Recent advances in regional anaesthesia 2014–15

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ABSTRACT

The use of ultrasound in regional anaesthesia practice has made it possible to introduce new blocks and improve old techniques. This paper discusses the various approaches of quadratus lumborum block, the Pecs 1, Pecs 2, the Serratus plane block, the advancements in techniques of brachial plexus blocks as well as blocks for relieving pain after knee arthroplasty surgery.

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1. Introduction

The use of ultrasound in regional anaesthesia has not only helped in the introduction of new blocks but also in further improving classical block techniques. This has been achieved by re-exploration of the relevant anatomy in cadavers and visualization of ultrasound images in patients.

This paper aims to outline the important, new regional anaesthesia techniques that were either introduced or discussed avidly in 2014–15 and early 2016.

2. Abdominal blocks – quadratus lumborum block

One of the newest blocks to be introduced into regional anaesthesia practice has been the Quadratus lumborum block (QLB). Rafael Blanco first described this block at a conference in 2007 [1]. Subsequently there was scant information about this block until a paper by Carney and colleagues where it was described as an ultrasound guided (USG) posterior transversus abdominis plane (TAP) block [2]. Unlike the classical USG TAP block where local anaesthetic (LA) is injected in the mid-axillary line between the internal oblique and transversus abdominis muscles, in the posterior TAP block, it was recommended that LA be deposited between the posterior edge of the transversalis fascia and the anterolateral border of the quadratus lumborum muscle [2] (Fig. 1).

On contrast enhanced magnetic resonance imaging (MRI) it was shown that the drug deposited at this point could spread around the quadratus lumborum muscle to the paravertebral space [2]. It was therefore opined that the posterior TAP or QLB could provide both visceral and somatic pain relief unlike the classical USG TAP block that provided only parietal pain relief for lower abdominal surgeries by blocking of the terminal branches of T10-L1 nerves [2].

Borglum and colleagues subsequently described the
transmuscular approach of the QLB, wherein with the patient in the lateral decubitus position, LA was deposited in the plane between the QL and psoas major muscles at the level of the fourth lumbar vertebra [3] (Fig. 1).

Subsequently, Blanco et al. described the QLB1 and QLB2 blocks. QLB1 was similar to the USG posterior TAP block described earlier. The QLB2 involved depositing LA at the postero-lateral border of the QL muscle, in the intermuscular plane between the QL and the latissimus dorsi muscle (Fig. 1). On doing contrast enhanced MRI studies, the authors demonstrated more reliable spread of LA to the paravertebral space with this technique. They recommended that QLB2 should be adopted as the technique of choice, as it was superficial, safer and technically easier to perform [4] (Fig. 1). All information about the QLB upto this time was in the form of abstracts, correspondences or descriptive reports [1–4].

Blanco et al. in 2015 published the first randomized controlled trial (RCT) assessing the efficacy of the QLB for providing postoperative analgesia for up to 48 h following Caesarean sections [5]. The surgery was performed under spinal anaesthesia and the QLB2 performed at the end of surgery. Patients in the study group received 0.2 ml/kg of 0.125% bupivacaine and those in the control group received an equivalent volume of normal saline. The QLB group patients consumed significantly lesser morphine for the first 12 h, had lower pain scores at rest and on movement in the 48 h study period. The authors concluded that the QLB provided effective analgesia for up to 48 h postoperatively after Cesarean sections. A limitation of the study was that the dermatomes anaesthetised after the QLB were not evaluated for fear of un-blinding the participants [5].

Therefore, the Quadratus lumborum block (QLB) appears to be a promising technique with the ability to provide visceral as well as somatic pain relief unlike the TAP block that provided only parietal pain relief. The QLB has been used for providing analgesia after various surgeries such as pyeloplasty, Caesarean section and hip arthroplasty. However, a limited number of RCTs studying the QLB have been published. Studies need to assess whether the transmuscular approach as described by Borglum or the QLB2 technique as described by Blanco is more effective. Further studies also need to compare the efficacy of QLB to epidural analgesia for providing pain relief following major abdominal surgeries.

3. Chest wall blocks – Pecs 1, 2 & Serratus plane block

Other relatively new blocks that were still of interest in 2014–15 were the Pecs I & II and the Serratus plane block [6,7]. Blanco and colleagues introduced these blocks. All of these are intermuscular plane blocks that can be performed only under ultrasound guidance.

Blanco et al. first described the Pecs 1 & 2 blocks in 2011–12 [6]. The Pecs 1 block involves depositing 10 ml of local anaesthetic solution in the intermuscular plane between the Pectoralis major and minor muscles so as to anaesthetise the lateral and medial pectoral nerves innervating these muscles and overlying tissue (Fig. 2). This block was recommended for providing analgesia for patients undergoing insertion of subpectoral breast expanders or prosthesis under general anaesthesia.

Blanco and colleagues realized that patients undergoing extensive breast cancer surgery and axillary dissection would require blockade of the thoracic 2nd to 6th intercostal nerves (T2-6), the long thoracic and the thoracodorsal nerves. To achieve this goal they developed the Pecs 2 block, as an alternative to the paravertebral block [6].

The Pecs 1 block involves keeping the linear array US transducer probe slightly obliquely under the clavicle on the side to be blocked. With this position of the probe, the axillary artery, vein and the first rib can be visualised. Moving the probe further outward and inferiorly towards the axilla brings into vision the two pectoral muscles and the inter-muscular plane between them. This is the site where 10 ml of LA can be safely deposited with the needle introduced in-plane in the cephalad to caudad direction (Fig. 2).
Pecs 2 block involves moving the probe further laterally and inferiorly so as to visualize the lateral border of the pectoralis minor. At this site the serratus muscles overlying the 2nd and 3rd ribs can be seen. Pecs II block involves injecting 20 ml of the LA in the plane between the pectoralis minor and the serratus muscles (Fig. 2). On gadolinium enhanced MRI images, dye spread to the axilla and extending from T2-T6 intercostal levels was visualised [6]. Pecs II block also includes the Pecs I injection, i.e., depositing LA between the pectoralis major and minor (Fig. 2).

In the Serratus plane block, the ultrasound probe is moved further laterally and inferiorly to lie over the 5th rib in the mid-axillary line [7]. At this level the latissimus dorsi, the teres major and the serratus muscle overlying the ribs can be identified. The LA can be deposited either superficial or deep to the serratus muscle [7] (Fig. 2).

Blanco et al. injected similar volumes of LA either superficial or deep to the serratus muscle on either side in 4 volunteers [7]. Thirty minutes later, the authors found consistent loss to pin prick sensation from T2-T6 on both sides. However, the duration of sensory and motor block was significantly longer on the side on which injections superficial to the serratus had been performed as compared to the side on which injections deep to the serratus had been done. The authors opined that injections superficial or deep to the serratus muscle would both provide effective analgesia for patients undergoing breast and anterolateral chest wall surgery [7].

This paper was published in 2013 accompanied by an editorial titled “Serratus plane block: do we need to learn another technique for thoracic wall blockade?” [8] The paper however, captured the attention of the regional anaesthesia practitioners and there were various letters about this technique and its applications. These helped to clarify certain aspects of this block [9–12].

In a reply to a letter by Sebastian about Serratus plane block as compared to Pecs II block, Blanco clarified that LA injections superficial to the serratus tended to spread more posteriorly and distally whereas those deep to the serratus tended to spread more anteriorly and had a limited distribution [13].

Therefore Pecs I is a superficial block that targets the lateral & median pectoral nerves by injecting local anaesthetic in the interfascial plane between pectoralis major & minor muscles.

Its main use is for insertion of breast expanders & subpectoral prostheses. Other potential uses are for surgeries in the pectoral area such as traumatic chest injuries, iatrogenic pectoral muscle dissections, pacemaker, port-a-catheters and chest drains insertions.

Pecs 2 is indicated in patients undergoing breast surgery where in addition to mastectomy or wide local excision of a breast tumour, axillary clearance or sentinel lymph node biopsy is also required. It breaks through the ‘axillary door’ and can anaesthetise the long thoracic nerve and at least 2 intercostal nerves reliably.

The Serratus plane block may more reliably block more T2-6 intercostal nerves and the long thoracic nerve in patients undergoing breast or chest wall surgery.

In terms of efficacy of block Blanco opined that Pecs 1 may be the simplest block to perform, Pecs 2 the most effective and the
serratus plane block somewhere between the two. Blanco further qualified that the choice of block should depend on the surgery being performed and correspond to the dermatomes that needed to be blocked [13]. Bashandy et al. in a recent study compared the efficacy of pre-operatively performed Pecs blocks (1 and 2) for providing analgesia in patients undergoing unilateral modified radical mastectomy under general anaesthesia [14]. The Pecs group patients were found to have lesser intraoperative fentanyl requirement, lower pain scores and lesser morphine requirement for as long as 12 h post-operatively. The authors recommended that this block is an easy to learn USG regional anaesthesia technique that can provide analgesia for patients undergoing radical breast surgery.

4. Upper limb brachial plexus blocks

The ability to visualize the anatomy with ultrasound has made it possible to explore ways to refine techniques of doing standard peripheral nerve blocks. One such example was the paper by Burckett-St Laurent and colleagues that described the superior trunk approach of the USG interscalene brachial plexus block (ISB) [15]. The classical method of ISB involves doing the block at the level of the cricoid cartilage (Fig. 3A). This technique is effective but is associated with a high incidence of ipsilateral phrenic nerve palsy as well as a rare chance of injury to the long thoracic and dorsal scapular nerves (branches of roots).

In the superior trunk block the cervical 5th & 6th nerve roots are followed more distally to where they coalesce to form the superior trunk. The authors have shown sonoanatomy pictures where the superior trunk can be seen as cohesive structure composed of nervous tissue surrounded by hyper-echoic connective tissue sheath that lies just below the deep cervical fascia (Fig. 3B). Doing the block at this level could avoid phrenic nerve palsy and chance of injury to the branches of the roots of the brachial plexus. However, the authors caution about the presence of the transverse cervical artery that may cross the plexus at this level [15]. Since this was a report of a single patient further studies are awaited to establish the efficacy of this technique.

Lee et al. demonstrated in a series of 51 patients that single injection of LA into the central cluster of the supravacular brachial plexus was associated with a success rate of 92.2% (47 out of 51 patients needed no LA supplementation for hand and forearm surgery) [16] (Fig. 4). The authors opined that this approach was associated with lesser chance of injury to the pleura or subclavian artery, which may be a risk with the corner pocket approach of doing the block (Fig. 4). Further studies need to be done with a control group to replicate these findings [16]. Bharthi et al. demonstrated that the USG ISB is as effective as the supraclavicular or infracavicular block for providing anaesthesia for upper limb surgery. However, the onset time of the ISB was longer and it was associated with an unacceptable incidence of phrenic nerve palsy [17]. Petrari et al. in a RCT similarly demonstrated a higher incidence of complete hemi-diaphragmatic palsy with supraclavicular (34%) versus infraclavicular (3%) brachial plexus block [18]. The paper was unique because the diaphragmatic paralysis was assessed using the M mode of the ultrasound and not based on symptoms of respiratory distress. This paper showed that though chances of phrenic nerve palsy are minimal with an infracavicular block they are not totally absent [18]. Yazer et al. in another RCT demonstrated that targeted intracuteral supraclavicular block (TISCB) had a success rate and adverse...

Fig. 3. (A): Classic Interscalene block performed at level of cricoid cartilage showing C5, C6 (has 2 divisions), C7 nerve roots. (B): Superior trunk, the C5, C6 nerve roots coalesce into the superior trunk (ST) well encapsulated with its own sheath once ultrasound probe is moved down the neck. ASM, anterior scalene muscle; MSM, middle scalene muscle; CA, carotid artery; IJV, internal jugular vein; SCM, sternocleidomastoid; VA, vertebral artery.

Fig. 4. Ultrasound picture of the supravacular brachial plexus lying anterolateral to subclavian artery (SA). Central cluster injection of LA involves injecting in the centre of the plexus marked by an orange star as opposed to redirecting the needle 2 or more times. 1, injecting LA below prevertebral fascia (marked by green arrow) ensures spread around trunks and divisions of the plexus; 2, centre corner approach needle directed close to artery especially to anaesthetise lower trunks for hand surgery.
events (vascular puncture, paraesthesias) similar to single injection infraclavicular block [19]. However, the quicker onset time of the TISCB resulted in shorter anaesthesia related time.

5. Lower limb – optimal analgesia for total knee arthroplasty (TKA)

5.1. Intrathecal morphine as compared to continuous femoral nerve block

Olive and colleagues assessed the efficacy of intrathecal morphine, continuous femoral nerve block and a combination of the two for providing analgesia for up to 24 h postoperatively in patients undergoing TKA [20]. The study showed that the patients in the continuous femoral nerve block group had lower pain scores, lesser morphine requirement and faster mobilization compared to the intrathecal morphine group. This paper demonstrates that continuous peripheral nerve blocks are more effective for providing analgesia as compared to central neuraxial opioids.

5.2. Adductor canal block

It has been demonstrated in a number of RCTs that USG adductor canal block or block of the distal branches of the femoral nerve in the adductor canal provide analgesia comparable to that provided by a femoral nerve block. The primary advantage of the adductor canal block is sparing of the motor branches to the quadriceps muscles resulting in earlier patient mobility following TKA [21].

In a study by Hanson et al. a continuous adductor canal block as compared to placebo was demonstrated to reduce opioid consumption for 48 h, improve quadriceps strength as well as the distance ambulated on post TKA day 2 [22].

The adductor canal contains the saphenous nerve (the largest sensory branch of the femoral nerve), the medial femoral cutaneous nerve of the thigh, the nerve to the vastus medialis (a motor nerve and also second largest sensory branch of the femoral nerve). The obturator nerve might enter the distal part of the adductor canal and follow the femoral artery into the popliteal fossa supplying posterior medial capsule of the knee joint [23,24].

There has been debate in recent literature about the nomenclature of the block, the best site of injection and method of identification of this site [25]. Bendtsen and colleagues defined the boundaries of the adductor canal and emphasized that these should be identified with the ultrasound rather than surface landmarks [24]. Anatomically the adductor canal extends from the apex of the femoral canal to the hiatus in the adductor magnus muscle. The roof of the canal is formed by the vastoadductor membrane (VAM), a tough aponeurotic sheath extending between the adductor muscles medially and the vastus intermedius laterally. Overlying the VAM is the sartorius muscle; hence the block has also been referred to as subsartorial block. As the sartorius muscle extends both proximally and distally beyond the adductor canal, this may not be the correct nomenclature to use for the adductor canal block [24,25].

The proximal edge of the canal can be identified anatomically as well as sonographically as the site where the medial borders of the sartorius and adductor longus cross (apex of the femoral triangle) [24] (Figs. 5 and 6).

The distal end of the canal is identified sonographically as the site where the femoral artery appears to dive down into the adductor hiatus so as to further continue as the popliteal artery in the posterior aspect of the thigh. Withdrawing the probe 2–3 cm back from this point and injecting 5–10 ml of LA anterolaterally to the artery is the method of performing the distal USG adductor canal block. It was thought that a block at this level was would ensure maximum sensory block with minimal quadriceps weakness. Anatomically at this site the sartorius forms the medial border, the adductor longus is no longer seen, the adductor magnus becomes less bulky, more tendinous as further down it gets inserted on the medial tubercle of the medial condyle of the femur (Figs. 5 and 7).

There have been isolated reports of quadriceps weakness (femoral nerve block) and even the popliteal — sciatic nerve getting blocked after an adductor canal block [26,27].

To investigate whether proximal or distal LA spread is possible, Yuan et al. fluoroscopically evaluated the distribution of continuous infusion of contrast after injection in the distal adductor canal in 10 patients following primary TKA [28]. The evaluation was done after approximately 20 h of continuous infusion of LA through a catheter so as to assess maximum possible spread of contrast. Contrast was administered @0.5 ml/h up to a maximum of 5 ml so as to simulate administration of LA @8 ml/h [28]. The authors found that in no patient did the contrast reach the level of the lesser trochanter (proximal landmark just distal to the common femoral nerve) or the medial femoral epicondyle (distal landmark for the popliteal sciatic nerve). Sixty percent of the subjects had spread of contrast limited to either the same sector as the catheter or one sector

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Fig. 5. Diagrammatic representation of anatomy of the Adductor canal. A, proximal end of the adductor canal, note medial margins of sartorius and adductor longus intersect at this level; B, distal end of adductor canal, note sartorius forms medial boundary and adductor magnus alone is present at this level; ASIS, anterior superior iliac spine; MT, medial tubercle; PT, pubic tubercle.
on the were those having severe movement related pain or VAS > 60 mm on the first or second postoperative day after TKA [29]. The ACB group received USG adductor canal block with 30 ml of 0.2% ropivacaine and the FNB group a USG common femoral nerve block with the same volume of LA. The blocks were a part of a comprehensive multimodal analgesic regimen consisting to preoperative gabapentin, round the clock paracetamol, non-steroidal anti-inflammatory drugs (NSAIDS) and opioids. Maximum voluntary isometric contraction (MVIC) was assessed using a hand held dynamometer 120 min after the end of the block in all patients. Baseline MVIC values had been previously assessed in the postoperative period prior to doing the block. The MVIC increased to 193% (95% CI, 143–288) of the baseline values in the ACB group and decreased to 16% (95% CI, 3–33) of the baseline values in the FNB group. All patients in the ACB group could perform the timed-up and go test as compared to 7 patients in the FNB group who could not do the test mainly due to muscle weakness. The authors opined that the adductor canal block, by producing effective analgesia without motor weakness, decreased the centrally mediated inhibition of voluntary contraction [29]. Further studies are needed to evaluate the optimal volumes and concentrations that should be used in the adductor canal block for relieving pain following TKA surgery.

In a recent cadaveric study Burckett-St. Laurant and colleagues showed that branches of the nerve to vastus medialis (NVM) might contribute more to the sensory supply of the antero-medial part of the knee than the saphenous nerve. The extra muscular and intra muscular branches of the NVM continue as sensory nerves without supplying the muscle. In order to block these nerves the authors recommend that the best site to perform the adductor canal block would be in mid-portion of the adductor canal and not distally, close to the adductor hiatus, as was previously described. The area can be sonographically identified as the midpoint of the proximal and distal ends of the canal. At this site both adductor longus and magnus form medial border of the canal, sartorius forms the roof and the saphenous nerve lies anterolateral to the artery [30].

5.3. Blocking nerve supply to posterior capsule of the knee

Grevstad and colleagues in a previous paper have shown that as high as 25% patients may be non-responders to the adductor canal block due to pain carried by nerves other than those in the adductor canal [29]. Some authors have attributed pain following TKA to the articular branches of the sciatic nerve, which supply the posterior capsule of the knee joint [31]. The problem with blocking the sciatic nerve proximally or in the popliteal fossa is that the ensuing muscle weakness can hamper patient mobility in the postoperative period. Therefore, the aim is to block the sensory branches to the posterior capsule without blocking motor nerves. This has been described in the iPACK technique, where USG infiltration of 30 ml of dilute LA solution is done in the interspace between the popliteal artery and the posterior knee capsule [32].

Another similar block is the SPANK block or the Sensory posterior articular nerves of the knee block [33]. This block aims to spare the main trunks of the tibial and common peroneal nerves and blocks only the terminal medial and lateral genicular branches that innervate the posterior part of the knee joint. The authors state that the junction between the medial epicondyle and shaft of the femur can be easily palpated even in obese individuals. A 22G spinal needle should be advanced to make contact with the bone at this point; the needle should be withdrawn by 0.5 cm (to avoid injecting into the periosteum) and 20 ml of LA solution injected here. The USG can be used to prevent vascular puncture and intravascular injection of LA. The authors have confirmed on cadaveric dissection that injecting 20 ml of LA at this point will block both the medial and lateral genicular nerves and provide pain relief to patients having posterior capsular pain after TKA. No motor block should result [33]. As this is a recent report more studies combining this technique with the adductor canal block need to be...
carried out to evaluate the full potential of this technique for providing analgesia post TKA to patients.

6. Summary

To summarise the quadratus lumborum block provides visceral and parietal pain relief following open or laparoscopic abdominal surgery and therefore has an advantage over the TAP block that provides lower abdominal parietal pain relief alone.

The Pecs 1, 2 and Serratus plane blocks provide analgesia following breast and chest wall surgery. For breast surgery involving insertion of subpectoral implants, Pecs 1 may be sufficient. For extensive mastectomies that involve axillary lymph node biopsy or clearance Pecs 2 or Serratus plane block would be suitable. Area covered would be more extensive with serratus plane block especially with the LA injected superficial to the serratus muscle.

Single intra-cluster injection in the supravacuclavicular brachial plexus may be used instead of multiple injections for hand and forearm surgery with a high success rate. The success and complication rate of the single intra-cluster supravacuclavicular block maybe similar to the infravacuclavicular block for arm surgery but it has a faster onset. Interscalene block is associated with a high incidence of phrenic nerve palsy and a slower onset as compared to supravacuclavicular or infravacuclavicular block when used for upper limb surgery.

Phrenic nerve palsy may be minimized if instead of a classical interscalene block a selective superior trunk block (involving C5, C6 nerve roots) is performed slightly lower down in the neck. Similarly an infravacuclavicular block is associated with a lower incidence of phrenic nerve palsy than a supravacuclavicular block.

However, the level at which a block is performed must be contiguous to the dermatomes involved in the surgery. To clarify, an infravacuclavicular block may have lesser chance of phrenic nerve palsy in a respiratory cripple but it will not provide adequate analgesia for shoulder surgery. Therefore in such a patient for shoulder surgery, a superior trunk interscalene block may be more appropriate.

For TKA adductor canal block performed at the mid–adductor canal level (sonographically identified) may provide more effective analgesia than a distal adductor canal block. Further, it remains to be studied whether additional blockade of the genicular nerves supplying the posterior capsule will enhance pain relief following TKA.

Not all literature described in this article consists of high quality RCTs, but this is a collection of innovative techniques and studies that in time could help in refining and improving the practice of regional anaesthesia.

Conflict of interest

The author has not received financial assistance for writing this article and there is no conflict of interest.

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