Fascial plane blocks: a narrative review of the literature

David H Kim,[1,2] Sang Jo Kim,[1,2] Jiabin Liu,[1,2] Jonathan Beathe,[1,2] Stavros G Memtsoudis [1,2]

[1]Anesthesiology, Critical Care & Pain Management, Hospital for Special Surgery, New York, New York, USA
[2]Department of Anesthesiology, Weill Cornell Medical College, New York, NY, USA

Correspondence to
Dr Stavros G Memtsoudis, Anesthesiology, Critical Care & Pain Management, Hospital for Special Surgery, New York, New York, USA; memtsoudiss@hss.edu

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ABSTRACT

Fascial plane blocks (FPBs) are increasingly numerous and are often touted as effective solutions to many perioperative challenges facing anesthesiologists. As 'new' FPBs are being described, questions regarding their effectiveness remain unanswered as appropriate studies are lacking and publications are often limited to case discussions or technical reports. It is often unclear if newly named FPBs truly represent a novel intervention with new indications, or if these new publications describe mere ultrasound facilitated modifications of existing techniques. Here, we present broad concepts and potential mechanisms of FPB. In addition, we discuss major FPBs of (1) the extremities (2) the posterior torso and (3) the anterior torso. The characteristics, indications and a brief summary of the literature on these blocks is included. Finally, we provide an estimate of the overall level of evidence currently supporting individual approaches as FPBs continue to rapidly evolve.

INTRODUCTION

Facilitated by the rapid expansion of ultrasound availability, advances in technology and emergence of innovative techniques the field of regional anesthesia and analgesia has and continues to evolve at an accelerated pace. Regional anesthetic techniques have moved from the deposition of local anesthetic near large peripheral nerves to more peripherally conducted interventions requiring visualization and making use of neurovascular sheaths and anatomic planes. These approaches have been suggested to achieve sensory blockade without major motor involvement in the area of surgical trauma, arguably with different levels of evidence. This development is nowhere as obvious as in the area of newly described fascial plane blocks (FPBs). Indeed, the last few years have seen the emergence of a flurry of FPBs described in the literature. However, the pace of the publications of these interventions has left many clinicians confused. As 'new' FPBs are being described, questions regarding their effectiveness remain unanswered as appropriate studies are lacking and publications are often limited to case discussions or technical reports. Further, it is often unclear if newly named FPBs truly represent a novel intervention with new indications, covering different nervous distributions and providing advantages in terms of safety and efficacy; or if these new publications describe mere ultrasound facilitated modifications of existing techniques.

The purpose of this article is, therefore, to present an overview of the current state of the published literature in respect to major FPBs in the form of a narrative review. The presentation of different plane blocks does not seek to be exhaustive but discusses the most commonly performed interventions in this arena while presenting supportive evidence on the topic. In this context, we sought to first present broad concepts and potential mechanisms of FPB. Following we discuss major FPBs of (1) the extremities (2) the posterior torso and (3) the anterior torso. In the process, we will remark on a particular block's characteristics, indications, a brief summary of the literature on these blocks and where data is available on safety. We further sought to provide an estimate of the overall level of evidence currently supporting the individual approaches. Finally, we would like to indicate to the reader that the science of FPBs is rapidly evolving and we encourage to seek updates from time to time.

General concepts and potential mechanisms of action

FPBs are increasingly numerous and are often touted as effective solutions to many perioperative challenges facing anesthesiologists. Potential advantages include the increased distance between the needle and neurovascular structures, less potential for motor or hemodynamically significant autonomic blockade and avoidance of serious neuraxial complications such as hematoma or infection.

FPBs are conceptually simple. Although the principle of injecting local anesthetic between layers of muscle is basic, closer examination of fascia and associated anatomy reveal significant intricacies that are often overlooked. Parallel to the rapid growth of FPBs, multidisciplinary interest in fascia research has increased. Even a cursory review of the literature reveals a breadth of inquiry into the anatomy and function of fasciae.

Regional anesthesiologists may agree that fascia surrounds and separates musculature, but this understanding is incomplete. Embryologically, fasciae have both mesodermal and ectodermal origins. This fact underscores the difficulty in clearly delineating the boundaries of fascial tissue.[1] Precise definitions of fasciae vary greatly, but they can be divided into two categories: morphological and functional.[2] In an effort to combine alternative views and clarify terminology, a contemporary definition of the fascial system was proposed. Accordingly, fasciae are a continuum of soft, collagen-containing, loose and dense fibrous connective tissues that permeate the body. This definition incorporates anatomical elements such as adipose tissue, neurovascular sheaths, epineurium, periostea, 'and all the intramuscular and intermuscular connective tissues including endomysium/perimysium/epimysium.'[2] Clearly, the narrow concept of delivering local anesthetics between layers of muscle neglects the complexity of the fascial system and how it varies by location.

Differences in fascial layers, function and involvement with organs has been described as regional fascial variation.[3] This concept acknowledges anatomic differences at varying FPB locations that may have clinical significance. For instance, cadaveric dissections reveal that the fascia lata is independent of underlying muscle, has up to three layers and over three times the mean thickness of the pectoral fascia, which has a single thin layer.[4] It seems reasonable to hypothesize that these specific sublayers of fascia influence the distribution of local anesthetic and subsequent effects. As described by Elsharkawy *et al*,[3] the biomechanical properties of fascial tissue may also play a large role in the migration of local anesthetics. This leads to questions as to whether anesthetic depth, intrathoracic pressure or other variables such as patient position may ultimately influence block effects.

Assessing the effects of local anesthetics and adjuvants within the fascial space requires looking beyond local anesthetic surrounding a target nerve. Clearly defined nerves are often not present during ultrasound-guided FPBs, but other innervation within the fascial system merits attention. For example, evidence exists for nociceptive, proprioceptive and vasoconstrictive functions for nerve endings within the thoracolumbar fascia (TLF).[5] Fascial innervation is likely a significant contributor to proprioception, considering the abundance of mechanoreceptors such as Ruffini and Pacini corpuscles observed in the deep fascia of the upper limb.[6] Injection of hypertonic saline within the TLF also reveals that it is the most painful soft tissue of the low back, eliciting pain descriptors consistent with A-fiber and C-fiber nociception. It is likely that the TLF plays a significant role in the complex pathophysiology of low back pain, as the mechanoreceptors and nociceptors of the TLF connect to the most common nociceptive neurons in the dorsal horn (wide-dynamic range neurons).[5] Fascial innervation may also vary considerably across different FPB locations. The clinical significance of these findings remains to be determined and presents opportunity for inquiry.

Systemic effects are also at play, considering the higher local anesthetic volumes that are commonly used with FPBs. Both muscles and fascial surfaces have a potentially rich vascular supply, which facilitates systemic absorption and the risk of local anesthetic systemic toxicity.[7] This is consistent with observations that the transversus abdominis plane (TAP) block leads to significant plasma concentrations of local anesthetic.[8] It is also established that systemic absorption varies between FPB sites.[9] Considering the evidence that intravenous lidocaine may improve postoperative analgesia and recovery,[10] the systemic effects of local anesthetics administered during FPBs may also be clinically relevant. Even relatively low blood concentrations of local anesthetic may have significant beneficial effects related to nociception, ileus duration, opioid requirements and length of hospital stay.[11]

The selection of local anesthetic and the volume administered also have important clinical implications. The most commonly described local anesthetics used for FPBs are bupivacaine and ropivacaine, in concentrations ranging from 0.0625% to 0.75%. Volumes administered tend to be higher than traditional nerve blocks. For example, 15–30 mL per side in adults is commonly used for TAP blocks to facilitate the spread of local anesthetic.[12] The TAP block is one of the most frequently performed and researched FPBs, and provides some insight into the effects of local anesthetic dose and volume. For instance, there is a trend toward superior analgesic outcomes with TAP blocks performed with higher volumes (above 15 mL).[13] Additionally, the overall dose of local anesthetic appears to be more impactful on analgesic effect than either concentration or volume alone.[14] Lower opioid consumption was also observed after erector spinae block performed with higher concentration (0.375%) of bupivacaine when compared with an equivalent volume (20 mL) of lower concentration (0.25%) after radical mastectomy surgery.[15] Higher concentrations (0.5%–0.75%) of ropivacaine used for serratus anterior plane (SAP) block (SAPB) have, however, demonstrated prolongation of analgesia and superiority of postoperative analgesia as compared with lower concentrations (0.375%).[16] It is also unclear if there is a significant clinical difference between continuous basal infusions of local anesthetic as compared with intermittent hourly bolus doses.[17] Significant gaps in our knowledge remain and optimal dosing strategies continue to be poorly defined.

Table 1 Levels of evidence for therapeutic studies (adapted from Burns *et al*[18])

1a	Systematic review (with homogeneity) of RCTs.
1b	Individual RCT (with narrow CIs).
1c	All-or-none study.
2a	Systematic review (with homogeneity) of cohort studies.
2b	Individual cohort study, including low-quality RCTs (eg, <80% follow-up).
2c	'Outcomes' research; ecological studies.
3a	Systematic review (with homogeneity) of case–control studies.
3b	Individual case–control study.
4	Case series (and poor quality cohort and case–controlled study).
5	Expert opinion without explicit critical appraisal or based on physiology, bench research, or 'first principles'.

RCT, randomized controlled trial.

Level of evidence

We evaluated the quality of data available on each plane block and assigned a level of evidence as previously defined by the Centre for Evidence-Based Medicine[18,19] (table 1).

LOWER EXTREMITIES BLOCK

Pericapsular nerve group and iliopsoas Plane Block

Characteristics/anatomy

The pericapsular nerve group (PENG) block has been proposed as a motor-sparing analgesic block utilized primarily for hip surgery.[20]

The PENG block theoretically targets the articular branches of the sensory nerves that innervate the anterior hip capsule, namely the obturator nerve, accessory obturator nerve and femoral nerve.[21]Gerhardt *et al*[22] found that the anterior region of the hip joint contains the highest concentration of sensory nerves, highlighting its significance in optimizing analgesia for this area. Anatomic studies have identified landmarks that are located in the vicinity where articular branches of the femoral nerve and accessory obturator nerve travel through the pelvis. These branches are consistently positioned between the anterior inferior iliac spine (AIIS) and the iliopubic eminence (IPE) (table 2).[21,23]

Under ultrasound guidance, the probe is placed in a transverse plane over the AIIS and then rotated approximately 45° to

Table 2 Fascial plane blocks– lower extremities

Block	Technique	Comments	Clinical indications (level of evidence)	No of level 1 studies
PENG block	▶ Probe position: placed below the ASIS at 45° to align with the pubic ramus; identifying the AIIS, IPE, Iliopsoas tendon, and femoral artery. ▶ Injection site: lateral to medial, needle tip lateral and below the iliopsoas tendon. ▶ Dosing: 20–30 mL per block.	Volumes over 30 mL can potentially cause quadricep weakness.	▶ Hip fracture (3b) ▶ Hip Arthroplasty (4) ▶ Hip Arthroscopy (4) ▶ Medial thigh (4) ▶ Vein Ligation and Stripping (4) ▶ Pediatric congenital hip dysplasia surgery (4) ▶ Hip Dislocation (4)	▶ Systematic Review: 0 ▶ Meta-analysis: 0 ▶ RCT: 0
Iliopsoas plane block	▶ Probe position: sliding slightly caudad to the PENG block; identifying the acetabulum, head of femur, iliofemoral ligament, iliopsoas muscle and sartorius muscle. ▶ Injection site: lateral to medial, needle is placed between the iliofemoral ligament and iliopsoas muscle. ▶ Dosing: 5–15 mL per block.	Anatomical boundaries prohibit local anesthetic spread to the motor nerves, confining spread to the sensory nerves within the iliopsoas plane. Superiorly, the iliopsoas muscle, laterally, the rectus femoris, medially, the iliopectineal bursa. Potential for intra-articular injection.	▶ Hip Arthroplasty (4)	▶ Systematic Review: 0 ▶ Meta-analysis: 0 ▶ RCT: 0
Infrainguinal FICB (ultrasound guided)	▶ Probe position: placed transversely at the inguinal ligament. Identifying the iliacus muscle, iliopsoas muscle, fascia iliaca, femoral artery, femoral nerve. ▶ Injection site: the needle is placed in plane (lateral to medial) or out of plane (caudal to cranial) below the fascia iliaca, and above the iliopsoas muscle. ▶ Dosing: 30–40 mL per block.	Obturator nerve is often missed.	▶ Hip Fracture (1a) ▶ Hip Arthroscopy (2b) ▶ Hip Arthroplasty (1a) ▶ Knee Arthroplasty (1a)	▶ Systematic Review: 12 ▶ Meta-analysis: 11 ▶ RCT: 58
Suprainguinal Fascia Iliaca Block	Abdominopelvic: (Bullock) ▶ Probe position: longitudinally at the ASIS. Moving inferomedial, identify iliacus muscle and fascia iliaca. Rotate so cranial end points to umbilicus, and caudal end points to ASIS. ▶ Injection site: out of plane, caudal to cranial, needle tip insertion above the inguinal ligament under fascia iliaca Upper thigh (Hebbard): ▶ Probe position: parasagittal medial and inferior to ASIS, identify fascia iliaca and iliacus muscle. ▶ Injection site: 2–3 cm below the inguinal ligament, caudal to cranial in-plane insertion, advanced tip until under fascia iliaca near the deep circumflex iliac artery Upper Thigh (Desmet): ▶ Probe position: longitudinally at the ASIS. identify 'bow-tie' formed by sartorius, and iliacus muscle. ▶ Injection site: below the inguinal ligament, caudal to cranial in-plane insertion, advanced tip until under fascia iliaca near the deep circumflex iliac artery ▶ Dosing: 10–40 mL per block.		▶ Hip Arthroscopy (4) ▶ Hip Arthroplasty (2b) ▶ Knee Arthroplasty (4)	▶ Systematic Review: 0 ▶ Meta-analysis: 0 ▶ RCT:3
Adductor canal block	▶ Probe position: transverse, identify sartorius, vastus medialis, adductor longus muscles, femoral artery, saphenous nerve. ▶ Injection site: in-plane, lateral to medial, tip at anterolateral aspect of femoral artery under the vasto adductor membrane. ▶ Dosing: 15–30 mL per block.	Proximal adductor canal block with at least 10 mL covers the nerve to vastus medialis, saphenous, and posterior obturator nerve. Femoral triangle injections may cause quadricep weakness. Distal blocks will potentially spread to the popliteal plexus and sciatic nerve.	▶ Knee Arthroscopy (2b) ▶ ACL Repair (1a) ▶ Knee Arthroplasty (1a) ▶ Foot Surgery (2b)	▶ Systematic Review: 18 ▶ Meta-analysis: 22 ▶ RCT: 95
Interspace between the Popliteal Artery and Capsule of the Posterior Knee Block	▶ Probe position: transverse, identify femur, popliteal artery, tibial nerve, and common peroneal nerve. ▶ Injection site: in-plane, lateral to medial or medial to lateral, spread in between popliteal artery and femur ▶ Dosing: 10–30 mL per block.	Distal injections (at superior level of femoral condyles) spread to articulating branches of anterior and posterior capsule. Be wary of lateral spread to avoid peroneal palsy (foot drop).	▶ ACL Repair (4) ▶ Knee Arthroplasty (1b)	▶ Systematic Review: 0 ▶ Meta-analysis: 0 ▶ RCT: 2

ACL, anterior cruciate ligament; AIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine; FICB, fascia iliaca compartment block; IPE, iliopubic eminence; PENG, pericapsular nerve group; RCT, randomized controlled trial.

align with the pubic ramus. The AIIS, iliopsoas tendon, femoral artery and IPE can be easily identified. The needle is inserted lateral to medial, with the targeted end point being the musculofascial plane between the iliopsoas tendon and pubic ramus, directing local anesthetic spread from the IPE to the AIIS.[20] Volumes administered range from 20 to 30 mL of 0.25%–0.5% bupivacaine.[24 25] Of note, the ureter lies on the pelvic wall and is near the obturator nerve. Care must be taken to not advance the needle too medially to prevent iatrogenic injury to the ureter or bladder.[26]

Cadaveric dye studies have confirmed the spread of local anesthetic to the articular branches of the obturator, femoral and accessory obturator nerves.[27] However, there are currently no large randomized controlled trials (RCTs) validating its analgesic efficacy. Small studies that have administered volumes over 30 mL have described significant quadriceps weakness, likely from inadvertent spread to the femoral nerve, especially when directing the needle medial to the iliopsoas tendon.[28–30] At these higher volumes, few case reports have shown dermatomal coverage of the lateral femoral cutaneous, obturator and genitofemoral nerve.[27 28] Well-designed large studies are needed to validate if the PENG block can indeed provide reliable motor-sparing analgesia and to identify optimal volume and dosing.

An alternative block in the same fascial plane is the iliopsoas plane block (IPB).[31] The IPB is very similar to the PENG block.[31 32] However, it is targeting more distal sonographic landmarks and has a different endpoint of injection. Unlike the PENG block which targets bony landmarks (AIIS, IPE), the IPB is performed by sliding the ultrasound probe slightly distal until the acetabulum/femoral head, iliofemoral ligament (capsule) and iliopsoas muscle are identified. The needle is placed between the iliofemoral ligament and iliopsoas muscle. Care must be taken to not pierce through the capsule and enter the hip joint.

The proposed advantage of this block is that less volume (5 mL vs 20 mL) is needed to achieve similar spread to the targeted nerves.[23] Additionally, the iliopsoas muscle may theoretically provide a barrier to prevent inadvertent spread of local anesthetic to the femoral nerve, however firm evidence is lacking at this point.[31] Nielsen *et al* proposes that since the PENG block is performed more proximally, it targets higher branches of the femoral nerve proximal to the inguinal ligament, making it more susceptible for spread to the former. Nielsen *et al* demonstrated no motor blockade after administering a 20 mL IPB block in a randomized volunteer study. However, there are no large prospective studies published comparing the analgesic efficacy of the block or volume studies to support the claims of being more likely motor sparing than the PENG block.

Literature review

The literature on the PENG and IPB is very limited. The most cited publication[20] reports on five patients admitted with a fractured hip undergoing a PENG block, with all patients experiencing significantly reduced pain scores and no quadriceps weakness. As of the writing of this article, there are no RCTs that have been published on the topic. The majority of studies are case reports or case series with PENG blocks being used either alone or in combination with another regional anesthetic techniques[25 33–35] all of which suggest effective analgesia.

Future RCTs are needed to validate the proposed motor-sparing and analgesic benefits of the PENG block, alone and in combination with other blocks. Of note, there are more publications available on the PENG block than IPB.

Indications

The PENG/IPB blocks have primarily been performed for hip surgery. They have been used for hip fracture (level 3b),[20] hip arthroplasty (level 4),[36] hip arthroscopy (level 4),[24] open reduction and fixation of the hip (level 4), positioning hip fracture patients for neuraxial anesthesia placement (level 4), pediatric congenital hip dysplasia surgery (level 4)[37] and hip dislocation (level 4).

PENG and IPB blocks target the nerves that innervate the anterior capsule of the hip joint, leaving the skin, muscle and femur of the hip susceptible to pain. Achieving optimal analgesia for certain hip procedures may require blockade of multiple nerves, namely the lateral femoral cutaneous, sciatic and femoral nerve. Unfortunately, no publications are available comparing studies on PENG/IPB with other more established peripheral nerve blocks, for example, fascia iliaca or lumbar plexus.

Fascia iliaca compartment block

Characteristics/anatomy

Regarded as an anterior approach to the lumbar plexus, the fascia iliaca compartment block (FICB) targets the lateral femoral cutaneous, femoral and obturator nerves.[38] The fascia iliaca is the connective tissue layer that covers the iliacus and psoas muscles. It attaches to the iliac crest and surrounds the psoas fascia medially. The fascia iliaca compartment is the potential space between the fascia iliaca, the iliacus muscle and the psoas muscle.

There are three variants of the fascia iliaca compartment block (FICB): traditional infrainguinal (landmark approach), ultrasound-guided infrainguinal and ultrasound-guided suprainguinal.

For the traditional landmark approach to the FICB, a needle is placed 0.5 cm caudal to the point between the middle and lateral third of the line between the pubic tubercle and the anterior superior iliac spine (ASIS).[39] The ultrasound-guided infrainguinal FICB has been described by placing the probe in a transverse position inferior to the inguinal ligament in the inguinal crease, capturing the image of the femoral artery, femoral nerve, fascia iliaca, iliacus muscle and sartorius muscle.[3] The needle is placed in-plane from lateral to medial or out of plane under the fascia iliaca at the intersection of the iliacus and medial border of the sartorius muscle.

Another variant of the FICB is the suprainguinal fascia iliaca block (SIFI). For this approach, the initial needle insertion can be below or above the inguinal ligament, with the final needle tip placement superior to the latter directed to promote cranial spread. The compartment is thus accessed more proximally than when using the infrainguinal approach since the needle tip is superior to the inguinal ligament. Although the traditional landmark approach may direct spread cranially, the final location of the needle tip is posterior to the inguinal ligament.[40] Several techniques for the SIFI block have been described. Two approaches start in the upper thigh, inferior to the inguinal ligament,[40 41] and one originates in the abdominopelvic region, superior to the inguinal ligament[42]; however, all approaches end with the needle tip superior to the inguinal ligament leading to cranial spread above the iliacus muscle, thus suggesting that the different descriptions of performance constitute essentially the same block.

Hebbarb *et al* described a parasagittal in plane approach. Here, the probe is placed over the inguinal ligament, medial to the ASIS and oriented in the parasagittal plane. The needle is inserted 2–3 cm inferior to the inguinal ligament,[40] advancing it beneath the fascia iliaca and cephalad to the inguinal ligament, at the level of the deep circumflex iliac artery. Alternatively, using the out of plane Bullock approach,[42] the probe is placed superiorly and medially to the ASIS, to identify the iliacus muscle and ASIS. The probe is then rotated in a line between the umbilicus and the ASIS, to identify the internal oblique muscle, transverse abdominus muscle and fascia iliaca overlying the iliacus muscle. The needle is introduced superiorly to the inguinal ligament, until the tip is posterior to the fascia iliaca. Desmet *et al*[41] describe an in-plane 'bow-tie sign' approach. The probe is positioned longitudinally at the level of the ASIS. The iliacus muscle and fascia iliaca are identified by moving the probe in an inferomedial direction. A 'bow-tie sign' is formed by the inguinal ligament serving as the knot, dividing the sartorius and iliacus muscles. Approximately 1 cm inferior to the inguinal ligament, the needle is inserted and advanced cephalad in plane until it is located under the fascia iliaca at the level of the deep circumflex iliac artery. Since the needle tip placement using all approaches is above the inguinal ligament near the deep circumflex iliac artery, with directed cranial spread, it is unlikely that the different approaches would lead to different results; however, future comparative studies between the different SIFI approaches are needed to confirm this assumption.

Using the landmark approach, local anesthetic spread has been demonstrated to be variable and not block all three nerves in more than one third of patients.[43] Dolan *et al* showed that the ultrasound-guided out-of-plane infrainguinal approach directing spread cephalad improved complete loss of sensation compared with the landmark approach (47% vs 82%).[44] However, Shariat *et al*[45] using an in-plane infrainguinal approach directing needle spread from lateral to medial showed variable block success, with only 31% (vs 90%) lateral femoral cutaneous, 38% (vs 92%) femoral and 25% (vs 95%) obturator nerves blocked. An MRI study by Swenson *et al*[46] demonstrated that local anesthetic placed with an ultrasound-guided infrainguinal FICB technique consistently produced spread to the lateral femoral cutaneous and femoral nerves but not to the obturator nerve. It is likely that the out of plane infrainguinal, caudal to cranial needle trajectory, with high volumes achieves greater block success. The transverse in-plane ultrasound guided infrainguinal approach might spread medially and have limited cranial spread, rendering it less effective. This may explain the conflicting results seen with fascia iliaca blocks when used for hip surgery. Further studies are clearly needed to compare the landmark and ultrasound guided infrainguinal approaches (out of plane vs in plane) to elucidate optimal needle insertion, direction of spread and volume needed to achieve maximal success.

The suprainguinal approach has been suggested to effectively block the lateral femoral cutaneous nerve, femoral nerve and obturator in cadaveric, imaging and clinical studies when volumes over 40 mL are used.[38 40 42 47]

The infrainguinal approach is believed to have limited cranial and medial spread. Medially, the spread to the obturator nerve might be limited due to the barrier formed by the iliopectineal fascia.[48] Studies demonstrate that the SIFI may lead to more consistent spread under the fascia iliaca and around the psoas muscle compared with an infrainguinal approach.[47]

Being a FPB, higher volumes may be needed to reliably spread local anesthetic to the targeted nerves. By injecting superior to the inguinal ligament, local anesthetic spreads to the lateral femoral cutaneous nerve as it courses down the iliacus muscle before it divides into three nerves distally under the inguinal ligament, resulting in a wider coverage of the lateral and anterior thigh.[49] The suprainguinal approach theoretically improves block success as the cranial spread more consistently blocks the targeted nerves, as they are more topographically closer in their proximal course.[40] However, given the large volume needed to achieve reliable spread to the obturator nerve,[41] a reduced concentration of local anesthetic is recommended to decrease the risk of local anesthetic toxicity.

Literature review

At the time of writing we identified 7 systematic reviews,[50] 3 meta-analyses[51] and 22 RCTs published in respect to infrainguinal FICB for hip fractures, which mostly show it to be effective in controlling peri-operative pain. One systematic review, 6 meta-analyses and 22 RCTs in respect to infrainguinal FICB for hip arthroplasty, largely show it to be effective in providing pain control. Additionally, one systematic review, three meta-analyses and five RCTs evaluating infrainguinal FICB for knee arthroplasty, suggest effective pain control. There are no systematic reviews or meta-analyses on infrainguinal FICB for hip arthroscopy, but five RCTs which suggest it be similarly effective compared with lumbar plexus,[52] or inferior to LIA[53] in providing analgesia. Mixed results were found for the infrainguinal FICB in the setting of hip arthroscopy procedures where pain control was not improved in one study.[54]

There are four RCTs (suprainguinal fascia iliaca vs no block),[41] suprainguinal fascia iliaca versus periarticular injection,[55] suprainguinal fascia iliaca vs infrainguinal fascia iliaca,[56] suprainguinal fascia iliaca versus sham block[54] as well as several retrospective and cadaveric studies, case reports and case series on SIFI. There are no systematic reviews or meta-analyses available. When comparing SIFI versus no block in hip arthroplasty patients, a significant reduction in morphine consumption was found.[41] In an investigation comparing SIFI to PAI in the same patient group, SIFI was associated with similar pain relief but more quadriceps weakness than PAI.[55] A study comparing SIFI versus infrainguinal fascia iliaca showed SIFI to be associated with superior postoperative analgesia and less morphine consumption.[56] Compared with sham blocks, SIFI with an intraarticular local anesthetic injection in hip arthroplasty patients did not improve pain control but caused quadriceps weakness.[54] There are no volume or dosing studies demonstrating effective analgesia while sparing quadricep strength. However, higher volumes (40 mL) have been shown to provide effective analgesia at the expense of significant muscle weakness.[41 56] Heterogeneity of evidence may be attributed to the difference of techniques (infrainguinal vs suprainguinal, landmark vs ultrasound guided) and spread (cranially vs transversely). Future studies comparing these different techniques and variable volumes are needed to help clarify which approach and dose is superior.

Indications

The infrainguinal FICB has been proposed to provide analgesia for hip and knee surgeries. The infrainguinal FICB has been used in the setting of hip fracture (level 1a), hip arthroscopy (level 2b),[52 54] hip arthroplasty (level 1a)[57] and knee arthroplasty (level 1a).[58]

The SIFI has been used for hip arthroscopy (level 4),[59] hip arthroplasty, (level 2b)[55] and knee arthroplasty (level 4).[60]

Adductor canal block

Characteristics/anatomy

The adductor canal block (ACB) is a motor-sparing block for knee and foot surgery. The adductor canal is formed by the sartorius muscle superficially, vastus medialis muscle anterolaterally, and the adductor longus and adductor magnus muscle posteromedially.[61] It extends from the apex of the femoral triangle to the adductor hiatus, roofed by the vastoadductor membrane. The ACB targets several essential nerves that mediate knee pain: the nerve to the vastus medialis (NVM), the saphenous nerve (SN) and the posterior obturator nerve (PON).[61] The SN and the NVM supplies genicular branches to the anteromedial knee capsule, which is important for surgery involving the medial region of the knee.[62] The posterior branch of the obturator nerve supplies genicular branches to the posterior capsule of the knee.[63]

There are four variants and approaches to the ACB: femoral triangle, proximal, mid and distal. Much debate regarding the optimal location and volume to maximize analgesia while preserving quadricep strength has taken place. Traditionally, surface landmarks[64] have been used; but recently, the use of sonographic imaging is redefining ACB approaches. Recent literature suggests that the redefined proximal ACB approach provides optimal pain relief and spares motor function. The most widely accepted approach to the ACB was first described by Lund *et al*,[64] using the surface landmarks of approximately the midpoint between the ASIS and the base of the patella. This approach has been shown to provide superior analgesia than the more distal approaches.[65–67] However, controversy arose after Wong *et al* discovered via ultrasound that these 'proximal' ACB blocks were actually performed at the level of the apex of the femoral triangle. Using ultrasound, the proximal end of the adductor canal can be identified where the medial borders of the sartorius and adductor longus muscles intersect.

Using sonographic instead of surface landmarks, the approaches to the ACB are being reexamined. Abdallah *et al* used the sonographic position of the femoral artery to the sartorius muscle to define proximal (femoral artery medial to the sartorius), mid-(femoral artery posterior to the sartorius), and distal (femoral artery lateral to the sartorius) approaches. In their comparison study to identify the optimal location for injection, the authors determined that the proximal approach was associated with decreases in opioid consumption and preservation of quadriceps function compared with the mid or distal techniques in patients undergoing anterior cruciate ligament reconstruction (ACLR). Distal injections are unable to reach the infrapatellar branch of the SN, medial femoral cutaneous nerves and the medial vastus nerve. Both, the surface landmark based femoral triangle and sonographic proximal adductor canal approach have proved most effective in providing analgesia and preserving motor function.[65–67]

Cadaveric dye studies have confirmed that the adductor canal and femoral triangle are connected.[68] Injections in the proximal adductor canal lead to cranial spread to the apex of the femoral triangle, reaching the NVM and medial cutaneous femoral nerve and vice versa. Injections at the apex of the femoral triangle spread distally into the canal.[69] Recent studies have compared proximal adductor canal to femoral triangle catheters and showed no differences in analgesia, functional mobility and opioid consumption.[70]

The femoral triangle houses the motor branches of the femoral nerve proximally and the SN, NVM and the medial femoral cutaneous nerve distally at its apex. Theoretically blocking all these nerves would provide pain relief to the anteromedial aspect of the patella but cause significant quadriceps weakness. To avoid the latter, volumes achieving adequate spread to the adductor canal and distal femoral triangle without spreading proximally to the motor branches of the femoral nerve have been advocated. Jæger *et al*, using the Lund surface landmark approach, suggested that the volume needed for spread throughout the entire adductor canal with little proximal spread into the femoral triangle was 20 mL.[69]

Injecting large volumes (>30 mL) in the apex of the femoral triangle has been associated with spread to the femoral nerve and significant quadriceps weakness.[71] Hence, the optimal approach appears to be the proximal ACB,[65] 'redefined' by ultrasound as the location where the femoral artery is medial to the sartorius muscle. The importance of this approach lies in the fact that an injection at the level near the apex of the femoral triangle allows proximal spread to the NVM, medial femoral cutaneous nerve, SN and some spread to the posterior obturator branch. Similarly, an injection at the mid- and distal level of the adductor canal (defined as the point where the femoral artery is posterior or lateral to the sartorius muscle) may reach the obturator branch but may have limited spread to the NVM.[71]

Literature review

At the time of writing of this article, there were 19 systematic reviews, 23 meta-analyses and over 100 RCTs in respect to the efficacy of ACB blocks. Several studies support that the ACB can facilitate early ambulation without sacrificing pain control when compared with FNB.[72] However, some studies suggest that ACB provides only modest analgesic benefit for knee surgery.[73]

There are six systematic reviews[74] and eight meta-analyses[75] comparing ACB to FNB suggesting the former to be the better alternative for total knee arthroplasty (TKA) patients. This conclusion is based on the observation of improved functional recovery profiles via the preservation of quadriceps muscle strength without compromising pain control.

There are three systematic reviews and two meta-analyses comparing ACB to FNB for ACLR that present conflicting conclusions. Two systematic reviews of level 1 RCTs with 442 to 655 patients showed preserved motor strength while providing similar analgesia.[76 77] One systematic review with 10 RCTs encompassing 714 patients suggested modest analgesic benefits that are not different than placebo or FNB, suggesting a limited role for both blocks for the ACLR. This finding lead the authors to offer only a weak recommendation for its use for ACLR.[78]

There are four systematic reviews and seven meta-analyses on ACB and local infiltration analgesia or periarticular injection in the setting of TKA. No definitive conclusions are available from the review of these publications. Studies comparing ACB to periarticular injections show mixed results.[79 80] One meta-analysis[81] favors periarticular injections over ACB in regard to postoperative pain scores and opioid consumption. A second meta-analysis comparing ACB with PAI for TKA suggested ACB to be associated with less opioid consumption.[82] Studies comparing ACB with periarticular injections versus periarticular injections alone showed no difference in the ability to ambulate, but suggested better pain relief in the combination group.[83–86] Systematic reviews[87] and meta-analyses[88] suggest a synergistic effect with the addition of ACB, leading to improvement in pain control and ambulation.

Interestingly, a Cochrane database systematic review[73] of 25 RCTs (18 TKA, 7 knee arthroscopy) conveyed that there is uncertainty regarding the benefits of ACB compared with a sham block or FNB for postoperative pain treatment after knee surgery. The overall evidence cited for the use of ACB for analgesia after knee surgery was mostly low or very low. Thus, further research in this field was suggested. One explanation for the conflicting results published includes the variable ACB approaches (proximal vs mid vs distal) used in the studies are not differentiated when being included in a systematic review. Given the recent support for the proximal ACB, future reviews might focus only on these approaches.

Indications

The ACB is most commonly used for surgery on the knee and foot. It has been used for knee arthroplasty (level 1a),[72 89] anterior cruciate ligament repair (level 1a),[65] knee arthroscopy (level 2b), quadriceps tendon repair, open reduction and fixation of the patella, meniscal surgery and ankle surgeries that require blockade of the SN distribution (level 2b, usually in combination with a sciatic nerve block).[90]

Interspace between the popliteal artery and posterior capsule of the knee

Characteristics/anatomy

The interspace between the popliteal artery and posterior capsule of the knee (IPACK) is a relatively novel block for knee surgery. It is used as a motor-sparing alternative to the sciatic nerve block for posterior knee pain.[91 92] Cadaveric studies have shown that it theoretically targets the 12 articular branches of both the anterior and posterior knee capsule.[93–95] Depending on the location and volume of injection (distal vs proximal IPACK),[96] several of these 12 articular branches are blocked.

Since its first description by Sinha,[97] several variations of the location of needle placement have been reported. There are three variants of the IPACK block: proximal, distal and intercondylar. The ultrasound probe is placed transversely at the level of the femoral shaft (proximal IPACK), immediately superior to the femoral condyles (distal IPACK) or in between the condyles (intercondylar IPACK). Sinha[97] describes the proximal IPACK injection as 1–2 fingerbreadths above the superior edge of the patella, along the shaft of the femur. Kim *et al*,[98] Niesen *et al*[95] and Thobhani *et al*[92] describe the distal IPACK injection by sliding the ultrasound probe from the popliteal crease cranially until the medial and lateral femoral condyles disappear and the shaft of the femur is visible. Kampitak *et al*[99] describe the intercondylar 'distal' IPACK injection by sliding the ultrasound probe distally until the tibial nerve is visualized above the popliteal artery and the needle is placed in between the femoral condyles.

For either location of injection, the needle can be placed in a medial to lateral direction or vice versa, using an in-plane approach after identifying the femur, popliteal artery, and sciatic/common peroneal (CPN)/tibial nerve. The targeted plane of the infiltration is between the posterior wall of the femur and the popliteal artery. The nerves of the tibial and CPN are located superficially and laterally to the popliteal artery. Care must be taken to avoid needle trauma to these nerves. The needle is advanced past the midline of the femur, lateral to the popliteal artery and the injection is performed ensuring that the spread reaches the lateral and medial edges of the femur, while keeping the CPN in view as one injects laterally. This is important as to avoid spread of injectate to the CPN potentially resulting in a postoperative foot drop. Volumes used for the IPACK range from 20 to 30 mL with a concentration of 0.25%–0.5% of bupivacaine.[96 98 99]

A cadaveric dye study by Tran *et al*[94] showed the spread of distal and proximal injections with 10 mL of dye. Distal injections spread to most of the genicular nerves that innervate the posterior capsule and the anterolateral capsule. The proximal injection spread to some of the genicular nerves that innervate the posterior and the anteromedial capsule. A recent RCT by Kampitak *et al*[99] comparing distal IPACK, intercondylar IPACK, and tibial nerve blocks, using 20 mL of 0.25% levobupivacaine with 1:200 000 epinephrine, demonstrated that the intercondylar IPACK preserved motor function of the CPN while maintaining effective posterior knee analgesia. The intercondylar IPACK provided better posterior pain control than the distal group, possibly by covering more articulating nerves than the latter approach. Future studies using various volumes will help elucidate if the differences found among intercondylar, distal and proximal injections persist at higher injectates.

Literature review

There are no systematic reviews or meta-analyses on this topic to date. A paucity of RCTs exists. In the few available RCTs, IPACK was added to the ACB[100] or to the combination of a periarticular block and an ACB for TKA.[96] In both studies, pain scores were improved on the day of surgery without affecting motor function. In another RCT, IPACK was compared with tibial nerve block in TKA recipients.[99] The authors reported preserved sciatic motor function while maintaining effective pain relief on postoperative Day (POD) 1. Several retrospective studies support the additive analgesic benefits of the IPACK block when added to a multimodal regimen for TKA,[91 101–103] significantly reducing opioid consumption on the day of surgery, improving rehabilitation and leading to earlier discharges. One study noted two transient foot drops out of 166 patients[98] that resolved on POD 2.

A case series showed IPACK block augmented analgesia for ACLR. There are no RCTs, prospective or retrospective studies on the utility of IPACK for ACLR.

Indications

The IPACK is used to provide analgesia for posterior knee pain (posterior capsular or bony involvement). It has been used for knee arthroplasty (level 1b), and anterior cruciate ligament repair (level 4).[96 98 104]

POSTERIOR TRUNK BLOCKS

Erector spinae plane block

Characteristics/anatomy

The erector spinae plane block (ESP) has received significant attention in recent years and is being actively explored for its utility in various surgical settings. It was first described by Forero *et al* for the treatment of thoracic surgical pain.[105] The erector spinae muscles is formed by the spinalis, longissimus thoracis and iliocostalis muscles. The ESP block is usually performed by depositing local anesthetics in the fascial plane deep to the erector spinae muscles, while the needle targets the tip of the transverse process of the vertebra. The muscle fibers of these erector spinae muscles are primarily vertically oriented and thus the distribution of local anesthetics is more likely to spread in a cranio-caudal pattern. Although the exact mechanism of action is unclear, it is generally believed that local anesthetics block the ventral and dorsal ramus of the spinal nerve. Early cadaveric studies indicated spread of local anesthetics in the intercostal and paravertebral space.[106–108] However, other cadaver studies also reported lateral spread.[109 110] A recent study in patients indicated that thoracic ESP injectates consistently spread along the erector spinae muscles, neural foramina and intercostal space when ESP was performed at the T10 level.[111] Bang *et al* described a case in which lateral spread from T2 to T12, and anterior spread to the costotransverse ligament was seen after a bolus injection of 30 mL through a catheter placed at T5.[112] In the lumbar area, authors indicated that after injection at the L4 level, local anesthetic was seen spreading into the paravertebral, foraminal, and partially into the epidural space (table 3).[113]

ESP blocks are usually performed under ultrasound guidance. The described locations of injection sites also vary significantly, spanning from T2 to L4 depending on the surgical procedure.[114] The probe is first placed in a transverse orientation at the midline of the spine to identify the spinous processes. It is then moved laterally until the transverse processes are visualized. The probe can be maintained in this orientation or rotated 90° for an out of plane approach. The needle insertion is usually performed in a cranio-caudal or caudo-cranial direction. The

Table 3 Fascial plane blocks—posterior trunk

Block	Technique	Comments	Clinical indications (level of evidence)	No of level 1 studies
Erector Spinae Plane Block	▶ Probe position: Placed in a transverse orientation at the midline of the spine to identify the spinous processes. It is then moved laterally until the transverse process are visualized. ▶ Injection site: T2–L4 depending on surgical procedures. ▶ Dosing: 15–30 mL per block.	Some authors argue that ESP blocks could be considered among anticoagulated or coagulopathic patients.	▶ Thoracic wall (level 1a) ▶ Breast (level 1a) ▶ Cardiac (level 1b) ▶ Thoracolumbar spine (level 2b) ▶ Upper or lower abdominal surgeries (level 1a) ▶ Urological (level 4) ▶ Gynecological procedures (level 4) ▶ Hip and knee surgeries (level 4)	Total publications: 540 ▶ Systematic Review: 36 ▶ Meta-analysis: 4 ▶ RCT: 16
Rhomboid intercostal and subserratus plane block	▶ Probe position: placed in transverse orientation lateral to the midline of the spine. Slide to identify the plane between the rhomboid and intercostal muscles, while deep to the scapula and serratus anterior muscles. ▶ Injection site: T6/7 level, with expected T3–T9 coverage of the lateral cutaneous branches of the intercostal nerves. ▶ Dosing: 30 mL per block	There is one case report which described an alternative injection site at T3/4 level for mastectomy surgery coverage.	▶ Breast surgery (4) ▶ Thoracic surgery (4) ▶ Rib fractures (4)	Total publications: 10 ▶ Systematic Review: 0 ▶ Meta-analysis: 0 ▶ RCT: 0
Quadratus lumborum block	▶ Probe position: patient could be either in lateral or supine position. Convex probe is placed in a transverse, oblique orientation at the L2 level to identify the QL muscle. ▶ Injection site: ▶ QL1/posterolateral approach with injection in the area where the QL comes into contact with the transversalis fascia. ▶ QL2/posteromedial approach with injections performed between the posterior QL and medial lamina of thoracolumbar fascia ▶ QL3/anterior approach with injections performed in front of the QL at the level of its attachment to the transverse process of L4 vertebra ▶ QL4/intramuscular injection ▶ Dosing: 20–30 mL per block	None of these four approaches has been shown to be superior to another. It is generally believed to cover the T10–L3 dermatome distribution.	▶ Abdominal surgery (level 1b) ▶ Cesarean section/hysterectomy (level 1a) ▶ Prostatectomy/ kidney surgery (level 1b) ▶ Laparoscopic gynecologic surgery (level 1b) ▶ Laparoscopic colectomy/ cholecystectomy (level 1b) ▶ hip surgery (level 1b).	Total publications: 258 ▶ Systematic Review: 33 ▶ Meta-analysis: 7 ▶ RCT: 28

ESP, erector spinae plane; RCT, randomized controlled trial.

essential concept of ESP is that the local anesthetic should be deposited deep to the erector spinae muscles and at the tip of the transverse process of the vertebra. ESP blocks are commonly performed with 15–30 mL of local anesthetic on the side of the surgery with maximum local anesthetic volume limited by safe dosing standards.

Literature review

At the time of writing there were more than 500 publications on ESP, including 36 systemic reviews, 4 meta-analyses, 16 RCTs and many more case reports. Systematic reviews and meta-analyses strongly support a postoperative analgesic benefit of ESP for up to 24 hours when compared with no block in thoracic surgery,[115–117] breast surgery[118–120] and abdominal surgery.[116] There are also reported applications of ESP in spine surgery, but with evolving evidence regarding efficacy.[116 121]

Among the RCTs, the studied surgical patient cohorts include thoracic surgery,[105 122] breast surgery,[123–127] cardiac surgery[128 129] and laparoscopic cholecystectomy.[130]

In comparison to other regional techniques, ESP has been suggested by some to provide comparable analgesic efficacy to paravertebral blocks,[131] and superior analgesia compared with serratus plane (SP) blocks[132] for thoracic surgical patients. For breast surgery, the efficacy of ESP has been reported to be similar to[133 134] or inferior to[135] paravertebral blocks. In addition, ESP has been shown to be inferior in opioid consumption to pectoral nerve block,[124 136] and comparable to SAPB[137] after breast surgery. Equivalent outcomes between ESP and thoracic epidural analgesia (TEA) among cardiac surgical patients have been reported.[129] Although data are limited, ESP has been suggested to be superior to TAP block after laparoscopic cholecystectomy surgery,[123] and to have similar analgesic benefits compared with quadratus lumborum block (QLB) for lower abdominal surgery.[138]

Indications

Indications for the ESP block include surgery on the thoracic wall (level 1a), breast (level 1a), cardiac (level 1b), thoracolumbar spine (level 2b), upper or lower abdominal surgeries (level 1a), urological (level 4), gynecological procedures (level 4), as well as hip and knee surgeries (level 4).

Rhomboid intercostal and subserratus plane block

Characteristics/anatomy

Rhomboid intercostal and subserratus plane block (RISB) was first described by Elsharkawy et al in 2016 as a single injection at the T6–T7 level between the rhomboid major and intercostal muscles with T2-9 spread, named rhomboid intercostal block (RIB).[139] The same group further published cadaveric and clinical evaluations of this technique in 2018 named RISB, which involved one injection at T5–T6 level medial to the scapula between the rhomboid major muscle and the intercostal muscles with the second injection of an RIB but directed caudally and laterally beyond the inferior angle of the scapula.[140] A case report including five patients receiving RIB for thoracotomy reported low visual analog score (VAS) scores for 48 hours.[141] Additionally, one case report which described an alternative injection site at T3/4 level for mastectomy surgery, suggested satisfactory analgesia and limited caudal distribution[142] It is noteworthy that the authors did not observe T1 dermatome coverage with the injection at T3/4 level.

Literature review

There are no RCTs published evaluating the efficacy of RISB. The available literature consists of case reports or case series.

Indications

The RISB has been described for breast surgery (level 4), thoracic surgery (level 4) and the analgesic treatment of rib fractures (level 4).

QL block (3–4 different types)

Characteristics/anatomy

The QL muscle originates form the posteromedial iliac crest and inserts into the twelfth rib and transverse processes of the first to fourth lumbar vertebrae. It lies anterior to the erector spinae muscle, and posterolateral to the psoas muscle. The surrounding TLF is multilayered, and thus, the exact distribution pattern of local anesthetics during QLB is ill defined. This uncertainty lead to the development of several QLB with different emphasis: the QL1/lateral approach with injection in the area where the QL comes into contact with the transversalis fascia, the QL2/posterior approach with injections performed between the posterior QL and medial lamina of TLF, the QL3/anterior approach with injections performed anterior to the QL at the level of its attachment to the transverse process of the L4 vertebra, and finally the QL4/intramuscular injection.[143–145] None of these approaches has consistently been shown to be superior over another, although some differences have been reported in the literature. It is generally believed to cover the T10–L3 dermatome distribution.

Cadaveric studies of the QL indicate that anterior QLB injections are able to cover the femoral nerve, lateral femoral cutaneous nerve, and ilioinguinal/iliohypogastric nerve,[146] while the posterior QLB approach can lead to a more cranial spread.[147]

The techniques of QLB vary with most being performed either in the lateral or supine position. A low frequency convex probe is usually placed in a transverse, oblique orientation at the L2 level to identify the QL muscle. A needle is then inserted into the target fascial plane according to various QLB concepts. The typical volume of injectate is 20–30 mL of local anesthetic.

Literature review

There are over 200 QL related publications at the time the writing of this article with mostly positive outcomes reported. There are 33 systematic reviews, 7 meta-analyses and 28 RCTs. Systematic reviews and meta-analyses suggest analgesic benefit of QL for up to 24 hours postoperatively in cesarean delivery[148–153] when compared with systemic analgesia. However, parturients receiving intrathecal morphine may not receive any additional benefit from QL.[150] QL has been reported to provide analgesia after renal surgery,[149] be possibly opioid sparing in hip surgical patients[148 149] and have some benefit in laparoscopic colectomy, laparoscopic gynecologic surgeries and abdominoplasties.[143 149]

It seems that there might be minor subgroup differences according to block approaches.[149 151] The posterior QLB has been suggested to exhibit analgesic benefits beyond 12 hours, while analgesia duration associated with lateral QLB may be shorter. The anterior QLB is conceptually more similar to a lumbar plexus/psoas compartmental block.[151] However, studies on QLB reported conflicting outcomes across various surgical procedures, and the difference in QLB approaches are likely contributing to this heterogeneity .[151] The most consistent supporting evidence for QL exists for cesarean delivery, while this superiority can be negated with the use of intrathecal morphine. Literature on the effect of QLB in other surgical procedures remains controversial.

In comparison to other regional analgesic approaches, the QLB may be comparable or superior to the TAP block depending on the publication[154 155] in providing analgesia for cesarian deliveries and abdominal surgery.[125 156–159] When compared with ESP, QLB may provide similar analgesic benefits in pediatric patients after lower abdominal surgery.[138] In one RCT, the QLB was not superior to systemic lidocaine for postoperative analgesia after laparoscopic colorectal surgery.[160]

Indications

The QLB is indicated for abdominal surgery (level 1b), cesarean section/hysterectomy (level 1a), prostatectomy/ kidney surgery (level 1b), laparoscopic gynecologic surgery (level 1b), laparoscopic colectomy/cholecystectomy (level 1b) and hip surgery (level 1b).

ANTERIOR TRUNK BLOCKS

Transversus abdominis plane block

Characteristics/anatomy

Rafi first reported the idea of performing an anatomy-based regional anesthetic block for anterior abdominal surgeries in 2001.[161] Initially described as the regional abdominal field infiltration technique, the approach was designed to provide sensory blockade of the anterior abdominal wall by instillation of the local anesthetic in the plane between internal oblique and transversus abdominis muscles.[161] Subsequently, Hebbard *et al*[162] proposed an ultrasound-guided block by directly visualizing the needle and the local anesthetic injection in the TAP (lateral approach). Since then, a plethora of RCTs, systematic reviews and meta-analyses have been published that examined: the efficacy of different TAP block approaches (subcostal, lateral, posterior) in patients undergoing various abdominal surgeries, the comparison of TAP blocks with newly emerging abdominal blocks, the role of adjuvants in respect to block duration and its safety profile. Compared with the newly emerging FPBs, there exist many expert narrative reviews with clinical recommendations for the TAP block, most notably from Tran and *et al*[163] and Chin *et al*.[164] To avoid redundancy, here we briefly highlight/summarize the most current evidence stemming from meta-analyses and expert narrative reviews where the TAP block has been shown to be efficacious as a postoperative analgesic technique.

The TAP contains aspects of the lower six thoracic and first lumbar (T6–L1) nerves that provide sensory innervation to the skin, muscles and parietal peritoneum.

The lateral approach, initially described by Hebbard *et al*, aims to directly inject local anesthetic in the TAP compartment between the transversus abdominis and the internal oblique muscles. A linear ultrasound probe is placed at the anterolateral abdominal wall superior to the iliac crest, visualizing all three layers of the external oblique, internal oblique and transversus abdominis muscles. Using an in-plane approach, the needle is directed from an anteromedial to a posterolateral position, posterior to the mid-axillary line, with direct injection into the TAP compartment.[162] However, the clinical usefulness of the lateral approach TAP block was limited by its coverage of primarily the lower abdomen (T1–L1 dermatomes).[165 166]

To perform the subcostal TAP block in order to increase the coverage area, a linear probe is placed perpendicularly to the abdominal wall, directing it parallel to the costal margin and oblique to the sagittal plane.[165] The needle is then inserted near the xiphoid process with local anesthetic injected between the transversus abdominis and rectus abdominis muscles. Lastly, the posterior TAP block targets the TAP at the triangle of Petit or the anterolateral aspect of the QL muscle.[161 163] Carney *et al* described the ultrasound-guided posteriors TAP technique crediting Rafael Blanco. For this purpose a linear probe is positioned obliquely over the posterolateral abdominal wall, posterior to the midaxillary line, between the iliac crest and the costal margin.[167] The block needle is advanced in an in-plane approach and inserted in an anteroposterior fashion at the intersection of the lateral abdominal muscles (superficial to transversus fascia) and the QL.[168]

Excellent visual illustrations and sonographic images as well as in-depth review of the nomenclature and history of TAP blocks are available in the reviews provided by Tran *et al*[163] and Chin *et al*[164]

Studies in healthy volunteers comparing these different approaches showed that subcostal and lateral approaches led to predominantly anterior spread of the injectate while the posterior approach led to more posterior spread.[167] This observation explains why the initial posterior approach was limiting its utility to procedures on the lower abdomen, below the umbilicus.[162 166 167]

Further, the posterior approach is the only approach that provides sympathetic blockade and visceral analgesia via its spread into the paravertebral spaces.[163]

Carney *et al* determined that site of the TAP block injection or approach determines the spread of the local anesthetic that varies among different approaches resulting in different sensory blockade.

Studies using injectates in cadavers echoed similar findings regarding spread. Milan *et al* demonstrated using 40 mL of dye in cadavers that spread was greatest for the subcostal, followed by the posterior (lumbar triangle of Petit) and lateral (mid-axillary) approach (85.1 cm^2 (T7–L1), 77.9 cm^2 (T10–L1) and 58.9 cm^2 (T10–L1). Støving *et al* delineated the cutaneous sensory block area after healthy volunteers received ultrasound guided posterior TAP blocks. They found that TAP blocks did not cross the midline and were more lateral in distribution with little variable medial effect. Furthermore, the three lateral abdominal wall muscles in all healthy volunteers were thinner compared with the control contralateral side, demonstrating muscle-relaxing effect of the posterior TAP block. These sensory and motor effects lasted approximately 10 hours after 20 mL of 0.75% ropivacaine injection.[169] A subsequent study investigating intraindividual variations of TAP blocks in healthy volunteers determined that while there was a moderate-to-poor reproducibility on block characteristics, cutaneous distributions were still below the umbilicus and lateral to the ASIS.[170]

With regard to safety, the ultrasound-guided TAP block was not associated with any major anesthetic complications in a meta-analysis of RCTs. Case reports of toxic levels of local anesthetic have been published, but none were seen in ultrasound guided studies, demonstrating possibly improved safety with such an approach.

Literature review

Over the course of two decades, a plethora of studies have examined and confirmed the analgesic efficacy of the TAP block. Summarizing this experience, a recent meta-analysis by Baeriswyl *et al*[171] examined the analgesic effect of ultrasound-guided TAP blocks that included a total of 31 RCTs with 1611 adults patients. The analysis included patients undergoing abdominal laparotomy, abdominal laparoscopy, and cesarean delivery. At 6 hours postoperatively, the cohort that received the ultrasound-guided TAP block required 6 mg of intravenous morphine less, irrespective of the timing of block performance in relation to surgical incision, block approach, local anesthetic dose or multimodal analgesic plan utilized. A separate meta-analysis of 14 studies showed that in patients undergoing cesarian delivery, low-dose versus high-dose local anesthetics were comparable with no differences in opioid consumption, time to first analgesic requirement, pain scores, nausea and vomiting, pruritus and patient satisfaction.[172] The meta-analysis excluded studies that used TAP catheters or studies with dissimilar intrathecal opioid use in intervention and control cohorts.[172] Numerous meta-analyses have shown that TAP blocks reduced opioid requirements in the postoperative period after abdominal surgeries,[173] laparoscopic surgeries,[174] total abdominal hysterectomy,[175] colorectal surgery,[176] laparoscopic colorectal surgery,[177] laparoscopic cholecystectomy,[178] hernia surgery[50] and cesarian section in the absence of intrathecal morphine use.[179] The comprehensive review on TAP block by Tran *et al* does provide the authors' expert clinical recommendations for TAP block based on their review of 245 articles.[163] The authors do not recommend using TAP blocks for caesarian sections if intrathecal opioid is used or when a thoracic epidural is used for open colorectal surgery. However, if intrathecal opioids and thoracic epidurals are contraindicated, the authors recommend posterolateral TAP for cesarian sections and a lateral/continuous subcostal TAP block for open colorectal surgery. The use of posterior or lateral TAP blocks for open appendectomy and subcostal over lateral TAP block for laparoscopic cholecystectomy were also recommended. Lastly, the authors advised against using lateral TAP blocks for laparoscopic hysterectomy, laparoscopic appendectomy and open prostatectomy. They emphasized that many trial designs lacked the use of multimodal analgesics in the control group and made it difficult to truly assess the efficacy of the TAP block as a postoperative analgesic Further, given that the TAP block technique seems to impact on (subcostal, lateral, posterior) block efficacy, authors advised to view any positive study outcome in the context of the approach used. Lastly, Tran *et al* recommended using either a subcostal or posterior approach based on the current evidence of block spread and resulting sensory blockade.[163]

Indications

The TAP block has been used to provide analgesia for various abdominal procedures including gastrointestinal (level 1a), gynecologic (level 1a) and obstetric (level 1a; in the absence of intrathecal opioid), bariatric (level 1a), urologic (level 2b) and colorectal surgeries (level 1a in the absence of thoracic epidural), as well as laparoscopic cholecystectomies (level 1a).[168 172 180–186]

Rectus sheath block

Characteristics/anatomy

Rectus sheath block (RSB) targets the ventral rami of the intercostal nerves (7–12th) that lie posterior to the rectus sheath flanking the linea alba. The intercostal nerves that run along the TAP plane continue medially to pierce through the rectus sheath, ending as anterior cutaneous nerves.[187] The block covers somatic but not visceral pain fibers. RSB can be performed with the probe in the longitudinal plane along the lateral edge of the rectus sheath with the ultrasound image showing rectus muscle and hyperechoic twin lines beneath it representing the posterior rectus sheath and fascia transversalis.[187] With the needle tip inserted at a 45° angle from cephalad to caudal direction, direct visualization of the needle tip in between the rectus muscle and the posterior sheath will allow for injection of local anesthetic with subsequent hydrodissection of the rectus muscle from the sheath.[187] The posterior rectus sheath does not fuse with tendinous intersections and may allow intercompartmental spread of the local anesthetic as well as catheter placement.[188 189] RSB performance under ultrasound guidance is considered safe. However, superior and inferior epigastric vessels run in the posterior rectus sheath, thus demanding caution to avoid intravascular injection.[187] Dolan *et al*[190 191] performed RSBs using a loss of resistance technique or ultrasound-based technique in 83 patients. Even with random assignment of trainees, 20.5% of the blocks using a loss of resistance technique resulted in intraperitoneal injection while there were 0% intraperitoneal injections when ultrasound was used. The authors also measured the distance to the anterior layer of the rectus sheath and determined that it varied among patients. The authors therefore recommended ultrasound use to prevent potential complications with RSB placement. Cases involving knots complicating RSB catheter placement have been reported. To avoid this issue, the authors recommend placing catheters more laterally and advance them no more than 4 cm.[192 193]

Literature review

Various studies have been performed to date to determine the efficacy of RSB in reducing postoperative pain. However, compared the TAP blocks, the number of available RCTs (41) and meta-analyses (2) is limited.

Meta-analyses of combined RSB and TAP blocks in children that included five studies demonstrated that RSB was effective in lowering pain and opioid use after abdominal surgery.[194] Four of the five studies included were from investigations evaluating the role of RSB on pediatric umbilical hernia repair surgery. One study assessed its role after laparoscopic appendectomy.[194] Gurnaney *et al* included 52 patients undergoing umbilical hernia repair. While there was a lower perioperative opioid consumption in the RSB group, there was only a trend toward significance in the opioid consumption in the postoperative period with no difference in time to the need for rescue analgesics.[195] Similarly, of the 14 patients included in a study by Isaac *et al*, there was no difference in total morphine consumption, pain or sedation scores between those receiving RSB versus local infiltration analgesia (LIA).[196] On the contrary, Dingeman *et al* concluded that RSB did provide superior analgesia when the RSB and the LIA were administered at the conclusion of the surgery with ultrasonography.[197] Flack *et al* reported similar results with superiority of RSB over LIA with those receiving LIA having a twofold increased risk of requiring morphine with a shorter time to first dose.[198] The limited number of studies does provide some support for analgesic efficacy of RSB after pediatric umbilical hernia repair. Kartalov *et al* demonstrated in their RCT that adult patients undergoing umbilical hernia repair also benefited from RSB blocks with lower pain and morphine consumption at 24 hours postoperatively.[199] Few additional studies have shown the efficacy of the RSB as a postoperative analgesic after laparoscopic abdominal surgeries including gynecologic surgery and appendectomy.[200–202]

A Cochrane review that examined the TAP block and RSB showed that only one of three studies that met inclusion criteria demonstrated efficacy in reducing postoperative analgesics after abdominal surgery without any impact on nausea, vomiting and sedation level.[203]

Block duration was also limited in some of the single injection studies. Kim *et al* reported that bilateral RSBs were effective only during the first hour after robotic cholecystectomy.[204] Hong *et al*[205] used bilateral RSB in patients undergoing open gastrectomy and found that their use lowered the total intraoperative as well as the postoperative analgesic requirement compared with the control cohort with a sham block. However, the effects did not persist after 3 hours postoperatively. The median duration for the TAP block was also noted to be significantly longer than those receiving the RSB in patients undergoing laparoscopic ovarian surgery.[9]

Where duration of the RSB is the only limiting factor, catheters can be used to bridge the gap. Sandeman and Dilley[188] reported the use of ultrasound-guided RSB and rectus sheath catheters in patients undergoing abdominal surgeries with midline incisions. Successful use of rectus sheath catheters have also been reported with intermittent local anesthetic boluses after elective midline laparotomy for gynecological cancer surgery.[206] The cohort with catheters had lower morphine consumption at 24 hours and lower pain scores at 48 hours postoperatively.

Yassin *et al*[207] examined the postoperative opioid requirement for elective abdominal surgeries with midline incisions using either RSB catheter versus low TEA. As expected, patients with a low thoracic epidural required less opioids and time to first morphine dose was longer. However, their time to ambulation compared with the RSB group was also prolonged. Further, patient satisfaction scores between the two groups were comparable.

Current evidence shows some support for the use of the RSB for pediatric umbilical hernia repair. A number of RCTs have demonstrated that RSB can also be used for laparoscopic abdominal surgery. However, duration of action is limited as has been shown in adults. In the pediatric setting RSB with catheters for elective abdominal surgeries with midline incisions have been performed, but additional studies are needed to further validate findings.

Indications

RSBs are usually performed under ultrasound guidance and are primarily used to help with surgeries with surgical incisional pain near the midline of the anterior abdominal wall (level 2a). It has also been used with umbilical hernia repair (level 1b), open gastrectomy (level 1b), splenectomy (level 1b) and laparoscopic procedures including laparoscopic gynecological surgery (level 1b) and pediatric laparoscopic appendectomy (level 1b).

Pectoral nerve blocks (PEC I, II)

Characteristics/anatomy

The ‘pecs block’ was originally described by Blanco.[208] The author reported a postoperative analgesic effect after injection of 0.4 mL/kg of 0.25% levobupivacaine in the interfascial plane between pectoralis major and minor muscles targeting the medial and lateral pectoral nerves in patients undergoing breast surgery.[208] The following year, the authors reported the ‘modified pecs block’ or ‘pecs block type II’ where pectoral, intercostobrachial, intercostals III–VI and long thoracic nerves are targeted.[209] The modified pecs II block encompasses the original pecs I block but also includes a second injection (20 mL of local anesthetic between the pectoralis minor and the serratus muscle).[209] The authors reported the novel approaches as alternatives or rescue blocks to paravertebral and thoracic epidural approaches for breast surgeries.[209] To perform the pecs I block, Blanco described using a linear ultrasound probe positioned similar to that when performing an infraclavicular brachial plexus block.[208] Following the visualization of the pectoral branch of the thoraco-acromial artery where the lateral pectoral nerve lies, local anesthetic is injected.[208]

To perform the pecs II block, the probe is placed at the lateral third of the clavicle. Once the pectoralis minor muscle is identified the first rib will be seen under the axillary artery. While using the pectoralis minor muscle as a reference, the probe is moved inferolaterally until the lateral border of the pectoralis minor muscle is visualized. Girdy's ligament and the serratus anterior muscle run continuously over the ribs 2–4. The injection of the local anesthetic between pectoralis minor and serratus muscle occurs at the level of the third rib. Blanco *et al*[209] noted a potential for intravascular injection into the pectoral branch of the acromiothoracic artery and puncture of the axillary fascia as potential complications of pecs II blocks. However, meta-analyses that examined pecs and SAPB reported no complications with low risk of hemodynamic instability and concluded the blocks to be safe as analgesic options in cardiac, thoracic and trauma surgeries.[210]

Literature review

Over the past decade, a plethora of studies has been published on the use of pecs blocks for patients undergoing breast surgeries. On review of the relevant meta-analyses delineated below a number of outcomes have been repeatedly studied. Pecs II block, like any other upper or lower extremity block that is used with GA, decreases both intraoperative and postoperatively opioid requirements (up to 24 hours) for patients undergoing breast surgeries. As expected, those receiving the pecs block compared with GA-alone also have lower postoperative pain scores and post-operative nausea and vomiting (PONV). Pecs II blocks were comparable to PVB with regard to postoperative analgesic requirement and pain scores after breast surgeries. Jin *et al* performed a meta-analysis to assess the initial proposal by Blanco *et al* that pecs blocks were easier and safer alternatives to PVB for patients undergoing breast surgery.[211] Using information from 10 RCTs the meta-analysis determined that no significant differences were found in respect to 24-hour opioid consumption or time to rescue analgesia. Two cases of pneumothorax and one case of unintentional bilateral block were notable complications after PVB with none in the pecs group. Pecs II blocks were used in 90% of studies.

Sun *et al* compared the effect of pecs block to general anesthesia (GA) alone in patients undergoing mastectomy for breast cancer in their meta-analysis.[212] A total of 13 RCTs with 940 patients were included. Pecs blocks added to the GA reduced pain immediately in the recovery room and at 24 hours after surgery compared with those who received GA alone. Opioid use was also lower intraoperatively, in the recovery room, and at 24 hours while prolonging time to first analgesic request in the pecs cohort. Pecs II blocks were used in 11 of 13 studies.

Versyck *et al* compared pecs II blocks with two different cohorts (PVB, GA-alone) in their meta-analysis that included 13 RCTs and 815 patients. Similar findings to the aforementioned meta-analysis were reported. While pecs blocks were superior compared with GA-alone in reducing postoperative opioid requirement and pain during the first 24 hours, it was comparable to thoracic PVB with similar postoperative opioid requirement and pain scores.[213]

Another meta-analysis that included eight RCTs with 993 patient evaluating pecs I and pecs II blocks versus no blocks for radical mastectomy procedures under GA showed that pecs II block was effective in lowering both intraoperative and postoperative opioid analgesic requirements, PONV, rescue analgesic requirements and pain scores in the first 6 hours after surgery.[214] However, those benefits were not seen with a pecs I block.[214]

Grape *et al* performed a meta-analysis on the efficacy of pecs and SP blocks after breast surgery (mastectomies and other breast surgery). The inclusion criteria grouped any pecs block which was either defined as pecs I, pecs II and SP blocks in combination or alone. A total of 16 trials with 1026 patients were included. Twelve of 16 studies used a pecs II block, the remaining four studies used a pecs I block alone, pecs I block with SP block, pecs II block with SP block and SP block alone. The authors concluded that there was a moderate to high level of evidence that pecs block provided postoperative analgesia and reduction of PONV when compared with the GA-alone group. Pecs blocks reduced rest and dynamic pain scores for 2 hours, opioid consumption at 2, 12 and 24 hours, as well as PONV. The authors highlighted that the analgesic efficacy of the blocks was more pronounced in the absence of axillary node dissection which the authors attributed to unreliable coverage of thoracodorsal and intercostobrachial nerves with the pecs blocks.[215]

A number of recent studies that compared the pecs II blocks to ESP blocks for radical and modified radical mastectomies demonstrated the superiority of pecs blocks in reducing postoperative pain scores and opioid requirements.[136 216]

An investigation that examined pecs II combined with GA compared with GA alone in patients undergoing mastectomy or quadrantectomy in a prospective single-center study showed that even at 3 months after surgery, the pain scores were lower in those who received the block.[217] Case reports and series have demonstrated the feasibility of performing breast surgeries with a combination of pecs blocks with or without additional thoracic paravertebral blocks using total intravenous anesthesia.[218–220] In conclusion, pecs II blocks are effective in decreasing perioperative opioid requirement in patients undergoing breast surgeries including mastectomy with lower pain scores when compared with GA alone. However, its effects are comparable to paravertebral blocks.

Indications

Since their introduction, the pecs II blocks have been utilized for a wide array of breast surgeries. The pecs II block provides additional axillary clearance and complete analgesia after breast surgery involving wide excisions, sentinel node harvesting and mastectomies (level 1a).[209] It has been used for cardiothoracic surgery (level 1a). Since its introduction, its use has been rapidly extended as a proof of concept to facilitate pacemaker placement (level 4), subpectoral bicep tendinosis (level 4), anterior shoulder (level 4), cardiac and upper limb fistula surgery (level 4).[212 214 217 218 220–230] With regard to the use of pecs I block alone, there is insufficient evidence demonstrating efficacy that is comparable to pecs II block.

SP block

Characteristics/anatomy

The SP block was first described by Blanco *et al*.[231] The authors stated that the SP block was a progression from the pecs I and pecs II blocks featuring an enhanced safety profile given that only one injection was required and the insertion point was remote from vascular structures.[231] The SP block provides near complete analgesia to the hemithorax by targeting the intercostal nerves (T2–T9). Franco *et al* noted that lateral branches of the upper intercostal nerves and not branches of brachial plexus provides sensory innervation to the chest wall.[232]

The block is performed by using a linear probe placed over the mid-clavicular level of the thoracic cage (sagittal plane).[231] The ribs are counted as the probe is moved inferolaterally. When the fifth rib is encountered in the midaxillary region, visualization of the latissimus dorsi, teres major and serratus muscles can be seen. The thoracodorsal artery can be seen in the plane superficial to the serratus muscle as an additional reference point. The needle is directed from supero-anteriorly to posteroinferiorly. With the superficial SP block, local anesthetic is placed between the latissimus dorsi and serratus muscle. In the case of the deep SP block local anesthetic is injected deep to the serratus muscle between the fourth and fifth rib.[231] It is important to note that SP blocks can be performed at different coronal planes of the body, apart from superficial to deep of the serratus muscle. The SP block can be placed anywhere between the second and the seven ribs between the anterior and posterior axillary lines.[233]

The meta-analyses that examined pecs and SP blocks did not report any major complications[210] although there remains a small risk of infection, hematoma, local anesthetic toxicity, nerve and vascular injury.[234]

Studies that evaluated the spread of the injectate in cadavers showed that lateral cutaneous branches of the intercostal nerves were reliably stained by the dye and latex injectate supporting the anesthetic efficacy of the block in the lateral thorax and the axilla.[235] A separate cadaveric study with 39 hemithoraces showed that independent of the approach (superficial vs deep injection), the volume (20 mL vs 40 mL) of the injectate influenced the extent of spread to the anterior chest as well as cephalad to caudad, but not posteriorly.[236] The injection technique described by Biswas *et al*[236] using 20 mL of methylene blue were either superficial or deep to the serratus anterior muscle at the fifth rib. The injection technique using 40 mL of methylene blue included the same 20 mL injection as aforementioned with a second 20 mL injection either superficial or deep to the serratus anterior muscle at the third rib level. Kunigo *et al*[237] reported similar findings after injecting 20 mL vs 40 mL of methylene blue on each side of the hemithoracic walls. Both 20 mL and 40 mL injections occurred at the interfascial plane between serratus anterior and pectoralis major muscles at the fourth intercostal space. The hemithoracic wall with the 40 mL injection showed staining of T2-5 intercostal nerves while the side with 20 mL injection revealed staining of T3–4 intercostal nerves. Lateral or pectoral nerves were not frequently stained on either side. Clinical studies that followed using either 20 mL vs 40 mL of ropivacaine demonstrated that larger volumes correlated with more dermatomes being affected without influencing the time to first postoperative analgesic dose requirement.[238] While the results of cadaveric studies do not fully translate into clinical outcomes, it is apparent that techniques using larger volume do allow for additional cephalad-to-caudad spread.

Literature review

Franco *et al* recently proposed pecs and SP blocks to be similar in clinical efficacy as the end target for both blocks were the lateral cutaneous branches of the intercostal nerves which pierce through the serratus muscle.[232] Hence, it is no surprise that SP blocks provide similar dermatomal coverage in the lateral thorax and the axilla as do pecs II blocks. A recent meta-analysis by Chong *et al* examined the SP block for post-operative analgesia following breast and thoracic surgery.[239] A total of 19 RCTs with 1260 patients were included with six trials in thoracic and 13 in breast surgical patients. The authors determined that SP block reduced pain scores for up to 24 hours postoperatively compared with the non-block group. Furthermore, the cohort with the SP block had longer time to first analgesic request, lower 24-hour opioid consumption and reduced PONV. Five of 19 RCTs compared SP blocks to PVBs and showed no differences.

Jack *et al* recently performed a qualitative systemic review on the use of SP block and pecs block in cardiac surgery, thoracic surgery and in trauma.[210] Fifty-one studies were included with 9 RCTs, 13 cohort studies, 19 case series and 10 case reports. The authors highlighted the promising analgesic efficacy of SP and pecs blocks in reducing pain scores and opioid consumption following cardiothoracic surgery, cardiac-related interventional procedures and chest trauma compared with the GA-alone group. The authors described many of the emerging proof-of-concept studies that attempt to extend the use of SP block for potential procedures in the anterolateral chest wall including device implantation (cardiac device, portacath insertion), transcatheter aortic valve replacement via the subclavian approach, rib pain secondary to cardiopulmonary resuscitation, rib fractures, latissimus dorsi tendon transfer surgery, chest wall liposuction and extubation following thoracotomy. However, the majority of their RCTs (seven of nine) included SP blocks in thoracotomy or video-assisted thoracoscopic surgery (VATS). Mean duration of single shot injection of SP or pecs blocks were noted to be approximately 6–12 hours, longer than intercostal blocks and shorter than the PVB. One of the RCTs compared the SP block to pecs blocks and showed comparable post-thoracotomy analgesia in the pediatric patient population with similar 12-hour opioid consumption and pain scores 10 hours after extubation. At 12 hours, the SP group did have slightly lower pain scores compared with the pecs group.[240]

Liu *et al*[241] performed a meta-analysis evaluating the analgesic effect of SP blocks after thoracic surgery. Eight RCTs and 542 patients were included. Compared with a placebo group (no block or saline), the cohort with SP block had lower pain scores, 24-hour opioid consumption, and PONV after thoracic surgery. Zhang *et al* examined the efficacy of SP blocks in VATS procedures which included four RCTs and 262 patients. Here too, the cohort receiving the SP block had lower pain scores, morphine consumption at 24 hours postoperatively and better satisfaction. However, analgesic superiority did not translate into faster chest tube removal or shorter length of stay.[242]

One of the first studies to determine the efficacy of the SP block with a catheter was published by Khalil *et al* comparing the postoperative analgesic effect of SP blocks vs TEA.[243] The study enrolled 40 patients undergoing thoracotomy for various indications. Patients had either a thoracic epidural or a SP block (superficial approach) with a catheter placed for postoperative use. Both groups received a loading dose at the end of the procedure prior to extubation.[243] Visual Analog Scores, and total 24-hour morphine consumption did not differ between the two groups, while SAP was associated with less hypotension.[243] A recent study by Beard *et al* evaluating SP versus thoracic epidural and paravertebral catheters among patients who suffered multiple rib fractures demonstrated no significant difference in postblock inspiratory volumes or pain scores.[244] The relative ease of SP catheter placement in patients with multiple rib fractures is favorable given that thoracic epidural, paravertebral, ESP blocks all require patients with rib fractures to sit or lay on their side.

Compared with thoracic epidurals, paravertebral blocks and intercostal nerve blocks the reduced side effect profile of a SP block has provided significant momentum for its use. There is clear overlap in its efficacy with the pecs block but nonetheless it has shown promising results in patients undergoing breast surgery, thoracic surgery and cardiac surgery to date. Newly emerging proof-of-concept studies are showing potential broad applicability.

Indications

Indications for the SP block include breast (level 1a) and thoracic surgeries including video-assisted thoracic surgery (level 1a) by providing reliable coverage from the anterolateral chest wall, axilla, to the posterolateral chest wall region.[231] Its use has also been reported as a proof-of-concept for managing pain secondary to blunt chest trauma, multiple rib fractures[244] and inferior scapular fractures (level 2b), postmastectomy and postthoracotomy pain syndrome (level 1b), chronic pain secondary to post-traumatic neuropathies of the chest wall (level 4), lung transplant surgery (level 4) and implantable cardiac devices (level 4).[243 245–259]

Twitter Stavros G Memtsoudis @sgmemtsoudis

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ORCID iD

Stavros G Memtsoudis http://orcid.org/0000-0001-9093-0030

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