Best Practice & Research Clinical Anaesthesiology 33 (2019) 303–315

Contents lists available at ScienceDirect

Best Practice & Research Clinical Anaesthesiology

journal homepage: www.elsevier.com/locate/bean

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Interfascial plane blocks

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Keywords:
perioperative pain management
multimodal analgesia
regional analgesia
interfascial plane blocks

Many novel interfascial plane blocks have been developed in the last 10 years in the effort to improve perioperative pain management that are safe, efficacious, efficient, and inexpensive. These blocks have been widely adopted into clinical practice despite relatively few high-quality clinical investigations of the techniques and how they affect perioperative outcomes. This article defines interfascial plane blocks, discusses the potential benefits, reviews the most common techniques and evidence supporting their indication, and guides clinicians in selecting an appropriate interfascial plane block for different types of surgical procedures.

Introduction

In recent years, interfascial plane blocks have been increasingly utilized as important components of acute postoperative pain management [1] owing to their ease, rapidity, safety, and low cost of administering these techniques as well as the limitations and side effects of other analgesic techniques such as opioid analgesics and neuraxial analgesia (e.g., epidural analgesia and paravertebral blocks) [2]. Opioid analgesics are associated with a variety of severe and nonsevere side effects that limit their clinical efficacy and utility, including sedation, respiratory depression, opioid-induced hyperalgesia, tolerance and addiction, decreased gastric motility, itching, and urinary retention [3]. Epidural analgesia is limited by a significant rate of placement failure or catheter failure, the adverse sequelae of sympathetic and motor blockade, and mechanical failure, while paravertebral blocks are associated with placement failure, unreliable block distribution with single injection, the risk of pneumothorax,

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https://doi.org/10.1016/j.bpa.2019.08.001
1521-6896/

sympathetic blockade, and intravascular injection [4–6]. Additional motivation has been generated by the proliferation of minimally invasive surgical techniques, which have less tissue trauma and reduced acute postoperative pain than open surgical techniques, as well as the advent and wide use of Enhanced Recovery After Surgery programs (ERAS) [7–10]. Interfascial plane blocks assist in balancing analgesic benefit with physiological homeostasis and reducing the surgical stress response, and they are less potent than central neuraxial blockade. Interfascial plane blocks represent the minimally invasive evolution of regional anesthesia for acute pain management.

An interfascial plane block is one that targets a specific fascial plane as an endpoint for the deposition of an injectate, typically local anesthetic, such that it spreads within a potential space to affect one or more neural targets. Unlike a peripheral nerve block, multiple planar endpoints may exist for the same neural target due to the contiguous connection of fascial planes around the body [1]. The fascia is soft connective tissue made of collagen, loose and dense fibrous tissue, and surrounds all organs, muscles, bones, and nerve fibers [11]. Each fascia comprises multiple layers, and these layers represent the potential space for an interfascial plane block.

Ultrasound has revolutionized the ability to locate fascial planes throughout the body and is essential to the performance of interfascial plane blockade. This began with the application of ultrasound for the transversus abdominis plane block. Subsequent blocks including the pectoralis I and II blocks, serratus anterior plane block, erector spinae plane block, quadratus lumborum (QL) block, and rhomboid intercostal block were developed as ultrasound-only techniques. For the purposes of this discussion, an interfascial plane block is one where the neural target is typically not visualized with ultrasound. Although this distinction may be seen as somewhat arbitrary, the technical approach, block properties, and subsequent considerations may be viewed as different when there is a commonly visualized specific neural target, such as the fascia iliaca block (femoral nerve) and adductor canal block (saphenous nerve). An exception to this would be the ilioinguinal–iliohypogastric nerve block, which targets a specific nerve that is typically visualized in children [12,13]; however, it is often poorly visualized or not visualized by ultrasound in adults. Thus the ultrasound-guided approach to ilioinguinal–iliohypogastric blockade in adults is consistent with other interfascial plane blocks [14].

Potential benefits of interfascial plane blocks

Because the target plane of these blocks is superficial relative to epidural or paravertebral blockade, it is typically more easily visualized or identified and is at a significant distance away from sensitive structures such as major vasculature and organs. Because there may be limited autonomic nervous system blockade associated with some interfascial plane blocks, they are primarily somatic blocks—in contrast to epidural and paravertebral blocks, which may substantially impact the autonomic nervous system. These factors provide a measure of ease and potential efficiency of block placement. Although little has been published regarding their safety yet, because the procedures are generally performed at a significant distance from sensitive structures, they do not appear to have serious complications associated with them like neuraxial and paravertebral blockade, such as epidural hematoma, epidural abscess, and pneumothorax. In addition, interfascial plane blocks may be associated with less risk of serious bleeding complications in the presence of anticoagulation or antiplatelet therapy relative to neuraxial and paravertebral blockade because they are performed in compressible areas away from major blood vessels [15,16]. Nonetheless, there remains potential for clinically significant hematoma.

Transversus abdominis plane (TAP) block

The transversus abdominis plane (TAP) block was first described in 2001 by Rafi as a landmark technique and later by Hebbard as an ultrasound-guided technique [17,18]. It subsequently underwent numerous modifications to target specific portions of the abdominal wall or improve analgesia for a broader portion of the anterior abdominal wall. The approaches share fascial endpoints targeting the layer superficial to the transversus abdominis muscle and most often between the transversus abdominis and internal oblique muscles or transversus abdominis and rectus abdominis in the case of the subcostal TAP (see Figs. 1–3) [19]. Deposition of injectate in this plane will affect some or all of the ventral rami of thoracic nerves 7–12 and potentially the ilioinguinal and iliohypogastric nerves

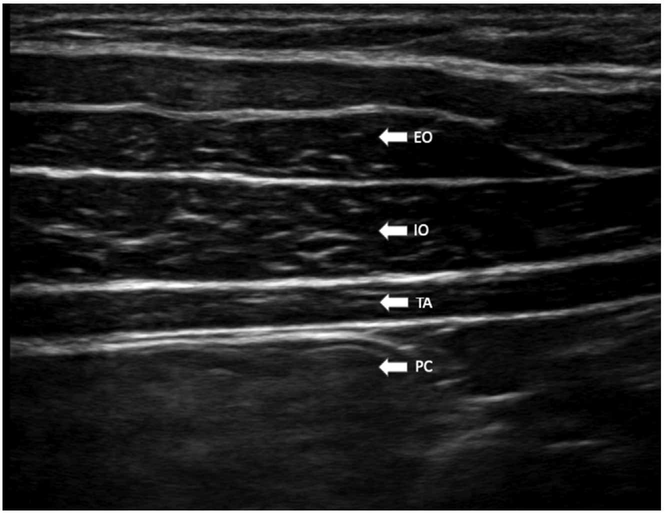

Fig. 1. Classic transversus abdominal plane block. EO = external oblique, IO = internal oblique, TA = transversus abdominis, PC = peritoneal cavity. Local anesthetic is injected between IO and TA.

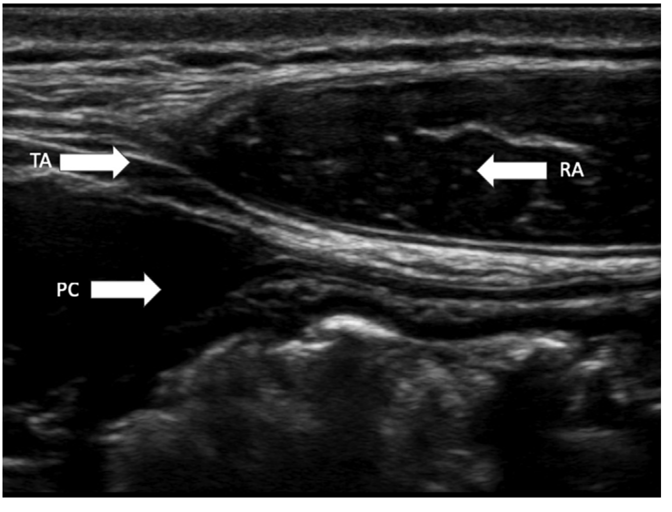

Fig. 2. Subcostal transversus abdominal plane block (medial). RA = rectus abdominis, TA = transversus abdominis, PC = peritoneal cavity. Local anesthetic is injected between RA and TA.

depending on the medial, lateral or posterior position of the injectate and whether the injection is done supraumbilical, infraumbilical or both.

To ensure blockade of all of the thoracic nerves, i.e., nerves 7–12, a four-injection site TAP block, known as the bilateral dual TAP and, later, the four-quadrant TAP block, was developed which combined a modified subcostal approach with a lateral TAP block [20,21]. Modest analgesic benefit evidenced by opioid sparing of 6–15 mg in the first 24 h, decreased pain scores in the first 24 h, and increased time to first rescue analgesia use has been found in multiple systematic reviews and many prospective randomized trials for many different types of abdominal and pelvic surgeries [22–27]. In addition, while the potential analgesic benefit often appears comparable to the benefit from wound

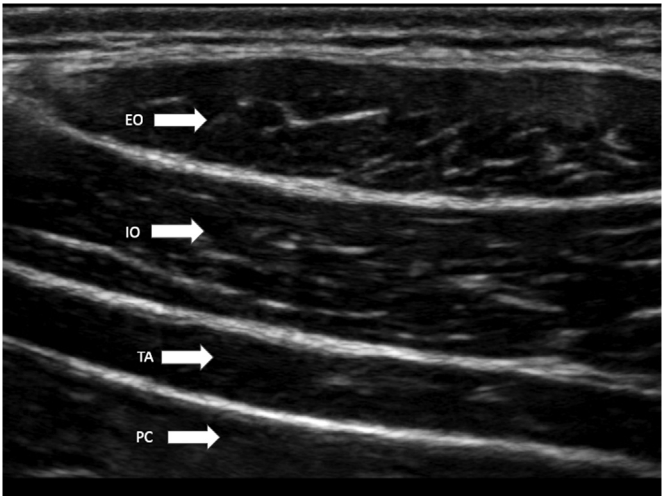

Fig. 3. Subcostal transversus abdominal plane block (lateral). EO = external oblique, IO = internal oblique, TA = transversus abdominis, PC = peritoneal cavity. Local anesthetic is injected between IO and TA.

infiltration for a variety of indications, the duration of analgesia is longer with a TAP block [28]. Two studies even found the analgesia from four-quadrant TAP combined with continuous posterior TAP catheters similar to epidural blockade—one for laparoscopic colorectal surgery and one underpowered study of major abdominal surgery [21,29]. Although several studies have reported improved pain relief with TAP blocks after laparoscopic surgery, its benefits over combination of nonopioid analgesics (e.g., paracetamol and non-steroidal anti-inflammatory drugs) and local anesthetic infiltration of trocar sites have been questioned [6,7].

While the evidence for the efficacy of TAP block is well established, methodology for some of the notable studies has been deficient [6]. Depending on the type of surgery, type of injectate, and other factors modifying perioperative pain, superior analgesia may be achieved by surgical site infiltration rather than a TAP block. This may reflect the lack of peritoneal infiltration with a TAP block, which may limit its efficacy for some indications. For example, in an investigation of TAP block with plain bupivacaine compared with surgical site infiltration with liposomal bupivacaine for open total abdominal hysterectomy in the context of a robust multimodal analgesia, Gasanova et al. found superior analgesia with surgical site infiltration [30]. However, there has not been a similar comparison published of TAP block with liposomal bupivacaine versus surgical site infiltration with liposomal bupivacaine.

Pectoralis I and II blocks

Pectoralis I and II blocks were first described in 2011 and 2012, and they target the interpectoral plane between pectoralis major and minor and the subpectoral plane below pectoralis minor combined with the interpectoral plane, respectively [31,32]. Pectoralis I block is performed in a position similar to that of an infraclavicular brachial plexus block, using the thoracoacromial trunk as a sonographic landmark, while the pectoralis II block is performed at the level of the third rib deep to or beside pectoralis minor in the axilla (see Fig. 4). By targeting these planes, the pectoralis blocks target the lateral and medial pectoral nerves, which usually arise from the lateral and the medial cord of the brachial plexus and, in the case of the pectoralis II block, the lateral intercostal nerves from T2 to T6. The deeper subpectoral plane targeted by the pectoralis II block is contiguous with that of the superficial serratus plane and may also result in blockade of the long thoracic nerve and thoracodorsal nerves [33]. The pectoralis blocks provide analgesia to the anterolateral chest and breast and have been primarily used and studied for breast surgery; however, other indications have been reported, such as ICD

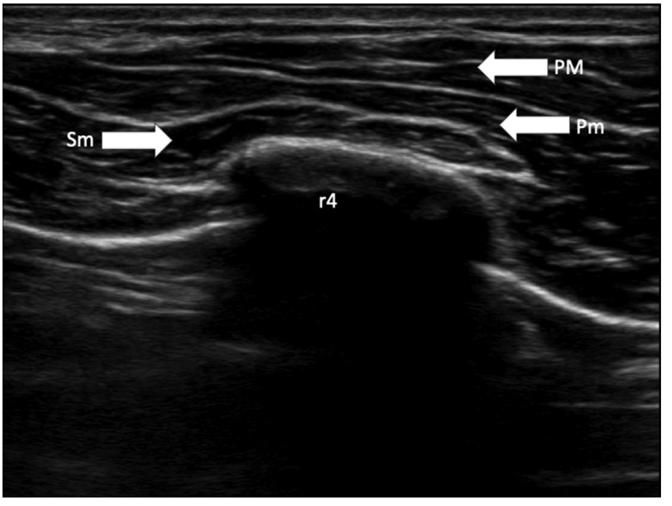

Fig. 4. Pectoralis II block. PM = pectoralis major, Pm = pectoralis minor, Sm = serratus anterior muscle, r4 = fourth rib. Local anesthetic is injected between pectoralis major and minor as well as between either pectoralis major and serratus anterior muscle or between serratus anterior muscle and the fourth rib.

implantation, minithoracotomy for minimally invasive cardiac surgery, and anterior shoulder surgery [34,35]. While the analgesic efficacy of the pectoralis I block has come into question, the pectoralis II block has been shown to provide effective analgesia for breast surgery in multiple prospective randomized trials and a meta-analysis and provides similar analgesia as that of paravertebral blockade [36–41]. In some cases, surgeons may perform the procedures intraoperatively when the surgical field is near to the interpectoral or subpectoral planes; however, there are no good studies assessing their efficacy [42].

Serratus plane block

The serratus plane block was first described in a Spanish-language medical journal in 2012 and in an English-language medical journal in 2013 [43,44]. The targets of the block are the lateral cutaneous branches of the thoracic intercostal nerves 2–6 that provide analgesia to the anterolateral chest wall and the lateral breast [45]. The serratus plane block is named for the serratus anterior muscle, which originates at the lateral surfaces of ribs 1–9 and attaches across the medial deep aspect of the scapula in a cephalad-caudad orientation. Immediately deep to the serratus muscle in the midaxillary line lie the ribs, external intercostal muscles and the intercostal nerves. Superficial to the serratus muscle in the midaxillary line is the anterolateral thoracic fascia, the lateral cutaneous branches of the intercostal nerves, the latissimus dorsi muscle, thoracodorsal vein, thoracodorsal artery, thoracodorsal nerve, and long thoracic nerve. The deep and superficial aspects of the serratus muscle form two planes, which wrap around the lateral upper thorax following the course of the serratus anterior muscle. Thus, the deep serratus plane is deep to the aponeurosis of the muscle and superficial to the ribs and external intercostal muscle. The superficial serratus plane is superficial to the muscle aponeurosis and deep to the anterolateral thoracic fascia and shares the plane of the subpectoral plane of the pectoralis II block. Both the deep and superficial planes of the serratus muscle are contiguous with adjacent fascial planes. In particular, the deep plane may be traced posteriorly to the latissimus dorsi, rhomboid, and erector spinae muscles and anteriorly to the deep pectoralis fascia. The superficial plane is adjacent to the axilla and contiguous with the anterolateral thoracic fascia, which becomes the retropectoral fascia. Multiple points of needle entry and injection targets have been described from the posterior to middle to anterior axillary lines, and deep or superficial to the serratus anterior muscle (see Fig. 5) [44,46]. Although there is no meta-analysis yet for the serratus block, a plethora of prospective randomized

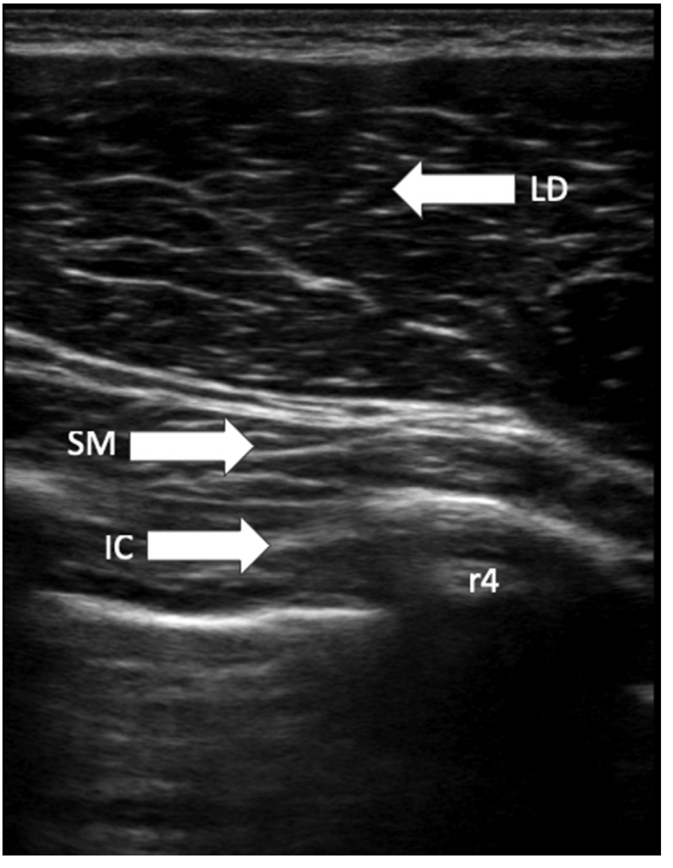

Fig. 5. Serratus anterior plane block. LD = latissimus dorsi, SM = serratus anterior muscle, IC = intercostal muscles, r4 = fourth rib. Local anesthetic is injected between either latissimus dorsi and serratus anterior muscle or between serratus anterior muscle and the fourth rib or intercostal muscles.

trials have been published in the last 2 years demonstrating analgesic benefit for breast surgery [47–50], video-assisted thoracoscopic surgery [51–53], and thoracotomy [54,55].

Erector spinae plane block

The erector spinae plane (ESP) block was first described in 2016, though a similar block, the retro-laminar block, was described in 2006 in German and in 2011 in English [56–58]. ESP was originally described as the interfascial plane that extends from the transverse process of the 5th thoracic vertebra deep to the erector spinae muscle (see Fig. 6). It has been applied subsequently throughout the length of the thoracic vertebral column at the transverse processes. This injection location permits extensive cranio-caudal spread and lateral spread toward the deep fascia of the thorax in the costotransverse region. Although it is theorized that injectate may also sometimes track medial and deep toward the paravertebral space and vertebral foramina, evidence from cadaver and radiographic imaging is lacking to substantiate this as a reliable mechanism for the analgesia associated with ESP [59,60]. Rather the mechanism may be blockade of the dorsal rami and the lateral cutaneous branches of the intercostal nerves. Given the wide cranio-caudal distribution of analgesia associated with the ESP block and diverse applications, a wide variety of postsurgical indications have been investigated with randomized controlled trials that demonstrate analgesic benefit: breast surgery [61,62], laparoscopic cholecystectomy [63], cardiac surgery [64,65], video-assisted thoracoscopic surgery [66], open epigastric repair [67], hysterectomy [68], and

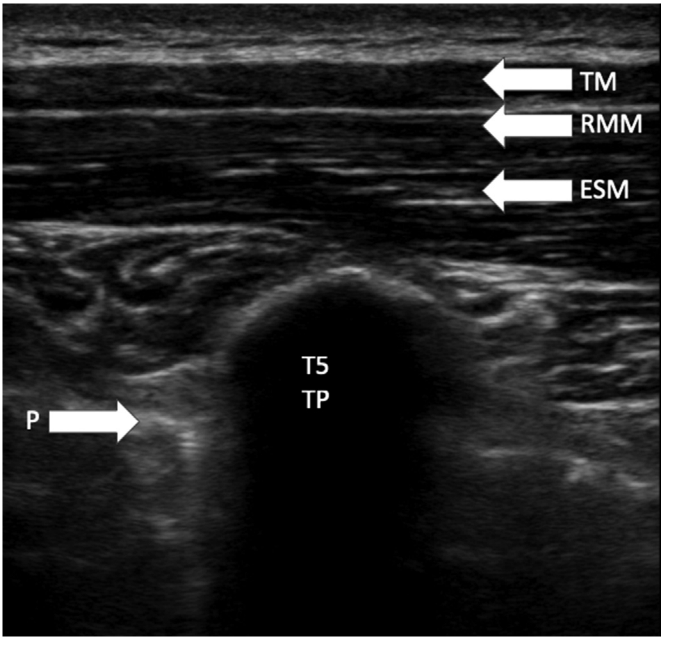

Fig. 6. Erector spinae plane block. TM = trapezius muscle, RMM = rhomboid major muscle ESM = erector spinae muscle, T5 TP = fifth thoracic transverse process, P = pleura. Local anesthetic is injected between the erector spine muscle and the transverse process.

lumbar spine surgery [69]. A far greater array of case reports for postsurgical pain of the thorax, abdomen, pelvis, and even upper extremities have been reported; however, there is no meta-analysis or systematic review of randomized trials yet. Additionally, ESP has been utilized for analgesia for trauma, such as rib fractures. Although no prospective randomized trials have yet been published for the efficacy of ESP for rib fractures, a retrospective cohort study showed improvement in pulmonary function, decreased pain, and decreased opioid consumption [70].

Quadratus lumborum (QL) block

The QL block first appeared in the literature in 2011 during investigation of the spread of a posterior TAP approach [71]. The QL is a posterior abdominal wall muscle [72]. Its origin is in the 12th rib and transverse processes of the first to fourth lumbar vertebra, and its insertion is in the posteromedial iliac crest. It is anterior to the erector spinae muscle and anterior thoracolumbar fascia and posterior to the transversalis fascia. Numerous approaches to the QL block have been reported and named variously, QL1–QL4, anterior QL, lateral QL, posteromedial QL, posterolateral QL, and posterior QL with regard to the target points' orientation to the QL muscle, leading to challenges in nomenclature and investigation (see Figs. 7 and 8) [73]. The QL block targets the ilioinguinal and iliohypogastric nerves, the ventral rami of T12-L2, and possibly more extensively spreads to as far as T5 and L5 nerve roots [74]. Depending on the approach utilized and other technical factors, analgesia may be provided to the abdominal wall, hip, and possibly other areas. Prospective randomized trials have shown benefit for cesarean section [75–77] and pediatric lower abdomen surgery [78], while case reports and case series indicate benefit for laparotomy, colorectal surgery, abdominal hernia repair, hip surgery, and above knee amputation. Owing to their deep locations, the various QL blocks are perceived to be technically more challenging and time consuming relative to other interfascial plane blocks [79]. Given their depth and proximity to organs and deeper vasculature, their full safety profile remains unclear. Moreover, spread may occur to the lumbar plexus causing motor weakness and delaying mobilization.

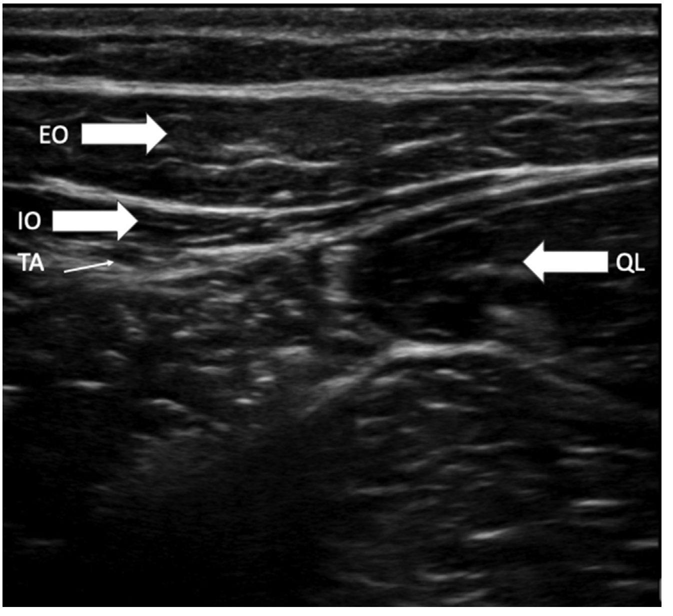

Fig. 7. Quadratus lumborum block (posterior or lateral approach). EO = external oblique, IO = internal oblique, TA = transversus abdominis, QL = quadratus lumborum. Local anesthetic is injected at the lateral border of the quadratus lumborum between the transversus abdominis and the quadratus lumborum.

Rhomboid intercostal and subserratus (RISS) block

The rhomboid intercostal and subserratus block (RISS) was also first described in 2016 [80]. It is located on the posterior chest wall at the level of the sixth and seventh ribs in the triangle of

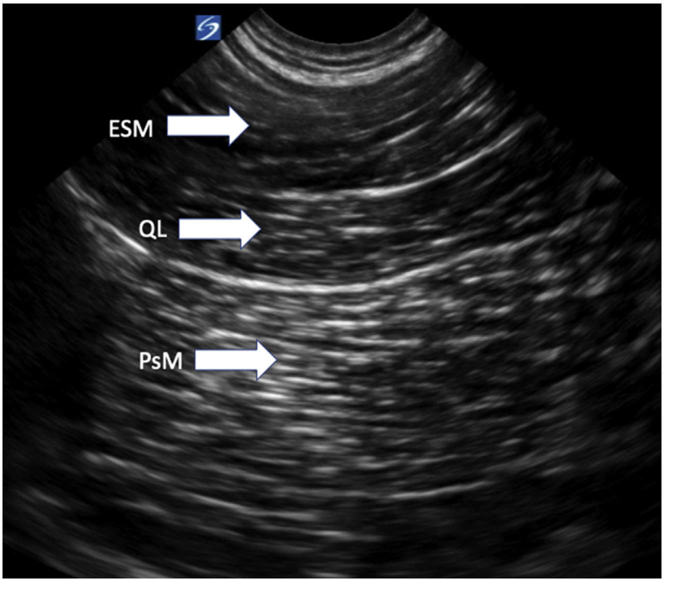

Fig. 8. Quadratus lumborum block (anterior longitudinal approach). ESM = erector spinae muscle, QL = quadratus lumborum, PsM = psoas major muscle. Local anesthetic is injected between the quadratus lumborum and the psoas major muscle.

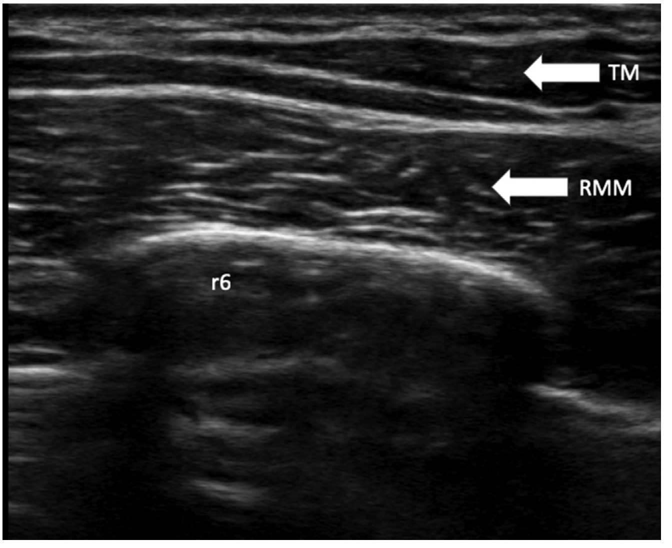

Fig. 9. Rhomboid intercostal and subserratus plane block (rhomboid intercostal portion). TM = trapezius muscle, RMM = rhomboid major muscle, r6 = sixth rib. Local anesthetic is injected between the rhomboid major muscle and the sixth rib.

auscultation, caudad to the trapezius, medial to the scapula, and cranial to the latissimus dorsi. The target interfascial plane lies between the rhomboid major and external intercostal muscle (see Figs. 9 and 10). Injection at this location spreads along the deep fascia to the subserratus plane to the lateral intercostal nerves T3-8 as well as the posterior primary rami providing analgesia to the anterior hemithorax and the posterior hemithorax [81]. No randomized controlled trials have been published yet. Cases series and case reports indicate utility for procedures of the thorax and upper abdomen, such as breast surgery, VATs, thoracotomy, lung transplant, pancreaticoduodenectomy, liver wedge resection, ventral hernia repair, and transapical transcatheter aortic valve implantation.

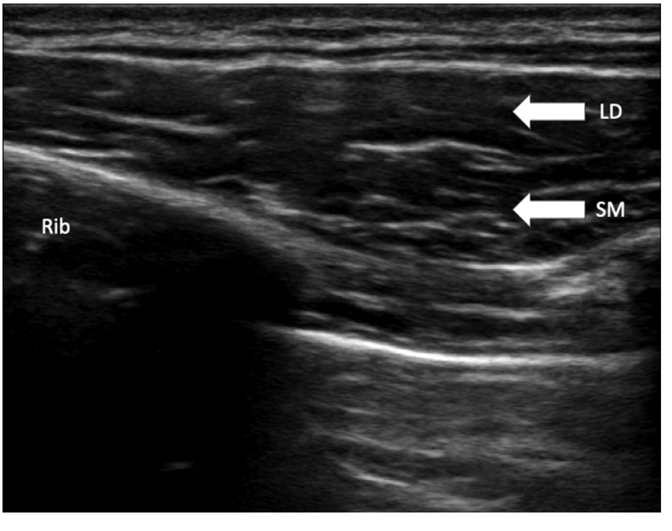

Fig. 10. Rhomboid intercostal and suberratus plane block (subserratus portion). LD = latissimus dorsi, SM = serratus muscle. Local anesthetic is injected between the serratus anterior muscle and the rib.

Summary

New interfascial plane blocks continue to emerge, revealing novel and potentially better means to provide interfascial plane analgesia. Given the multitude of different interfascial plane blocks, there is little evidence from prospective randomized controlled trials to guide the rational selection of an interfascial plane when multiple different techniques exist for the same neuroanatomical endpoints. It is suggested that ESP blocks may be superior to peripheral interfascial plane blocks (e.g., TAP blocks) because they provide somatic as well as visceral analgesia. However, these benefits need further study.

Few prospective randomized trials have been completed that compare traditional techniques such as epidural or paravertebral with interfascial block. However, when such comparisons have been done, some analgesic results appear comparable, while the resuls from other trials suggest that an interfascial plane block may provide, to some extent, inferior analgesia relative to epidural or paravertebral blockade. Given the drawbacks of the traditional approaches and the technical ease of interfascial plane blocks, many practitioners may opt in favor of interfascial plane blocks for their safety and simplicity. When combined with multimodal analgesic approaches and in the context of ERAS, interfascial plane blocks are satisfactory in providing consistent adequately efficacious analgesia in a simple manner.

It is not yet clear when to choose an interfascial plane block versus surgical site infiltration. From the available data, it is considered that interfascial plane blocks may provide a similar degree of analgesia as that of surgical site infiltration but appear to provide analgesia for a longer duration for most indications. In some instances, interfascial plane blocks may provide superior analgesia to surgical site infiltration, particularly if the surgical site infiltration is not performed in a systematic and meticulous fashion. Importantly, despite the cited published benefits, the analgesic benefit of interfascial plane blocks for perioperative pain is unclear for many minimally invasive surgical approaches when non-opioid multimodal analgesic combinations are used, such as acetaminophen and nonsteroidal anti-inflammatory medication in concert with local anesthetic infiltration of trocar sites [82].

Practice points

1. Although data are sparse, based on the current evidence, the following new interfascial plane blocks may be suggested for these indications:
   a. Breast surgery: erector spinae plane or pectoralis II or serratus plane blocks
   b. Mini-thoracotomy for minimally invasive cardiac valve surgery: pectoralis II block ± erector spinae plane blocks
   c. Thoracotomy: erector spinae plane or serratus plane blocks
   d. Open upper and lower abdominal surgery: erector spinae plane or quadratus lumborum or 4 quadrant TAP blocks
   e. Open lower abdominal surgery (e.g., hysterectomy and cesarean section): erector spine plane or quadratus lumborum or posterior TAP blocks
   f. Abdominal hernia repair: erector spinae plane or quadratus lumborum or TAP blocks
   g. Lumbar spine surgery: erector spine plane blocks
   h. Anterior Shoulder surgery: pectoralis II blocks
2. When considering which interfascial plane block to use when multiple blocks may address a given indication, consider whether the wide dermatomal distribution of an erector spinae block would work best for the given indication or, if doing a more lateral block such as quadratus lumborum or serratus plane, would better technically suit the situation.
3. If the provider desires to perform TAP blocks, the following is recommended. When providing analgesia for the entire abdomen, four-quadrant TAP blocks are recommended. When providing analgesia for just the upper abdomen, a subcostal TAP approach is recommended, and when providing analgesia below the umbilicus, a more posterior approach to the TAP is recommended.
4. There are no studies comparing surgical site infiltration with interfascial plane blocks for most blocks and indications. Evidence for TAP suggests comparable degrees of analgesia to surgical site infiltration and that TAP blocks provide significantly longer lasting analgesia.

Research agenda

1. There is an urgent need for properly designed randomized controlled comparative trials of interfascial plane blocks to epidural and paravertebral blockade as well as surgical site infiltration techniques for analgesic efficacy, functional outcomes, complications, safety, and economic impact. These studies should include simple analgesics such as paracetamol and nonsteroidal anti-inflammatory drug as basic analgesia in both the investigational and control groups.
2. Comparative trials of various interfascial plane blocks for specific surgical procedures, such as erector spine plane versus serratus plane block for analgesia for breast surgery or quadratus lumborum versus surgical site infiltration for hysterectomy.
3. Future investigations should define the optimal technique, injectate volume and dose, injection pressure, and type of medication for interfascial plane blocks.

Funding source

None.

Financial support

Girish P. Joshi has received honoraria from Baxter Pharmaceuticals and Pacira Pharmaceuticals.

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