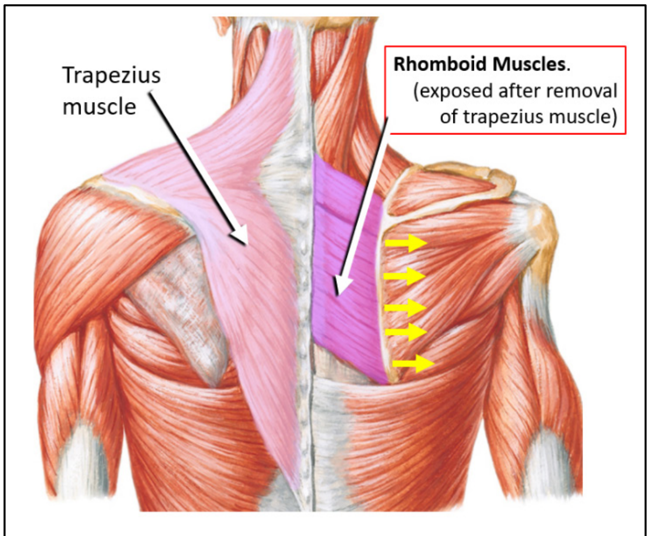


Fig. #46. On the right side of this dissection the trapezius muscle is removed to reveal the rhomboid muscles. If the scapula is pulled to lateral the posterior ribs will lie onlv under the rhomboid muscles.

The injection point is about 8 cm from the midline, and lateral to the erector spinae muscle. The patient was positioned supine and with the ipsilateral arm adducted and held across the chest. After awakening from general anesthesia, the patient had dermatomal loss of sensation from T3 to T9 in the lateral and anterior parts of the chest, except for the parasternal segments. That implied only the lateral intercostal nerves were blocked after they had exited the intercostal spaces. The anterior intercostal nerves which retain their position between the ribs within the intercostal muscles until near the sternum were not blocked. The lady reported bearable in the axilla region suggestion the intercosto-brachial nerve was blocked, but probably not the clavicular nerves supplying the pectoral muscles. The blocked is claimed to have lasted for 13 hours after the surgery, where after pain was manageable with standard protocols analgesics. In the absence of randomized prospective studies comparing this block to the gold standard thoracic paravertebral block it cannot be recommended. It is predicted that the correct duration of the limited analgesia will last much shorter than the anecdotal claim, as this is a fascial-plane block injected in an axis about 8 cm posterior to where the lateral branches of the intercostal nerves would exit the intercostal muscles.

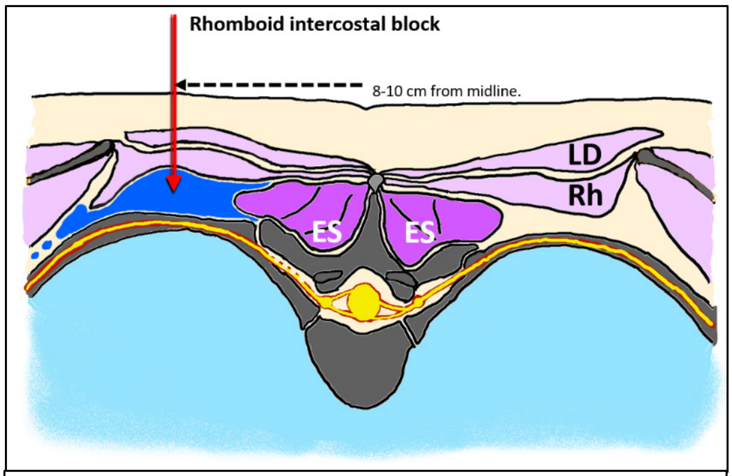


Fig. #47. Local anesthetic drug-fluid dispersal of the rhomboid intercostal nerve block.

8.3. THORACO-LUMBAR INTERFASCIAL PLANE (TLIP) BLOCK

This block is being promoted as another new fascial planes block. Instead of the drug being injected under the erector spinae muscle at some point, it is injected IN BETWEEN two portions of the erector spinae muscle halfway between the skin and the underlying bony vertebral lamina. The muscle portions are Multifidus and Longissimus. Hand designed and described the TLIP block[52].

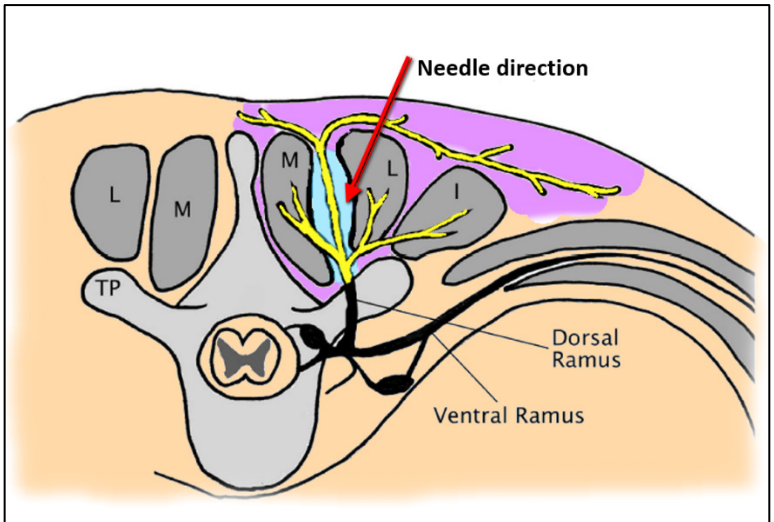


Fig. #48. The thoraco-lumbar inter-fascial plane block. NOTE; the zone of anesthesia effect in purple, confined to the back region.

Hand used 10 non-patient volunteers and injected 20 ml of 0.2% ropivacaine between the multifidus and longissimus muscle portions of their erector spinae muscle at approximately L3. Hydro-dissection was used to discover the inter-muscle space. All volunteers developed a zone of skin anesthesia on their backs 10 cm long and spreading to lateral of the back midline for about 6 cm. No anterior anesthesia occurred. Hand considered the prime indication for this block to be minimal access single level lumbar spinal surgery.

This block is only described here to reduce confusion about it with the other fascial plane blocks, related nerve blocks used for breast surgery.

8.4. SERRATUS ANTERIOR PLANE BLOCK.

Fig. #49.

Kunhabdulla used this block successfully for pain relief in a patient with traumatic rib fractures on one side from the 4th to 7th ribs[53]. The patient is positioned seated facing away from the physician. The arm on the side to be blocked is flexed forward to expose the axilla from posterior. A linear ultrasound transducer is positioned on the posterior axillary line over the 5th rib and parallel to it. Other authors have kept the transducer parallel to the body long axis. See figure number 47. Inject twenty milliliters of local anesthetic, e.g. 0.25% bupivacaine, onto the rib, and under the serratus anterior muscle. The can be held by an assistant or rested upon a table in front of the patient. A catheter can be placed and infused at 12ml/h, with e.g., 0. 625% bupivacaine. In the rib fracture patient this produced first signs on analgesia 15 minutes after the initiating injection. See figure numbers 49 and 50.

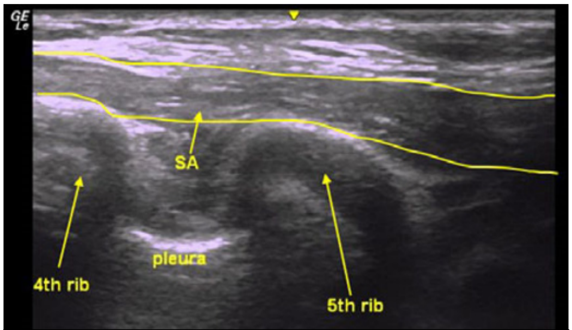


Fig. #50. The Serratus anterior plane block view

The serratus anterior plane block has also been reported to provide profound analgesia after esophagectomy done via a trans-thoracic approach only[54].

This block has found its greatest popularity amongst emergency room physicians treating the pain of new patients with rib fractures. It is likely it assists with analgesia of the bruised tissues in the region of the drug spread.

8.5. THE INTRAPLEURAL BLOCK

The intrapleural block has also been known as the interpleural block. The intrapleural block found its greatest popularity prior to very old paravertebral block finding its own revived popularity in the early 90s. It is rarely practiced any more, but is still a remarkably simple, easy and efficacious nerve block. Its only limitation is the fact that a needle has to be inserted into the pleural cavity, and practitioners feeling intimidated by that. It intuitively seems dangerous to insert a needle into the thoracic cavity, and to end with the needle touching the lungs. This block can provide analgesia of the T1 to T7 intercostal for breast surgery. It can equally provide analgesia for all the other thoracic nerve root segments down to T12 and L1 with a simple technique modification. These modifications will be described.

This author will describe the technique as he has personally evolved it, and used it with never a complication, nor a failure. This author abandoned the block once he discovered and mastered the paravertebral block. He would still however strongly consider utilizing the intra-pleural block again, if unilateral intercostal nerve analgesia was needed and a paravertebral block had some unique contra-indication. The intra-pleural block also has quality of block that is denser and longer lasting than alternative fascial plane blocks for intercostal nerves.

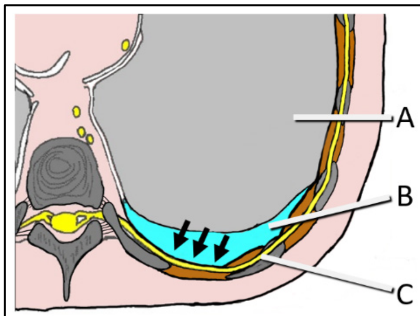


Fig. #51. An axial sectional view through the mid-thorax after injection of an intrapleural block. In the image "A" is the lung, "B" is the pool of local anesthetic pulled to gravity to lie the lung, and "C" are the intercostal nerves just beyond the posterior pleura. The arrows indicate the zone where the drug is only separated from the pleura by a single fascia, the pleura.

MECHANISM OF ACTION OF THE NERVE BLOCK;

See figure number 51. The mechanism of action of this block is that the local anesthetic drug is first injected into the space between the parietal pleura and the visceral pleural covering the lungs. Gravity pulls the drug fluid to lie under the lung. The local anesthetic absorbs across the posterior pleura onto the intercostal nerves. At the most medial 4 centimeters of the posterior intercostal space, the innermost intercostal muscle is deficient. At that point the nerves are directly under the parietal pleura, and are even visible at thoracotomy through that thin pleural covering. Moving further to lateral in the chest, the innermost intercostal muscle covers the intercostal nerves. It is probable that local anesthetic can still soak through the innermost intercostal muscle onto the intercostal nerves. It is certain however, that intrapleural

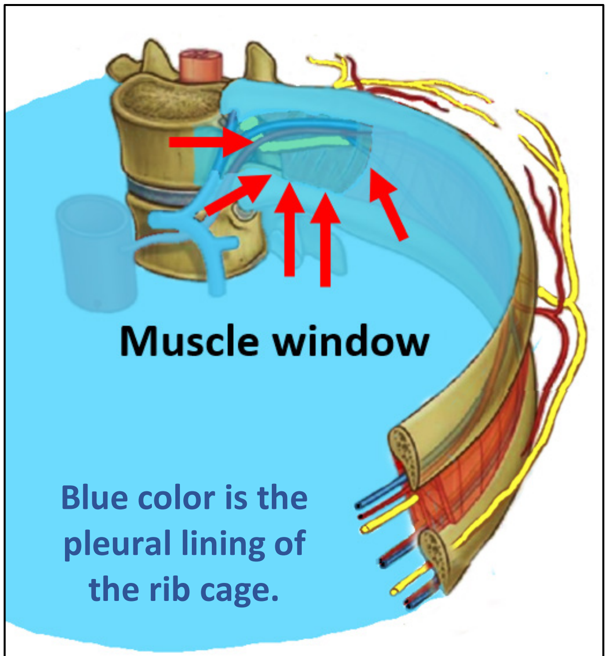


Fig. #52. Muscle window for the intercostal nerve. The blue represents the parietal pleural lining of the rib-cage.

local anesthetic drug mainly soaks onto the intercostal nerves in the more medial section that is muscle free and where the nerves lie only separated from the drug by a millimeter of fascia, of the parietal pleura.

This correlates with the fact that it has been observed that intrapleural blocks set up best with patients lying supine, compared to when they lie lateral decubitus with the side to be blocked downwards.

See figure number 52. The intercostal nerve is fully enveloped in muscle between ribs. That is the nerve is covered by muscle both to inside and to outside, except at the most posterior medial 3 to 4 cm where the innermost intercostal muscle is deficient. It is through that window where an intra0pleural flood of local anesthetic easily soaks through to the intercostal nerves.

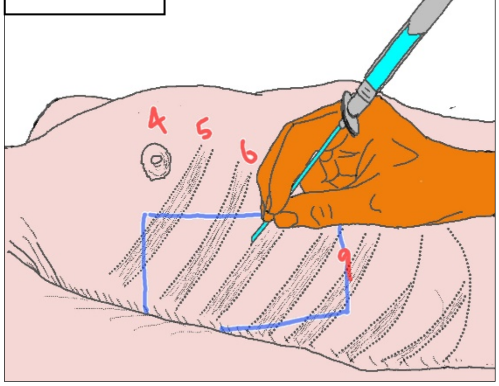
TECHNIQUE OF THE INTRAPLEURAL BLOCK.

Procedure Steps;

- Position the patient
- Insert the needle and catheter.
- Test the catheter.
- Inject drug.
- Manipulate the position of the pleural local anesthetic with the intra-pleura space.

Position the patient supine. They must be breathing spontaneously during the insertion of the block. This will ensure the intrapleural pressure is negative, as is normal. If the patient is being under positive-pressure ventilation, the pleural pressures will be positive. Then, the ventilator must be disconnected and the endotracheal tube left open to air, for the 60 seconds it takes to insert the needle and pass the catheter. That will ensure the intra-pleural pressure is negative. Thereafter recommence positive pressure ventilation.

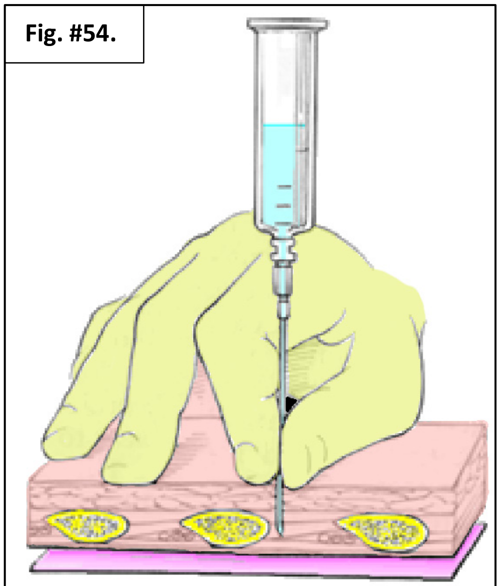
Fig. #53.



With appropriate sterility, and skin local anesthesia, insert a 16G or 17G Tuohy needle through the skin. Place it touching any of the 5th, or 6th or 7th ribs. This is very easy as a tactile technique, but ultrasound guidance may be used too. Do this anywhere onto the appropriate rib, in the zones between the anterior axillary line and the mid axillary line, as demonstrated in figure number 53.

Half fill a 2 or a 5 ml syringe with normal saline. Attach it to the syringe. After attachment withdraw the plunger and remove it. Provided the needle stays under the skin and the syringe is firmly connected the saline will remain within the syringe. Then hold the needle firmly with the hand resting in the chest wall. See figure number 54. Advance the needle off the *superior* (cephalad) edge of the rib VERY SLOWLY, while studiously observing the saline fluid level. When the needle penetrates the parietal-pleura the saline will suck into the chest. Cease advancing the needle.

Fig. #54.



Immediate disconnect the syringe, and take the epidural catheter in hand, which should already have been placed very close. Advance the catheter into the needle for a distance of only 4 cm beyond the needle tip. Remove the needle and seal the catheter by connecting its injection hub. It is a procedural objective, that both the inserted needle and the inserted catheter should only be open to air for a minimum of time. This will minimize air entrainment to the pleural cavity.

If after syringe removal, there is any delay in inserting the epidural catheter, it is a wise precaution to place a thumb over the needle hub opening to seal it, and prevent air from being sucked in. It takes about two minutes, for enough air to entrain via an *open* 16G Touhy needle to create a pneumothorax, with an X-ray visible airspace of 1 cm between the ribs and the lung. Such visible entrained air will not grow, and swiftly absorbs within one to two hours. A routine intra-pleural block does not result in any visible pleural air on an immediate follow-up chest X-ray. Any asymptomatic intrapleural air never needs drainage. It is not necessary to take a chest X-ray after a *routine* and *uneventful* intrapleural catheter placement.

Next test the catheter. See figure number 55.

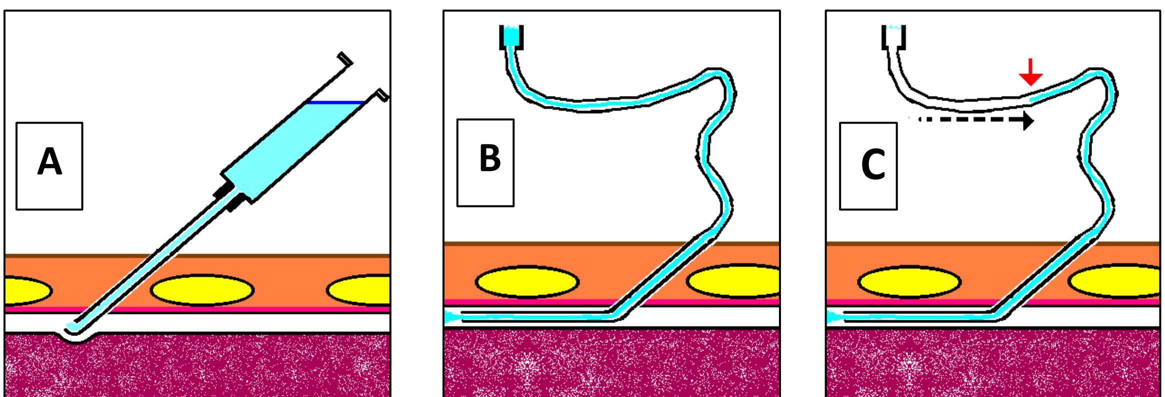


Fig. #55. The negative pleural pressure tests. In image **A,** the open to air syringe saline level falls when the needle tip enters in the intrapleural space. In image B the intrapleural catheter is filled with saline and is uncapped. In image C, on patient inspiration the saline in the catheter is sucked in, indicating correct insertion of the catheter within the intrapleural space has been done.

Fill the catheter with saline, leave it open to air, and hold it above the insertion point. Sometimes the saline will fall within the catheter immediately, and sometimes it will only fall during patient inspiration. The falling line of saline in the catheter confirms the catheter is within the intrapleural space, and not within some other tissue site.

LOCAL ANESTHETIC DOSES

The block is potentially long lasting as the pooled drug in the pleura acts as a reservoir of LA and the reservoir effect is enhanced by slowed drug absorption into the circulation, by the addition of adrenaline (epinephrine). From the authors clinical observations, a single dose of Ropivacaine tends to last about 4 to 6 hours while bupivacaine with epinephrine (adrenaline) tends to last about 12 to 15 hours. The nerve block also works best with highest concentrations and with large volumes.

The mixture that this author found highly successful was 35 ml of 0.5% bupivacaine with epinephrine (adrenaline) diluted to volume of 50 milliliters with normal saline. The addition to the solution of 1ml of Sodium Bicarbonate 8.5% to alkalinize the solution improves it even more. The fluid within the intrapleural space is absorbed very slowly and the intrapleural drug fluid it acts a reservoir. This one of only two reservoir nerve blocks, the other being the intraperitoneal block. The reservoir can sustain a block for 12 -18 hours. It is worth topping up the reservoir once or twice over the post-operative period before removing the catheter. Top up dose can the same as the initial main dose. Typically, this can be done on the first evening on the day of surgery, and on the first morning after surgery and then the catheter can be removed. Infusions work less well than intermittent big local anesthetic boluses.

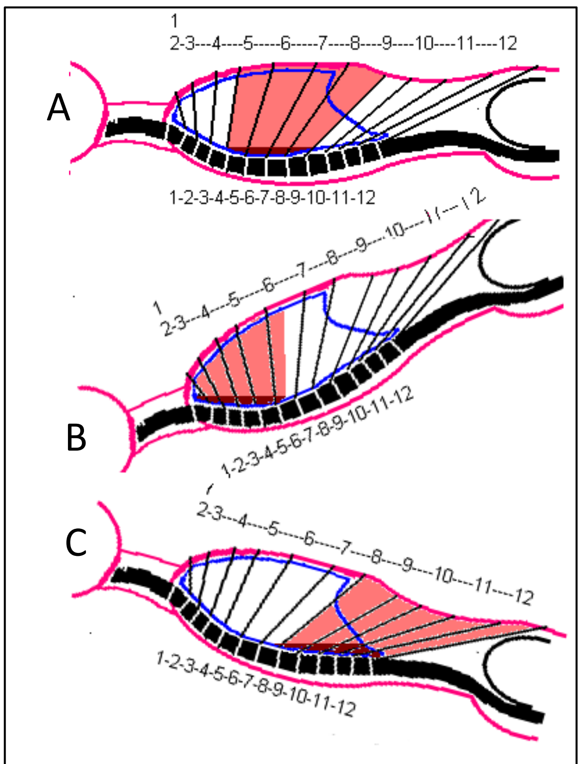


Fig. #56. The effect of the body position on where the intrapleural fluid and the block distributes.

The block is generally not of sufficiently high density for awake surgery, but is fully capable of providing total *post-surgical* analgesia when combined with general anesthesia.

It is very important to understand that the drug repositions it-self according to gravity. In this author's experience of this block, the upper 2 thoracic segments (T1-2) are commonly not blocked with initial dosing if the patient remains supine and fully horizontal. See image "**A**" of figure number 56. After the first dose and for breast surgery, tilt the operating table *head down* by 5 to 10 degrees *immediately* after insertion of the block. See image number 7. The reason is that the drug distributes under the influence of gravity to the most dependent parts of the pleural cavity. As the thoracic spine has a kyphosis with the most dependent part of the being at T6 in the supine patient, drug pools there and may not reach T1 and 2. If a lady, after breast surgery sits all the time, the block in the breast region will resolve in about 6 hours, and dense block will develop in the T11-2 and L12 region. See Image "**C**" of figure number 56. This problem can be resolved by having the patient be instructed lie down for 15 to 30 minutes every four hours with a pillow under the buttocks to tilt the thorax head-downwards. See figure number 56. This will move all the local anesthetic fluid within the intrapleural space to move as in image **C** of figure number 56. Segments T1-7 will become blocked again.

The site of insertion can be influenced by the surgical skin incisions. For lumpectomy size incisions without axilla dissection the catheter can be placed in the posterior or mid-axilla line before surgery. That will allow best block setup during the course of surgery and general anesthesia. If this insertion point interferes with the planned surgery incisions then the block can be place after completion of surgery, but the patient may awaken with slight brief (10 minutes) of pain before the block sets up. The block can take 15 to 30 minutes to become apparent.

CONTRAINDICATIONS TO INTRAPLEURAL BLOCK

General contra-indications would be those considered standard for any nerve block, such as sepsis at the site in intended needle insertion, lack of patient general consent for anesthesia, allergy for amide local anesthetic drugs, and operator lack of skills and experience with performing the nerve block etcetera.

One very specific indication does exist. Do not perform the nerve block if there is any pathology of the pleura such as effusions, presence of blood, pleural inflammation, or prior pleural adhesis surgery. The result can be the following. The local anesthetic fluid may not be able to flow to posterior where it has to be, to be able to diffuse through to the intercostal nerves. A second problem is that there may be no potential intra-pleural space where the needle gets inserted into the rib-cage and the needle could only move on an into the lung parenchyma. The block would fail. Local anesthetic toxicity would likely occur from very fast drug absorption in the blood streams, and air could escape the punctured lung as well. Furthermore, if the pleura is inflamed, and thus also highly vascularized, the drug would experience accelerated absorption from the pleural space and local anesthetic toxicity would result.

8. NERVE BLOCKS FOR THE PECTORAL NERVES

Section index:

8.1. PECS-1 block
8.2. PECS-2 block
8.3. The modified PECS-2 block
8.4. The infraclavicular pectoral nerve block. (PECS-infraclav.)

8.1. PECS-1[55].

This block was first described by Blanco[56]. Ekinci evaluated the optimal local anesthetic dose to use for it[57]. Ekinci considered the block being safe and simple to perform, as being its foremost feature. He, at that time, considered the PECS-1 block best suited to providing meaningful post-surgical analgesia for cosmetic sub-pectoral synthetic-implant breast cosmetic augmentation. He determined that 20 ml of 0.25% bupivacaine provided the best analgesia obtainable, and further increasing the volume to 30 milliliters of local anesthetic produced no analgesia betterment. Ekinci also showed that the modest clinical benefit of the PECs-1 block only lasted for 2 hours after surgery, during which period it reduced opiate consumption only about 50%. Cros studied the PECS-1 alone in simple mastectomy-with-axilla-node-dissection patients and found no analgesia benefit[58]. A subgroup analysis of the patients whose surgery included radical mastectomy {with excision of the pectoral muscle} did find significant gain in analgesia, that was too small to be clinically relevant.

LIPOSOMAL BUPIVACAINE IN PECS-1 BLOCKS:

One feasibility case-report from 2014 injected 15 ml liposomal bupivacaine, per side, between the pectoral muscles following simple bilateral mastectomy with silicone implant submuscular insertion. The study omitted many critical clinical and pharmacological details, but claimed amazing analgesia benefits despite lack of controls or historic case data[59]. The manufacturer (Pacira Pharmaceuticals) of the liposomal drug co-wrote the article.

In a related study (implants after standard-mastectomy with skin preservation) of 24 woman the liposomal bupivacaine was infiltrated around the breast pocket due to receive the implants[60]. The "control" group received a 20ml 0.25% bupivacaine (total 50mg) injected into the tissues of each breast pocket. The "study" group total of 133 mg liposomal bupivacaine injected into the tissues surrounding the implant pocket. The liposomal bupivacaine released over 72 hours, which would equate to an infusion of 5 ml/h into each breast of 0.035% bupivacaine per hour. No reduction in nausea or pain scores was observed in the study (liposomal) group, although morphine equivalent consumption was slightly reduced by three quarters of a mg per hour.

No studies yet exist, that compares liposomal bupivacaine block for breast surgery compared to best peripheral nerve blocks.

8.2. PECS-2.

This is two-part injection involving 10 of local anesthetic injected in a PECS-1 position and an additional 20 ml of local anesthetic injected a bit deeper and in between the pectoralis minor muscle and the serratus anterior muscle over the fourth rib. The second injection supposedly blocks the long thoracic nerve, the nerve to serratus anterior muscle, and the adjacent intercostal nerves. Kamiya reported in 2017 performing the PECS-2 block in a study of sixty-woman, half to get a placebo and half to get the PECS-2 block[61]. The patients all underwent simple mastectomies some with axilla dissection or sentimental lymph node removal. There was zero evidence of any clinically beneficial analgesia benefit to the nerve block patients intra-operatively or post-operatively. Levobupivacaine 0.25% was used.

Amit Pawa's 2018 study is more substantial[62]. A prospective pilot study was done on 16 woman undergoing unilateral non-radical mastectomy, some with sentinel node dissections, some with axillary node clearances, and some with prosthesis insertion attempted without general anesthesia. Everyone received thoracic paravertebral single shot blocks at T3 or T4 with 10 ml 0.4% levobupivacaine / 1.6% lidocaine solution. In addition, a PECS-2 block was done using 30 ml of 0.25% levobupivacaine / 1% lidocaine solution. Sedation was with propofol and fentanyl as needed. One case needed conversion to general anesthesia, possibly due to (a) a wider dissection than anticipated, and (b) block deficiency in the intercosto-brachial nerve (T1-2) distribution. Eleven patients tolerated surgery with conscious sedation, and four needed deep sedation. It can be concluded that thoracic paravertebral blocks provide surgical grade nerve blocks. It can also be concluded that the PECS-2 block is effective for the pectoral nerves. Much more validating studies are still needed.

MODIFIED PECS-2 BLOCK, WITH CATHETERS, THE "PROXIMAL" PECS-2 BLOCK.

One study investigated use of catheters for the pectoral nerve blocks[63] in patients undergoing unilateral complete mastectomy. Catheters could not be placed pre-operatively without being interfering with the surgical field and sterility. Catheters were thus placed by the surgeon at the conclusion of surgery. Group 1 received PECS-1 type blocks. Group two received a "modified PECS-2" block, where the PECS-1 component was eliminated, and the catheter tip was positioned deep to pectoralis minor muscle, but superficial to serratus anterior muscle. The drug injected was 30 ml of 0.25% bupivacaine. Both groups had mean postoperative pains scores under 2 on an 11-point scale at all times during the first 24 hours. The modified PECS-2 group had significantly better mean pain score although clinically irrelevant small. It must be noted that it cannot predict how a modified PECS-2 injection would perform if injected prior to surgery and its surgical disruption of all fascial planes. The merits of the modified PECS-2 block however deserve further study used as a pre-surgical single shot block.

8.3. The infraclavicular pectoral nerve block.

This author prefers this technique and has used it for well over a decade. The ultrasound transducer is placed infraclavicular, as if to do infraclavicular brachial plexus block. The transducer must be held parallel to the sagittal plane and within 1 cm of the clavicle immediately medial to the coracoid process in the coracoclavicular trough. Seek to identify the axillary artery. See figure number 57.

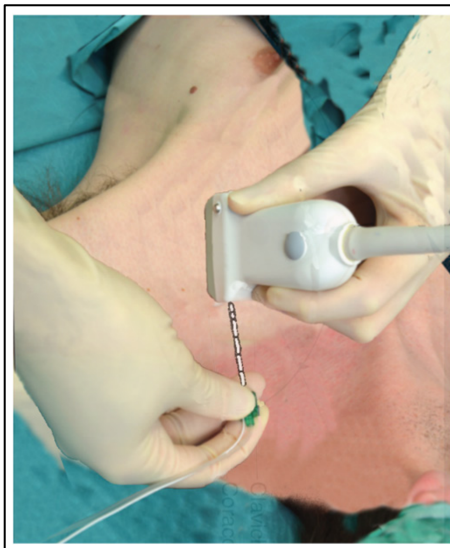


Fig #57. Infra clavicular pectoral nerve blockPECS-2 nerve block.

Insert the needle in-plane from cephalad and close to the clavicle. Aim the needle tip to a position immediately superficial (anterior) to the axillary artery. Do not touch the artery and aim above the coraco-clavicular fascia. The pectoralis minor muscle will be seen superficial to that and pectoralis major muscle superficial to that. Make test injection. Fluid should be seen to spread under pectoralis minor muscle. See figure number 58. Sometimes the thoraco-acromial artery can be recognized cephalad to the pectoralis minor muscle.

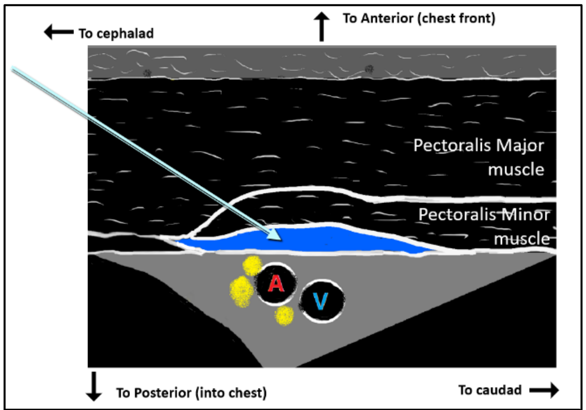


Fig #58. Proximal PECS-2 nerve block sonogram view.

Complete the injection using 10 ml of 0.5% Bupivacaine, or levobupivacaine, or ropivacaine. This author uses this block on all patients undergoing breast excision surgery greater than just a lumpectomy or segmentectomy. This author also has had selected patients undergo modified mastectomy with axilla exploration surgery using this block combined with thoracic paravertebral block and an intercostobrachial nerve block. Minimal to zero sedation was used and the patients had zero post-surgical pain for many hours afterwards. It is assumed thus from author clinical experience, that this preferred more proximal block position, from that that of the PECS-2 block results in good block of both the lateral and medial pectoral nerve at the superior margin of the pectoralis minor muscle where the nerves enters the mammary region via the opening in the clavipectoral fascia.

9. NERVE BLOCKS FOR THE LOWER ABDOMINAL WALL

Section index

10.1. Introduction.
10.2. Epidural anesthesia-analgesia.
10.3. TAP block.
51.4. Using the ultrasound for the TAP block.
10.5. TAP block Technical block tips.
10.6. Quadratus lumborum block.
10.7. Liposomal bupivacaine in TAP blocks.

10.1. INTRODUCTION

There are a variety of surgeries that are performed in the lower abdominal region, associated with breast reconstructive surgery. The lower abdominal wall dermatomes are T9 to 12. There are five options to block those dermatomes, and provide post-surgical analgesia for the lower abdomen.

The five lower abdominal wall nerve blocks are;

(1) Continuous epidural block.
(2) TAP blocks,
(3) Quadratus lumborum blocks,
(4) Erector spinae blocks.
(5) Thoracic paravertebral blocks (bilateral)

These blocks would stand fully separate from the nerve blocks needing to be done for the breast surgery.

10.2. EPIDURAL: Lower abdomen segmental epidural to cover dermatomes T9 to T12.

This will provide full thickness anesthesia and analgesia of the abdominal wall. Position the epidural catheter tip at T10 or T11. Inject ropivacaine 0.75% in a volume of 5 to 7 ml, and maintain analgesia with an infusion of ropivacaine 0.2% at 4 to 5 ml per hour. Alternative local anesthetic drugs can be used with proportional similar doses. Adapt the protocol according to whether general anesthesia is used as well. or not.

10.3. TAP Block: (Google ***18TABRAA*** for a substantive text on TAP blocks, in a broader discussion).

TAP blocks are suited to abdominal region surgery confined to only the abdominal wall. The modern TAP block should only be performed using ultrasound guidance.

Bilateral TAP blocks are very well proven effective for the abdominal wall pain[64]. The blocks can be extended by catheter redosing or infusing. Intermittent boluses may be more effective than continuous infusions. The TAP block alone reduces the total patient morphine consumption of breast-repair-surgery patients by 33%, if the breasts are not blocked as well. It also seems that the pain from the abdominal wall is only severe for about 2 to 3 days and an infusion longer than that offers little benefit over that of oral analgesic tablets.

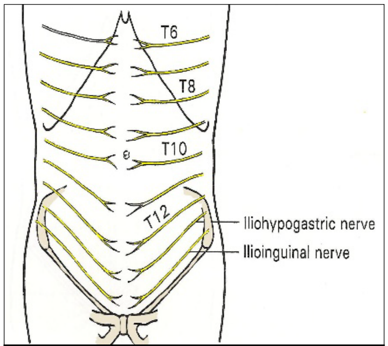


Fig. # 59. The dermatomes of the lower abdominal wall.

The surgeon can also insert the catheters at the time of surgery to lie on the transversus abdominis plain fascia. The big limitations of the tap blocks, is that they utilize a very large amount of local anesthetic, thereby limiting the amounts of local anesthetic drug that can still be safely used with the other chest and axilla surgery of the breast.

The abdominal dermatomes needing to be blocked for the harvesting of lower abdominal skin, fat and muscle, followed by skin closure with umbilicus transfer are T9 to T12. The line of incision matches the “bikini line”.

The abdominal wall consists of skin, subcutaneous fat, muscle-fascia layers, and an inner lining of peritoneum. These tissues all share the same nerve supply. It is the segmental somatic nerve supply direct from the spinal cord as anterior ramus intercostal nerves from T6 to L1. The center dermatome of that range is at the umbilicus which has a T10 nerve supply. See figure number 46. Any block of an intercostal nerve will block the corresponding segment of abdominal wall in its full thickness from skin to peritoneum. The very lowest part of the abdomen receives it nerve supply from Lumbar root 1 via the ilioinguinal and iliohypogastric nerves. A standard TAP block will cover those nerves too, even if not actually needed for the flap harvesting surgery.

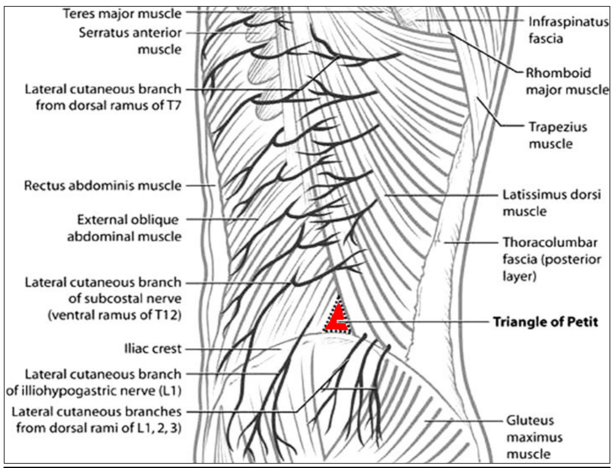


Fig. #60. The Triangle of Petit.

The triangle of Petit is also called the inferior lumbar triangle. See figures 60 and 61. The triangle of Petit lies in between the muscles latissimus dorsi (posterior), the external oblique (anterior) and the iliac crest (inferior). The Iliohypogastric nerve then runs in this transversus abdominus plane (TAP) and gives off a lateral cutaneous branch 2 cm anterior to the triangle of Petit. The remaining anterior cutaneous branch, remains in the TAP plane until it reaches 2 cm medial to of the Anterior Superior Iliac Spine (ASIS) where it penetrates the internal oblique muscle to run further to infero-anterior between the two oblique muscles before it finally becomes subcutaneous 3 cm cephalad of the superficial inguinal ring.

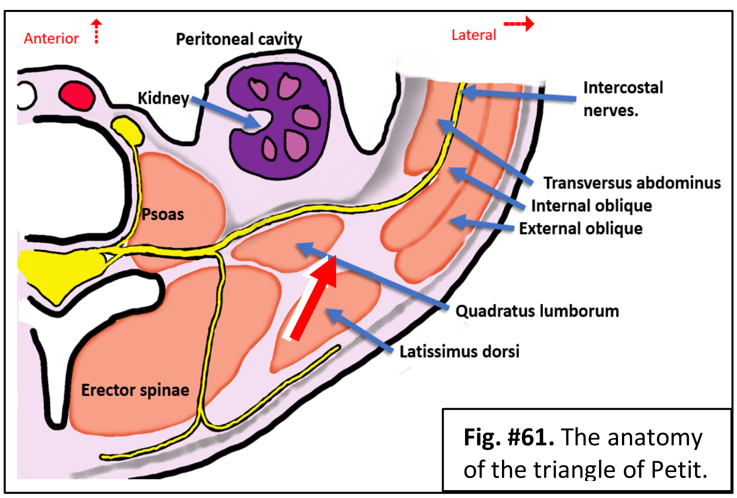


Fig. #61. The anatomy of the triangle of Petit.

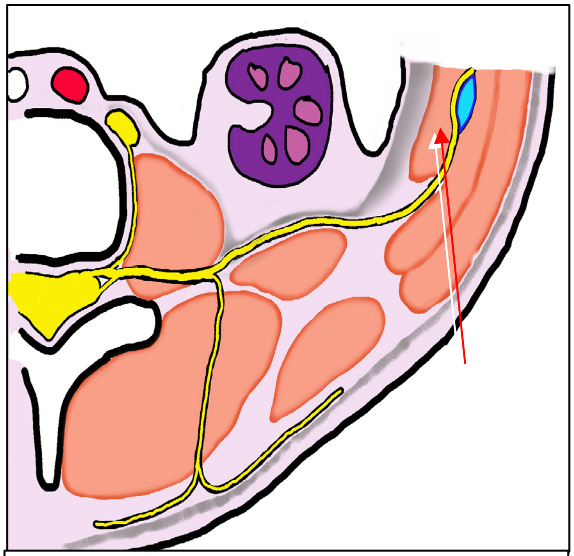


Fig. #62. Drug injected into the TAP space.

The *transversus abdominis plane* (TAP) block was originally described as the fascial space *in between* the internal oblique muscle and the transversus abdominis muscle. See figures 61 and 62. The TAP plane extends from posterior immediately lateral to Quadratus lumborum muscle to near midline where the transversus fascia merges with the posterior fascia of the rectus muscle sheath near the midline.

Superiorly this space is limited by the abdominal wall muscle attachments to the ribs and inferiorly this TAP space is limited by the abdominal wall attachments to the iliac crest and inguinal ligament.

The TAP space is misleadingly named. It is not truly a space between two sheets of fascia. See figure number 63. There is only one sheet of fascia between the innermost abdominis transversus muscle and the adjacent more superficial muscle, the internal obliquus muscle. Each of these two muscles is lightly attached to this TAP fascia. All the intercostal nerves and blood vessels are loosely buried WITHIN the TAP Fascia. Both these two muscles can be stripped off the TAP fascia very easily with hydro-dissection.

One cannot create the TAP Space by open dissection of a cadaver (author's research), or by fluid injection during an ultrasound guided TAP block.

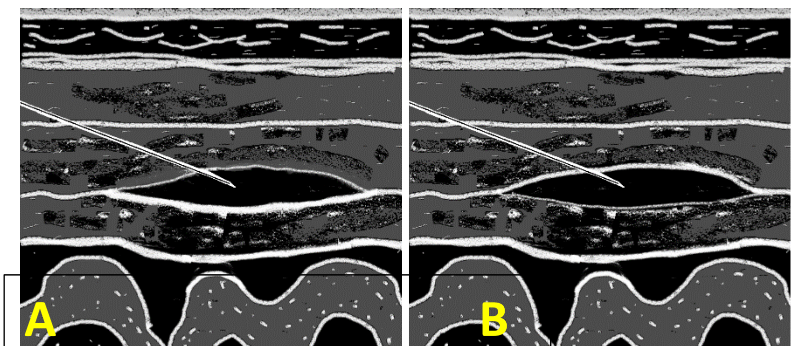


Fig. # 63. Sketch sonograms of the TAP space filled with injected local anesthetic drug. In image **A** the fluid is above the TAP fascia. In image **B** it is below the TAP fascia.

The visible sonographic space created with local anesthetic fluid injection, will form in one of two manners. On ultrasound the TAP fascia may move deeper and the internal obliquus bulge upwards with the new fluid cavity lying between these two structures. See figure 50, image A. Alternatively, the fascia may move towards superficial with the transversus abdominis muscle bulging downwards and the fluid cavity is held between these two structures. See figure 50 image B. In one situation the fluid is below the fascia and in the other the fluid is above the fascia.

Clinical experience suggests that the resultant nerve blocks perform identical. This alters the concept of performing the nerve block slightly. It is now easiest and most practical is to only simply advance the needle to the point where it is felt, and seen to be pushing on the TAP fascia. There is no reason to penetrate the fascia with the needle. Start injecting at that point. It will be seen that a visually well-defined fluid space forms above the fascia as the internal obliquus muscle is fluid dissected off the fascia. If it appears on sonogram that there is a fascia limiting the superficial boundary of the fluid cavity it is always clearly less substantive than the actual

TAP fascia that is on the deep side of the new fluid cavity. This is a very easy nerve block to perform.

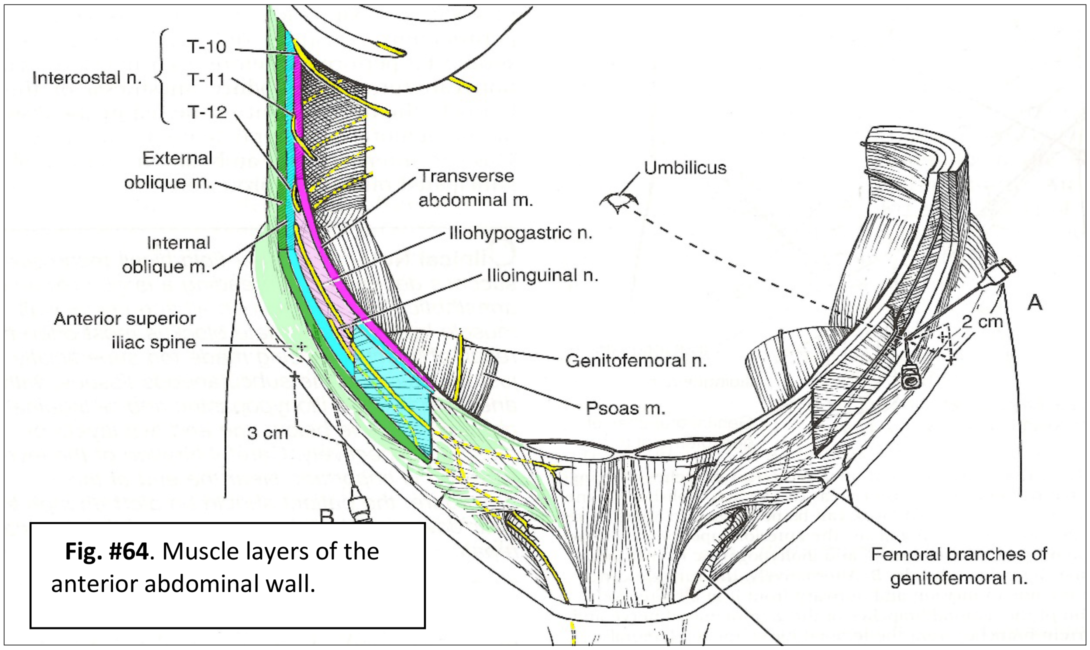


Fig. #64. Muscle layers of the anterior abdominal wall.

10.4. USING THE ULTRASOUND FOR THE T.A.P. BLOCK

The TAP block was first described in 2001 by Rafi as the "Abdominal field block" injecting into the triangle of Petit[65,66]. The same block was independently described again as the Transversus Abdominis Plane block (TAP block) [65]. The first description was a tactile "two-pops" block performed in the triangle of Petit by McDonnell in 2004. Shortly after that it was re-described as an ultrasound guided (USG) technique after which it became widely known. Virtually no complications are ever reported using ultrasound guidance.

Using ultrasound guidance, the transversus abdominis plane can be accessed more easily is slightly *anterior* to the triangle of Petit. The names of Ultra-Sound Guided (USG) Ilioinguinal, USG iliohypogastric and USG TAP block are interchangeably used to refer to the same block effectively for the lower abdomen. Use a Quincke point 3 ½ inch 22G spinal needle. Blunt needles penetrate fascia at shallow angles with difficulty. A sharp Quincke point needle is easiest to use.

Fig. #65.

Moving slightly anterior the muscular portions of the oblique muscle are well developed and this may assist ultrasound visualization. It is thus strongly recommended to only perform the TAP block where all three abdominal wall muscles are seen. Also, the fleshy transversus abdominis muscle gives some protection from puncturing the peritoneal cavity. It is however important not to move the injection point too anterior, as fewer intercostal nerves will be blocked and also the lateral cutaneous branches of the intercostal nerves may be missed. The lateral cutaneous branches penetrate to subcutaneous in the mid axilla line.

10.5 TAP BLOCK TECHNIQUE.

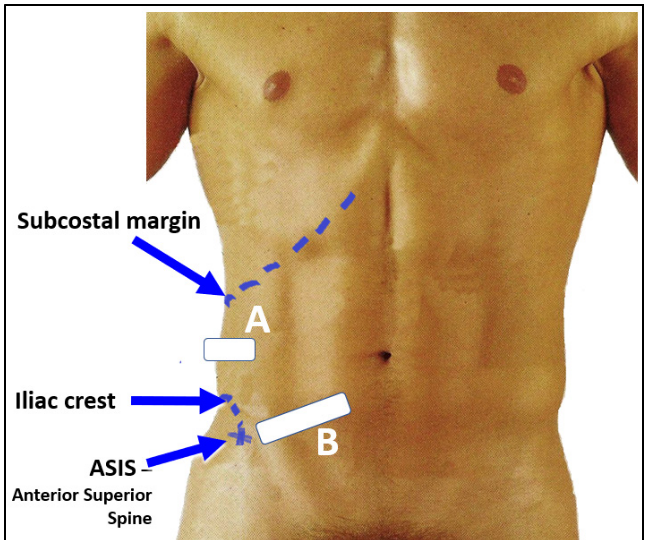


Fig. #66. Two TAP block transducer positions. Position "A" is the routine one. Position "B" is better for inguinal surgery.

Place the transducer over Petit's triangle as in figure no. 65. Slide the transducer slightly towards anterior, until all three wall muscles are seen have a fleshy full form. That is the good view. However, it is important to take the most posterior "good view" position that is achievable. The three layers of muscle are the external oblique, internal oblique and transversus abdominis muscles. That should also replicate the position of transducer "A" in figure 63. Hold the ultrasound transducer so the sound imaging plane is coronal and insert the needle *in-plane from anterior*. Insert the needle until the tip lies deep to the internal oblique muscle and superficial to the transversus abdominis muscle as in figure 64. Repeated small injections of 0.5 to 2 ml of 5% Dextrose water (5DW) can be made to aid precisely locating the needle tip visually.

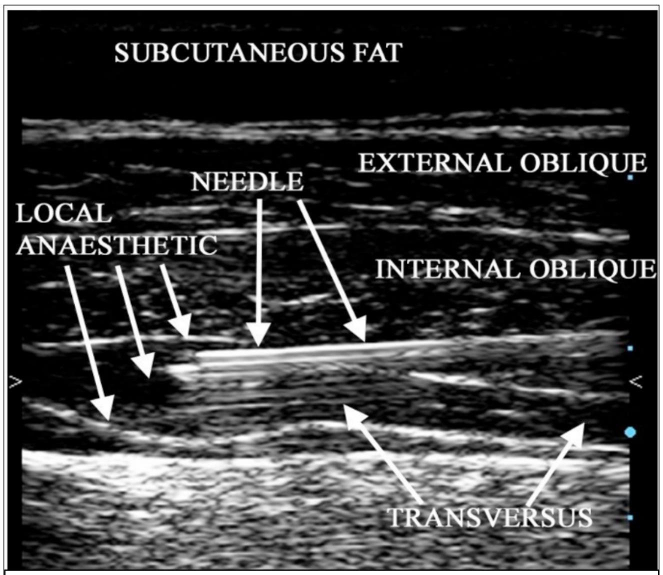


Fig. #67. Ultrasound appearance of a TAP block immediately after injection.

Have a 10 to 20 ml syringe of 5DW to inject as ultrasound image contrast and for hydro-dissection while advancing the needle. This will help place the needle confidently onto the TAP plane, before local anesthetic injection. In general, be conservative with hydro-dissection fluid as it tends to ultimately corrupt the deeper image if the fluid has bubbles in it.

Use a linear high frequency ultrasound transducer.

Inject 20 ml of local anesthetic in a typical adult.

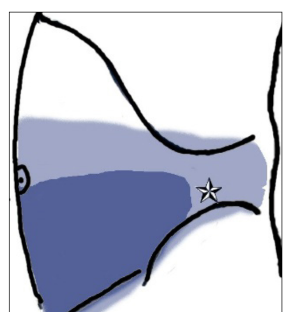
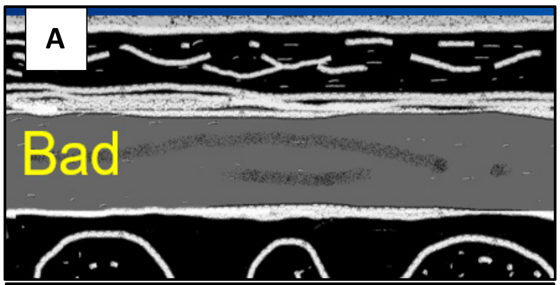


Fig. #68. The spread of anesthesia and analgesia with a TAP block.

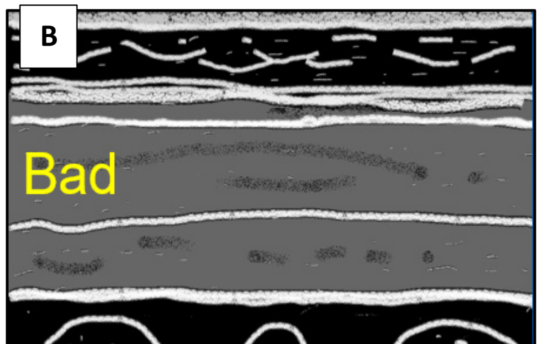
Tips on how to optimize performing the TAP block.;

TIP#1

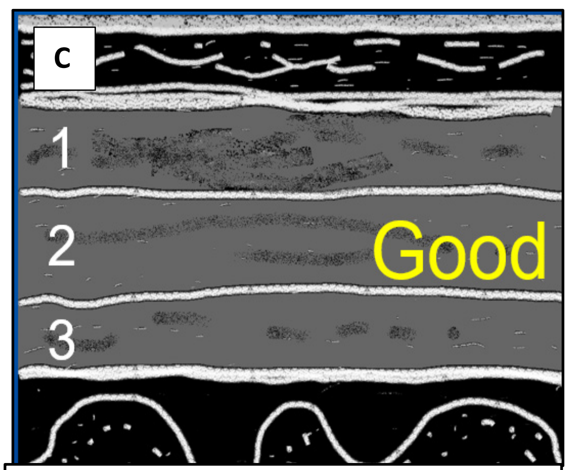
Place the transducer about one finger's breadth cephalad to the iliac crest. Orientate the transducer in the transverse so that it lies on a line that will cross the umbilicus. Next slide the transducer sideways along that line, and find the ultrasound image that contains the three thickest abdominal muscles. The two obliquus and the one transversus muscles do not all span from the front all around to the back with a fully fleshy muscle. For portions of that distance they may only exist as be tendinous fascias. Each muscle is different. There is also variation in muscularity between individuals. The point where all three muscles are fleshy is relatively lateral and is the best point at which to inject the TAP block. See the three ultrasound image sketches images below.



Only one abdominal muscle visible = bad TAP block location.

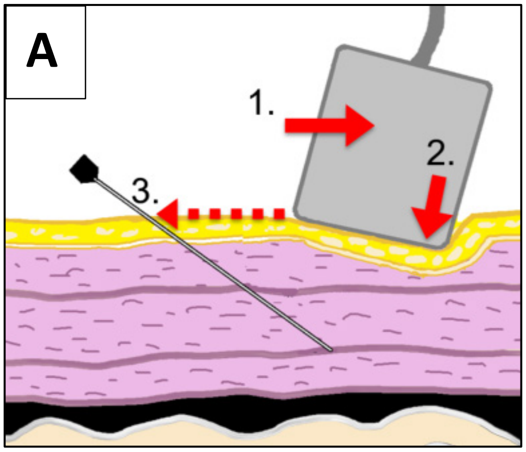


Only two full fleshed abdominal wall muscles visible = bad TAP block location.



Three full fleshed abdominal wall muscles = a good TAP block location. 1= obliquus externus. 2= obliquus internus. 3- transversus abdominus.

Fig. #69. Sketches of ultrasound images of the abdominal wall: There is individual variation as to where a muscle converts from a facia layer to a muscle, then ends again as a fused fascia. The best imaging-injection spot should be as far lateral from the umbilicus as is possible to inject, but in a region with three full muscles.



Tips on how to optimize performing the TAP block.

Tip #2. See fig. #29 A

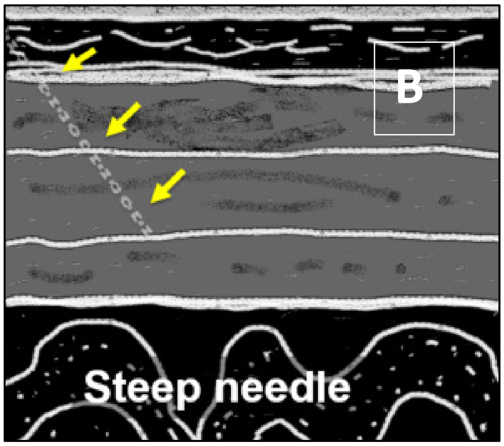
Use The retreat then heel-dig-in technique. This tip can be used with all ultrasound guided needle nerve blocks whenever the target is deep. The best needle images are formed when the sound waves hitting the needle are perpendicular and able to all bounce back to the transducer. That occurs when the needle is parallel to the imaging surface of linear transducer.

Thus, the closer a needle can be made to becoming parallel to the transducer surface the better the needle imaging is in an in-pane view.

Three handling maneuvers are needed to improve the needle and transducer being parallel.

1. RETREAT: Move the transducer sideways away from the needle insertion point. The target tissue will slide slightly out of view.
2. DIG HEEL IN: Tilt the transducer sideways so that its far lateral edge pushes (digs in) into the tissues. The target comes back into view. It is as if one took a step away then looked back to the target. This also makes the imaging surface look back to the tissue target zone that was chosen.
3. AIM SHALLOW; Insert the needle from 2 to 5 centimeters further from the edge of the transducer. This will (i) create a longer path to the target area, but (ii) aim the needle less steeply into the tissues.

These three maneuvers, each in modest amounts each can together, improve the needle imaging dramatically. See the ultrasound images sketches below.



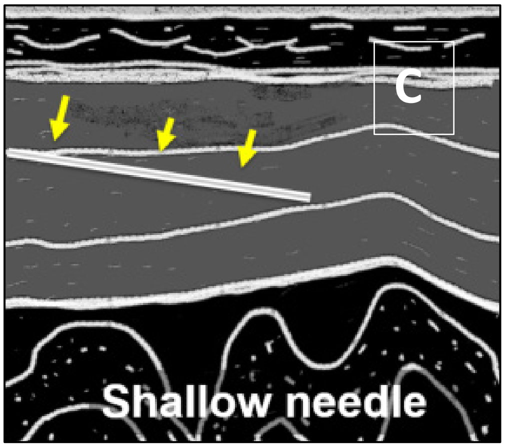


Fig. #70. Two sketched sonograms **B** and **C**. The image left shows poor needle imaging due to the steep angle of the needle relative to the transducer soundwaves. The image right shows improved, shallower, needle imaging due to the above described adjustments. Those adjustments made the sound waves hit the needle at closer to perpendicular angles.

ONSET OF ANALGESIA OF THE TAP BLOCK.

This is a slow onset block consistent with all fascial plane blocks, compared to individual peripheral nerve blocks. Standard TAP blocks consistently block down to L1 and up to T10, but only by thirty minutes after injection. It then spreads very slowly and may reach T8 or even T7 an hour later. It is thus ideal to do this block before surgery starts, in order for the analgesia to be effective upon the patient awakening from general anesthesia.

SUGGESTED DRUGS AND DOSES

- Levobupivacaine 0.75% (most long acting). Analgesia lasts about 22 hours. This drug is unavailable in the USA.
- Bupivacaine 0.5% to 0.25% (long acting). Preferably use preparations with added epinephrine (adrenaline). Using 0.5% bupivacaine with epinephrine (adrenaline) analgesia last about 18 – 20 hours. The big limitation of bupivacaine is that the total amount of drug needed for both the chest and abdomen in breast removal and reconstruction requires unworkably low dilution, in order to stay below toxicity risk limits.
- Ropivacaine 0.5% to 0.75% (medium long acting). There is no advantage to using this drug as the duration of analgesia is significantly shorter. Analgesia lasts about 8 to 10 hours

The optimum volume to be injected is between 15 to 20 milliliters of local anesthetic per side, for the TAP block.

Infusion doses of 0.125% Bupivacaine have been used in unilateral TAP blocks successfully in adults.

10.6. TAP blocks with liposomal bupivacaine.

Jablonka in 2017 reported on retrospective reviewed, experience with 128 patients[67]. Some patients got no block. Some patients got liposomal bupivacaine, and it was administered in a variety of fashions into the TAP blocks. All patients received general anesthesia. Other analgesia interventions were made in an uncontrolled fashion. In this very unscientific retrospective study, the author claims there was an earlier discharge in the patients who had received liposomal bupivacaine blocks. **Based on this study liposomal bupivacaine cannot yet be recommended for use in TAP blocks**. The Jablonka flawed study is a case study in itself on why prospective randomized and controlled research trials are needed, on which to base practice recommendations. The publishing journal standards must be questioned, for accepting this poor report for publication.

There is at the time of writing this chapter, despite much writing on this drug for this indication, no randomized, blinded, prospective trial demonstrating clinical merit yet. Multiple scientific prospective studies still need to prove benefit, if there is a worthwhile benefit. The glaring absence of such studies suggest no merit exists for the use of liposomal bupivacaine in TAP blocks. There are also many special safety precautions to be taken when using liposomal bupivacaine, as described in the trade written liposomal bupivacaine overview[68]. Of note. They also caution that a liposomal-drug-holding SUSPENSION of drug does not spread as readily as a water solution of the drug

10.7. Ultrasound guided Thoracic Paravertebral Blocks.

See page 23 and the beast region discussions on this block. For the harvesting of the abdominal tissue flaps insert the paravertebral catheters at T11.

10.6. THE QUADRATUS LUMBORUM BLOCK

The ultrasound guided quadratus lumborum nerve block (QLB) was first described in 2007. There is some similarity to TAP blocks. In truth, Rafi essentially first described the block as a tactile surface anatomy block in 2001, performed in the triangle of Petit[66]. Rafi called it the *abdominal field block*, and he injected after feeling the needle "pop" through two fascias. McDonnel described an ultrasound guided block in 2007 which he called the Transversus Abdominis Plane block (TAP)[65]. The exact sonographic views for the triangle of Petit TAP block were variable between different patients. Very soon practitioners of McDonnel's block discovered that an improved view existed slightly more towards anterior (closer to the umbilicus) and over a point where all three abdominal wall muscles were fleshy. This produced a reliable view and that it was easy to inject the local anesthetic drugs to a point between the deepest two of the three muscles for the TAP plane. The name TAP block however was kept.

The quadratus lumborum block (QLB) is simply a return to the original Rafi's abdominal field block, but instead now using ultrasound imaging as a guide instead of Rafi's tactile technique to guide needle tip placement. The QLB has a different injection point to the TAP block. The quadratus lumborum muscle is used as a visual reference point. It is also confusing for the novice, because there are four basic QLB variants of injecting relative to the quadratus lumborum block. Each variant has many different names, and each with different needle insertion directions. Each variation behaves differently in terms of where the drug spreads to. Each variant has its own "prophet" who lectures claiming their version is best. The QLB character is slightly like that of a paravertebral block, although displaced slightly more lateral than a thoracic paravertebral block by the psoas muscles. Also, there are no ribs acting as reference points. The QLB block is more challenging than a TAP block, which will handicap practitioners making exact precision injections each time.

Complete failure QLB has been described. Complications suggestive of neuraxial spread, and lumbosacral plexus spread have been described. That latter observation is supported by series reports of using it for analgesia for hip arthroplasty cases, although with only modest success. The overall impression is that although some analgesia efficacy can be shown for all the variants, the analgesic spread is inconsistent and many individual patients experience disappointing analgesia

This author will use the classification proposed by Ueshima, for ultrasound guided quadratus lumborum blocks[69]. Persons reading original scientific reports must read the full article and not the abstract, to establish which *Ueshima classification* the article fits.

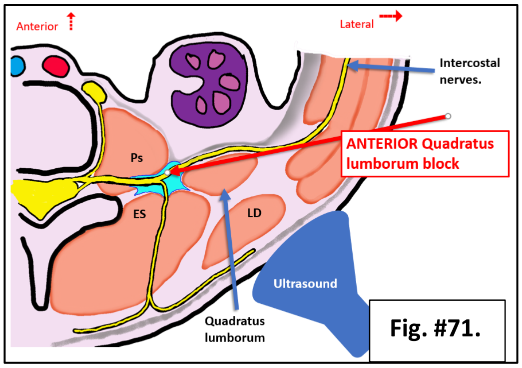


Fig. #71.

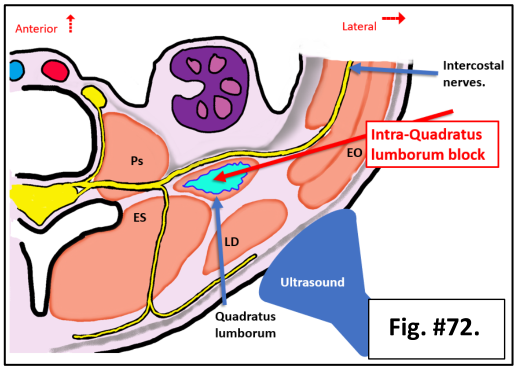


Fig. #72.

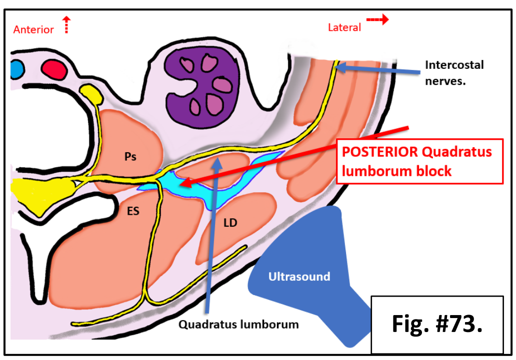


Fig. #73.

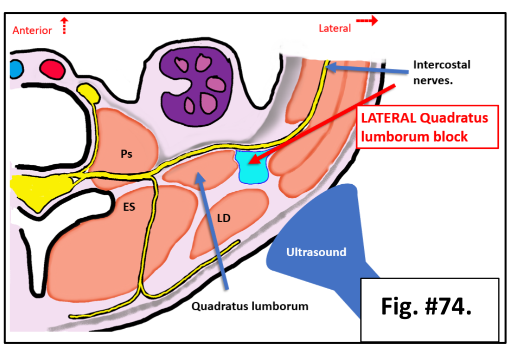


Fig. #74.

- **The Anterior QLB,** labeled improperly by some as a subcostal QLB or the transmuscular QLB. It is the deepest injection variant of the group. It is also the most difficult injection of the QLB group, in adults. The patient is positioned supine with a curved transducer positioned over the tringle of Petit. The needle is inserted from anterior and in-plane to the transducer.

The injection point is between the psoas muscle and the quadratus lumborum muscle. The drug seems to spread anterior to quadratus lumborum muscle. The needle is inserted through the quadratus lumborum muscle. Because of injection proximity to the psoas muscle, some drug diffuses into the psoas, sometimes yielding features of a L2 level psoas compartment block. There is a risk for the needle to penetrate the peritoneal cavity to poor imaging of the steep needle and the common lack of precision sonographic imaging. In children, as smaller subjects, with their enhanced ultrasound imaging, this variant has had some popularity used for acetabular-hip surgery. Efficacy is not 100%. This author prefers using the more specific L3 psoas compartment block supplemented with the simple subcutaneous iliac crest and subcostal nerve blocks for acetabular-hip surgery analgesia.

- The **Intramuscular QLB** or intra-quadratus lumborum block, is injected into the middle of the quadratus lumborum muscle. The local anesthetic spreads up and down the muscle, and then diffuses outwards onto adjacent fascial planes. It blocks a range of passing intercostal nerves in the T10 to L1 range.

The patient is positioned in the supine position. The transducer is placed transverse to the patient long axis, over the triangle of Petit. The needle is inserted from anterior in-plane. Some proponents prefer a linear transducer.

- The **Posterior QLB** is injected in between the erector spinae muscle and the quadratus muscle. The drug is considered to spread posterior to quadratus muscle. The drug ultimately will diffuse onto nerve structures in the region. The patient is positioned in the supine position. The transducer is placed transverse to the patient long axis, over the triangle of Petit. The needle is inserted from anterior in-plane.
- **The Lateral QLB** is injected with the patient supine and the transducer over the triangle of Petit and held transverse across the patient. The needle is inserted near the upper edge of the transducer in-plane. The tip is positioned at the lateral edge of quadratus lumborum muscle.
- ▪ The block is considered successful, by its proponents, if sonographically the drug appears to surround the quadratus lumborum muscle.

SUMMARISING COMMENTS on the Quadratus Lumborum block;

The fact that such a diverse range of QLB techniques have been shown to all cause some analgesia suggest that within the region, a large volume of injected local anesthetic, almost however injected, within the triangle of Petit is capable of diffusing far enough to reach some nerves in a large portion of patients, but not all. It is a fact that only when a drug primarily baths nerves immediately with injection, that the block will produce the fastest onset of nerve block, with the longest duration in effect. For these considerations, and from experience, the author considers the TAP block superior to the quadratus lumborum group of blocks for (i) reliability of benefit for most patients, and (ii) duration of analgesia.

This author does not recommend the quadratus lumborum block over the TAP block which is uniquely easy and effective for appropriately selected surgeries.

CLASSIFICATION OF THE QUADRATUS LUMBORUM BLOCK (per Ueshima)

<table>
<tr><th>Ueshima name</th><th>Point of injection</th><th>Technical ease of block</th><th>Safety of block</th><th>Consistency of analgesia</th></tr>
<tr><td>Anterior QLB</td><td>In between psoas muscle and quadratus muscle</td><td>Difficult</td><td>Less safe</td><td rowspan="4">Less consistent</td></tr>
<tr><td>Lateral QLB (QLB1)</td><td>Lateral to the quadratus lumborum muscle.</td><td>Not easy</td><td>Moderately safe</td></tr>
<tr><td>Posterior QLB (QLB2)</td><td>Posterior to quadratus lumborum muscle, in between erector spinae and quadratus muscle.</td><td>Not easy</td><td>Less safe</td></tr>
<tr><td>Intra-QLB</td><td>Within the muscle mass of quadratus lumborum.</td><td>Very easy</td><td>Moderately safe</td></tr>
<tr><td>TAP block</td><td>In between the transversus abdominus and interior oblique muscles</td><td>Very easy</td><td>Very safe</td><td>Very consistent</td></tr>
</table>

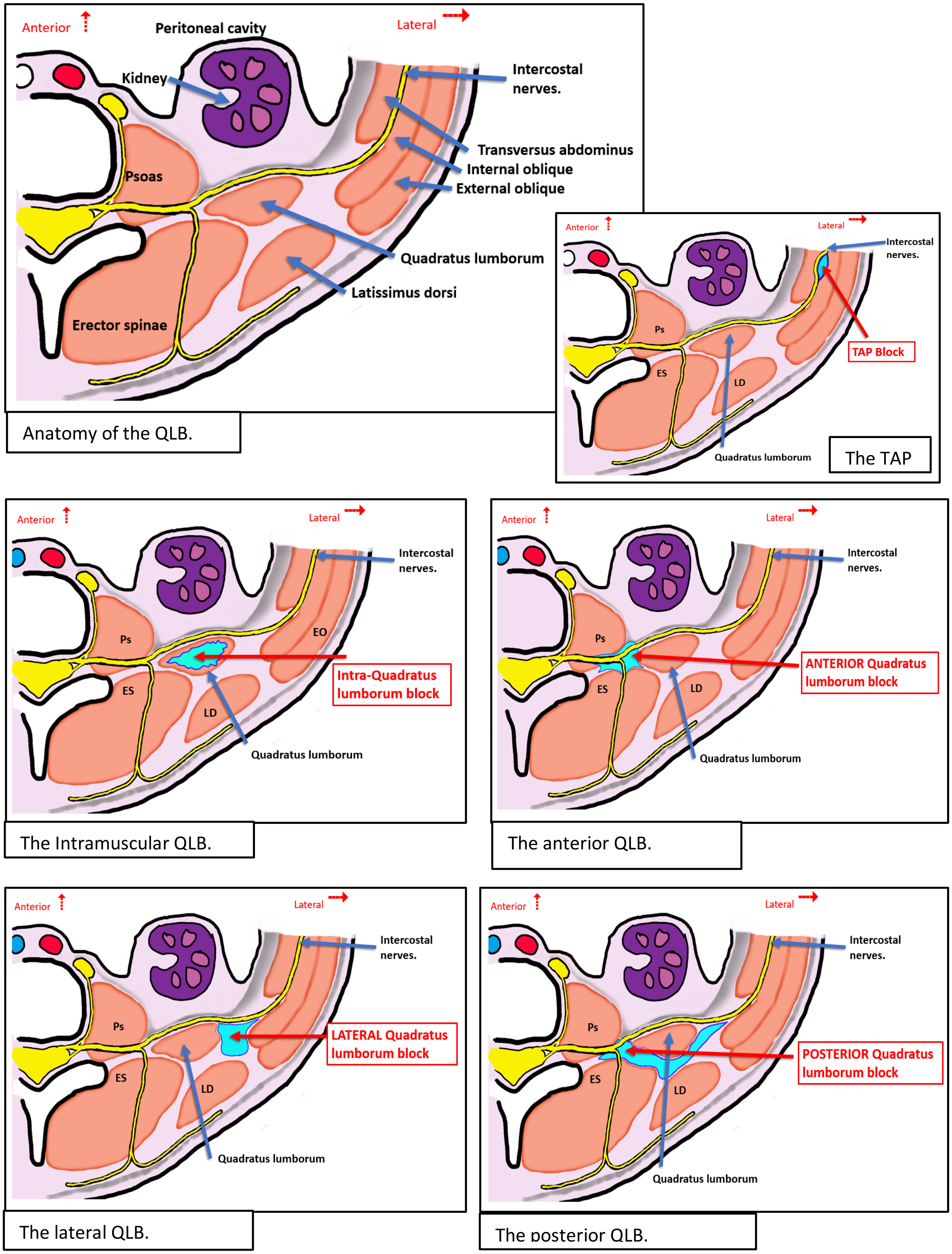


Fig. #75. Visual comparisons of the fascial plane blocks, covering the thoracic intercostal nerves.

10. INTRAVENOUS LIDOCAINE ANALGESIA.

There is suggestive evidence that infusions of lidocaine (lignocaine) possibly have mild analgesic beneficial effects on patients after intestinal surgery. Terkawi studied whether such benefits could also occur in patients undergoing mastectomy[70]. The study was prospective, randomized and blinded. No analgesia benefits were observed.

11. SURGEON ADMINISTERED NERVE BLOCKS

Surgeons can also inject local anesthetics within the sterile operating field. Shah injected the intercostal nerves within the operating field, when performing simple mastectomy, combined with placement of a sub-pectoral implant prosthesis [71,72]. He retracted the pectoralis muscles very strongly so that he could inject the intercostal nerves available within the surgical field, as far to posterior was possible. One pneumothorax did occur. Only partial post-surgical analgesia was demonstrated.

12. USE OF MULTIMODAL ANALGESIA.

Multimodal analgesia refers to using non-sedating analgesics such as NSAIDS, COX2Is, and acetaminophen, at least. The drugs must be administered from prior to surgery through to about the third day after surgery in fixed doses and in a fixed rigid schedule regardless of pain. Only beyond about those first 2 to 3 days post-operative, should the multimodal analgesics be administered on a discretionary basis. In one modest size regional anesthesia study a non-difference was found between one regional anesthesia technique and a placebo where it was expected to have had an effect[73]. This failure was attributed to the efficacy of the multimodal analgesia making the study underpowered to show the expected difference. Conversely this study result, can be used to demonstrated the high efficacy of the multimodal analgesia.

13. CONCLUSION

While full awake surgery for a partial or full mastectomy with axilla clearance is achievable it is a laborious anesthesia process to achieve the numerous nerve blocks and large doses of local anesthetic are used. This may be the optimum anesthetic in a sickly patient in whom it is desired to maximally avoid opiates. Often in a healthy patient the best balance of maximizing patient comfort and easiest overall anesthetic technique may involve only doing a general anesthetic with a pharyngeal airway (e.g. laryngeal mask) and doing a T1-6 paravertebral block. The unblocked tissues discomfort may be sufficiently well managed with a multimodal analgesia technique using non-steroidal anti-inflammatory drugs (e.g. ketorolac), a small dose of opiate once (e.g. 3 mg morphine), and a small dose of ketamine early in the case (e.g. 0.5 mg/kg). The exact design of the best anesthetic technique requires the surgeon inform the anesthesiologist the exact extent or lack of extent of the surgery. The anesthesiologist should also consider all the patient's co-morbid diseases. The anesthesia plan to achieve best analgesia at least risk can then be chosen.

More than with any other surgical specialty, the surgeon must be a harmonious team relationship with the anesthesia team. The surgeon must strongly promote the use of the nerve blocks.

Breast surgery is always a disfiguring experience for any lady and these patients deserve to have their post-surgical pain maximally treated more than any other. If there are additional consideration of known or possible malignancy the requirements to demonstrate the patient with very best pain control is even more so.

No woman should ever lose a breast and also have severe pain after surgery.

Know the surgery.

It is very important for the breast surgery anesthesiologist planning nerve blocks to fully understand the likely surgery.

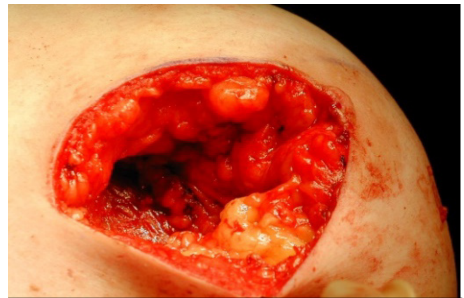


Fig. #76 A. Medial breast segmentectomy with part of nipple

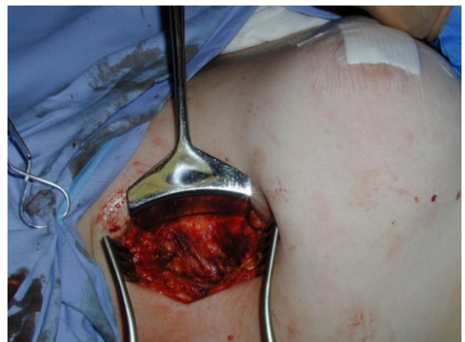


Fig. #78 B. Axilla exploration for lymph nodes, after segmentectomy.

Fig. #79 C. Happy patient 30 minutes after surgery. Anesthetic was general anesthesia, LMA airway, T4 paravertebral block plus a catheter. See the catheter lying over the patient's shoulder.

This is the author's patient. The photos are used for educational purposes, with patient consent.

14. FREQUENTLY ASKED QUESTIONS;

1. **Which is the best pectoral nerve block?** Answer: PECS-2 is definitely better than PECS-1. The modified-PECS-2 that only has one injection deep to the pectoralis minor muscle seems the best for most benefit, with economy of drug injected. A single cadaver study injecting dye into the PECS-1and into the PECS-2 positions on the two sides was done in Japan[74]. It showed the PECS-1 injectate spread to the axilla between the pectoral muscles. The PECS-2 injection (deep to both pectoral muscles) did not enter the axilla and spread included passing over the serratus muscle.
1. **Do the pectoral muscles always need to be blocked?** Answer: Only if the axilla is to be dissected, a modified radical mastectomy, or full radical mastectomy is to be performed.
2. **Do the posterior axilla muscle need to be block with a full mastectomy**? Answer: No. Only block the posterior axilla wall for awake surgical explorations of the axilla.
3. **Why do the posterior axilla muscles need blocking with awake axilla dissections?** The sensations of awake surgical axilla dissection, inflammation from tissue handling, small bleedings and use of electro-cautery are intolerable without posterior axilla muscles block in a fully awake patient.
4. **Can a patient be given two separate epidural blocks with catheters, at the same time?** Answer: Yes. One can be placed at T3 for the breast surgery, and one at T11 for the abdominal wall flap harvest.
5. **Are there nerve blocks for the flap harvesting from non-abdominal donor sites like the buttocks?** Answer: Conceptually the answer has to be yes. However, they are not yet described.

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