Effect of different truncal blocks under ultrasound-guidance on pain management after open reduction of pediatric developmental dysplasia of the hip: a randomized trial

Background:

Transversus abdominis plane block(TAP block)

The abdominal wall and parietal peritoneum are innervated by the ventral rami of the spinal nerves T6–L1[5]. The nerves run in a fascial layer that exists between the internal oblique (IO) and transversus abdominis(TA) muscles in the anterior abdominal wall. That is the transversus abdominis plane (TAP)[5].The entry points of the nerve in TAP are variable which may effect the analgesia and limit the clinical practice[6].The twelfth thoracic, ilioinguinal, and iliohypogastric nerves travel over the anterior surface of the quadratus lumborum muscle, which inserts on the 12thrib and the transverse processes of the vertebrae L1-L4. The twelfth thoracic nerve then continue runs a short distance deep to the aponeurotic which is the posterior extension of the transversus abdominis muscle

before going into the TAP[7].The ilioinguinal and iliohypogastric nerves continue run deep to the transversus muscle aponeurosis and later penetrate the aponeurosis in a more anterior and highly variable position[8].So it is difficulty to cover the twelfth thoracic, ilioinguinal, and iliohypogastric nerves when performing posterior transverses abdominis plane (TAP) block[9],while posterior injections in the triangle ofPetit.

Quadratus lumborum block(QLB)

Different approaches of transversus abdominis plane blocks techniques cause variations in analgesia features. With the recent description of the quadratus lumborum (QL)block, it seems to be an increasingly more popular alternative than the traditional TAP block, for postoperative pain management [10-14].Many see the various QL block techniques as a natural continuation of the original TAP block approach at the triangle of Petit [15].However, quadratus lumborum block and TAP block are essentially different categories of nerve blocks. A posterior TAP block is per definition superficial to the TAP and the transversus abdominis aponeurosis. The lateral QLB is deep to the transversus abdominis aponeurosis. Unlike the TAP block, the target point of the QLB is more posteriorly at the junction of the TA and the QL muscle just deep to the transversalis fascia. It can provide extensive abdominal wall and visceral analgesia(T7－L1)as a result local anesthetic secondary spreading to the paravertebral space [16].The analgesia characteristics of QLB attracts our attention. Blanco et al. performed a randomized controlled trial comparing a single shot injection of local anesthetic versus saline injection at the QL for caesarean section postoperative analgesia and showed a significant decrease in postoperative opioid consumption and dynamic pain scores[13],and also

believed the local anesthetic placed under QLM can be transported to paravertebral space along tissue plane. QLB is the extension of TAP block toward the dorsal region. A single shot injection of local anesthetic under posterior approach of TAP block covers all the dermatome segments from caudally L2 to cranially till T4 segments as the drug is expected to travel from the QL to the higher paravertebral spaces [17] .They also found the contrast enhancement from T4-L2 using magnetic resonance imaging(MRI)[17].The coverage of the dermatome segments depends on volume used. There are no guidelines on the volume of drug to be injected, especially in pediatric. McDonnell et al conducted a research on the analgesic efficacy of TAP block in the landmark technique, and demonstrated a single bolus dose (20ml of 0.375% levobupivacaine) were able to cover the incisions above and below umbilicus in adults undergoing large bowel resection [18]. Kadam VR reported 25ml 0.5% ropivacaine in ultrasound-guided quadrates lumborum block for laparotomy only covered sensory block T8-L1[19]. Based on a radiological study[17],0.3ml/Kg doses of local anesthetic maybe the low volume for adults and 0.6ml/Kg doses maybe the high volume which could have produced high systemic levels in landmark-guided TAP block[17]. Theoretically, it should be possible as the block spreads to the paravertebral space to cover the nerves as they exit. In an ultrasound-guided contrast study by Barrington et al [20], on cadavers demonstrated that multiple injections could involve more nerves. Believeing that accumulated up to at least 30-40ml in adults, local anesthetic spreaded to as high as T4 level and expected to last longer [20]. However, the experience of others suggests that these doses are safe and well tolerated. Two cases report showed that the ultrasound-guided continuous trans-muscular QLB by suing 0.3%

levobupivacaine 25 mL which has covered the dermatome segments from thoracic 11th to lumbar 4th and thoracic 12th to lumbar 2nd respectively is an effective analgesia for total hip arthroplasty (THA)[1].The local anesthetic injected between the PM and the QB spread to the paravertebral space and played the role of both a transverses abdominis plane block and a lumbar plexus block[1].A double-blind randomised controlled trial demonstrated that the quadratus lumborum block and the transversus abdominis plane block posterior approach are effective analgesic options, the similar action as the femoral block for patients undergoing femoral neck fracture[2].The sensory and motor blockade, satisfaction, and adverse effects, were similar in both groups[2].(figure 1)

Transversalis fascia plane block (TFP block)

Another kind of truncal block similar to TAP block is the transversalis fascia plane (TFP) block, which targets T12 and L1 nerve branches between the fascia of the transversus abdominis muscle and the transversalis fascia resulting in reliable blockade of the iliohypogastric and ilioinguinal nerves [3,21]. Technically similar to the TAP block, the needle tip is directed just deep to the fascia of the transversus abdominis muscle, anterolateral to the quadratus lumborum (QL). It has been demonstrated effectively for analgesia in iliac crest bone graft harvest, inguinal hernia repair, and appendectomy[3, 4,28].A patient undergoing left distal radius osteotomy with iliac crest bone graft harvest was given a single shot ultrasound-guided infraclavicular and TFP blocks who experienced unanticipated quadriceps and hip flexor weakness [4]. Steven Lee et al.[4]suspected that patients receive TFP block had a partial lumbar plexus block as a result of proximal spread of the LA. This is certainly credible because the lumbar plexus

plane is anatomically contiguous with the TFP. In fact, Hebbard [21]has suggested opening the TFP with fluid as an alternative lateral approach to lumbar plexus blockade. Previous work by Carney et al [17] has shown the spread of contrast into the paravertebral space in posterior TAP block. It follows that the TFP block, so technically similar, may also have the tendency for central and proximal LA spread. Borglum et al [10] advocate the trans-muscular QL block to deposit LA between psoas major (PM) and QL to achieve thoracolumbar anesthesia via cranial spread to the thoracic paravertebral spaces. This clearly demonstrates the existence of a “potential space” between the PM and QL where the presence of LA can emerge amazing anesthetic properties. We hypothesize that in the TFP block, proximal spread of LA to the potential space between the PM and QL can occur and contributed to the present clinical scenario. While investigating the mechanism, Rosario et al[22] performed a cadaver study and demonstrated that the plane between the transverses abdominis muscle and the transversalis fascia is continuous to the tissue plane deep to the fascia iliacus. This tissue plane incidentally houses the femoral nerve.(figure 2)

Potential benefits:

A major advantage of this technique compared to thoracic epidural analgesia(TEA)includes the avoidance of permanent neurologic sequelae in an anesthetized child.

Optimal acute perioperative pain management: Regional anesthetic techniques is a key component of multimodal pain regimen[23],which can effectively lower pain scores,lower

perioperative opioid consumption, decrease length of stay and improve the patient experience.

Potential risks:

The TFPB and QLB which technically similar to TAP and its variants are easy to perform and complications are rare. The most devastating complication of these block results from incorrect needle advancement through the peritoneum causing injuries to the organs beneath, such as liver laceration or bowel perforations [24]. Extra care may be necessary to avoid trauma to kidney. Toxic reaction of local anesthesia. (Toxicity is a concern to use such high volumes.) Lateral femoral cutaneous and cluneal nerveinjuries [25,26]. ilioinguinal nerve injury [27].

Risk/Benefit Analysis:

Risk and benefit analysis are always assessed prior to block placement, as the risk may overweigh the benefit in patients with poor identification of anatomy. For example, patients with previous abdominal surgeries with distortion of normal abdominal musculature, air in tissues after laparoscopic surgeries or extreme body habitus.

Study design and purpose:

The aim of the study is to evaluate the effectiveness of ultrasound-guided transversalis fascia plane block (TFPB) and quadratus lumborum block (QLB) on post-operative analgesia in pediatric patients with Developmental Dysplasia of the Hip (DDH) undergoing open reduction surgeries（Salter acetabular osteotomy，combined with proximal femoral rotation osteotomy）.The effectiveness of TFPB/QLB for perioperative analgesia in lumbar nerves (L1) innervated surgery have been

demonstrated in recent studies[1-4]. However, this regional technique rarely applied to children. The objective of our research is to assess the quality of postoperative analgesia in pediatric patients who had received a preoperative TFPB/QLB for hip surgery.

Study duration:

We estimate that the entire study will require 2 years, including patient recruitment, data collection, analysis, and report writing.

Abstract:

Methods:

90 pediatric patients(age **2-10** years) in the BeiJing Jishuitan Hospital and The Second Affiliated Hospital of Wenzhou Medical University with American Society of Anesthesiologists (ASA) physical status I or II, who are scheduled to undergo open reduction surgeries （Salter acetabular osteotomy，combined with proximal femoral rotation osteotomy）are selected and divided into 3 equal groups with **30 subjects**.The consent forms are approved by the institutional Ethics Committee.

Inclusion Criteria:

Pediatric patients aged between 2 years and 10 years with DDH, scheduled for unilateral open reduction surgeries（Salter acetabular osteotomy，combined with proximal femoral rotation osteotomy）.

Exclusion Criteria:

Patients will be excluded if they meet any of the following criteria: patients with known allergy to local anaesthetics, mental disability, peripheral neuropathy, a coagulopathy disorder, localized infection in the area,and any reason cause reoperation.

Sample Size: 90

Based on assumed 60% difference in the pain status between three groups by a priori study sample size calculation. A sample size of 30 would be expected to have an 80% power to check a minimum 60% difference between these three treatment groups by an uncorrected χ2 test with an α of 0.05.

Study population:

Pediatric patients aged between 2 years to 10 years diagnosed with Developmental Dysplasia of the Hip (DDH)with American Society of Anesthesiologists (ASA) physical status I or II, who are scheduled to undergo unilateral open reduction surgeries （Salter acetabular osteotomy，combined with proximal femoral rotation osteotomy）

An a priori study sample size calculation was performed based upon assumed60% difference in the pain status between three groups. Applying an uncorrected x2 test with an α of 0.05, a sample size of **30** would be expected to have an 80% power to detect a minimum 60% difference between these three treatmentgroups.

Electrocardiogram, non-invasive blood pressure, pulse oximetry, temperature, capnography, and end tidal anesthetic concentration values are monitored in patients Parental presence will be allowed if requested for the induction of anesthesia. Pediatrics without vein access will receive general anesthesia which induces with 8% sevoflurane in 70% nitrous oxide and 30% oxygen, via a facemask. When loss of consciousness is achieved, we need to establish vein access routinely. Intravenous induction for general anesthesia with endotracheal intubation is commenced using intravenous propofol 3 mg/kg, cis-atracurium 0.2 mg/kg, fentanyl 2. ug/kg. Anesthesia will be maintained using remifentanil, and a volatile anesthetic(sevoflurane). The inhaled concentration of sevoflurane will be adjusted to maintain hemodynamic stability, which is defined asa

change in systolic blood pressure and heart rate of no more than 20% of baseline parameters. The use of opioids during the perioperative periods at the discretion of the anesthetist. Some anesthetists administer opioids preemptively, however, in the majority of cases the decision is based on the cardiovascular response to stimulation; an increase in heart rate of 10% from baseline is usually interpreted as insufficient analgesia and is treated with opioids. Patients will be given either fentanyl in doses of 1-2mcg/kg, remifentanil as continuous infusion 0.01‐0.03 mcg/ (kg.min) or a combination of these.

TFPB group

Patients in transversalis fascia plane block group (Group T) will receive ultrasound-guided transversalis fascia plane blockusing0.3% ropivacaine(**0.7ml/kg**) after general anesthesia. A high-frequency probe (Sono-Site HFL50x, 15- 6 MHz, 55-mm broadband linear array) connected to an S-nerve ultrasound machine (Bothell, WA, USA) was positioned with a transverse orientation, between iliac crest and costal margin. With the patient in a supine position, the needle is advanced from the anterior using an in-plane technique. A linear ultrasound probe is orientated transversely over the lateral abdomen between the iliac crest and the costal margin. The external oblique, internal oblique, and transversus abdominis muscles are imaged, and the more posterior transversus aponeurosis is isolated from these muscles. The reflection of the peritoneum curving away from the muscles from anterior to posterior, and the perinephric fat, which lies behind the peritoneum and deep to the transversalis fascia, are both identified. The perinephric fat is generally more prominent closer to the iliac crest. The quadratus lumborum is identified medial to the aponeurosis of the transversus abdominis. The end

point is more visible if the needle is passed through the posterior "tail" of the transversus muscle, as the transversus aponeurosis is thinner and less distinct as a separate layer. After passing through the deep surface of transversus abdominis muscle, local anesthetic is injected to separate the transversalis fascia from the transversus muscle. The correct needle position was confirmed by injection of 2 ml of normal saline solution that was spreading antero-posteriorly between the anterior border of QLM and its fascia, in addition to a minimal anterior spread in TAP plane. After negative aspiration, 1 ml/Kg of ropivacaine 0.3%was injected.

QLB group

Patients in quadratus lumborum block group（Group Q） will receive ultrasound-guided quadratus lumborum block using0.3%ropivacaine(**0.7 ml/kg**).after general anesthesia. The TFPB is performed with the patient in the lateral position using a curvilinear low-frequency ultrasound probe. This is orientated transversely at the posterior axillary line between the iliac crest and the costal margin using a 22G 100-mm needle. The needle is directed in the posterior to anterior orientation with the practitioner standing behind the patient. The triangular quadratus lumborum (QL) muscle is adherent to the apex of the transverse process of L3 vertebra. Using the Shamrock method, anew transmuscular quadrates lumborum block technique, developed by Børglum (British Journal of Anaesthesia, 2013), the needle penetrates the QL muscle with an in-plane approach from the posterior side of the ultrasound probe. The target point is the inter fascial plane between the QL and the psoas major muscle just deep to the transversalis

fascia, in order to lessen the risk of unintentional penetration of the peritoneal cavity contrary to the technique. The correct needle position was confirmed by injection of 2 ml of normal saline solution that was spreading anteri-posteriorly between the QL and the psoas major muscle. After negative aspiration, **0.7 ml/Kg** of ropivacaine 0.3%was injected.

Control group

Patients in the third group as control (Group C)receive no nerve block. Patients will be extubated based on clinical criteria.

Patients will then be transported to the post-operative anesthesia care unit **(PACU)** after extubation. All pediatric patients will receive 6-hourly paracetamol postoperatively for two days and receive **sufentanyl** via nurse-controlled analgesia (NCA) or patient-controlled analgesia (PCA). The prescription of postoperative NCA/PCA is also at the discretion of the anesthetist. Children under the age of 6 years will receive **sufentanyl** via NCA continuously at a rate of 2 mcg kg-1 48h-1 with a bolus option of 0.01 mcg kg-1 every 15 minutes. Older children will receive sufentanyl via PCA continuously at a rate of 2 mcg kg-1 48h-1 with a bolus option of 0.01 mcg kg-1 every 15 minutes.

Data collection will include the type of procedure, age, weight, type of truncal block (QLB group vs TFPB vs control), intra- and postoperative analgesia given, complications, mean arterial pressure and heart rate registered at the key steps in the surgeries，the duration of surgery and hospitalization time ,and pain scores up to 48 hours post-surgery （at 1h,4h,8h,12h,16h,24h，48h after surgery） using age-appropriate and validated tools (ie, the Face, Legs, Activity, Consolability Scale [FLACC] in children).The intensity of pain

utilizing FLACC was classified as none or mild (≤ 4), moderate (5-7), and severe (≥ 8).

Overall use of rescue analgesics was calculated. The first use and the number of doses of rescue analgesics (morphine 0.05 mg/kg) in the postoperative period (48 h) will be recorded. Postoperative nausea and vomiting will be recorded in the same periods as those used for pain assessment. Rescue treatment of postoperative nausea and vomiting, will be treated with ondansetron (0.1 mg/kg) if needed. Side effects such as pruritus will also be noted.

Statistics:

Statistical analyses will be performed with a statistical package (SPSS version 11.0; SPSS, Chicago, IL).All data will be presented as mean±sd. Demographic data will be compared by using standard t-tests; comparison of incidence data between groups performed by using Fisher's exact tests. A P value < 0.05 will be considered significant.

Payment:

There is NO financial benefit or reimbursement for participation in the study.

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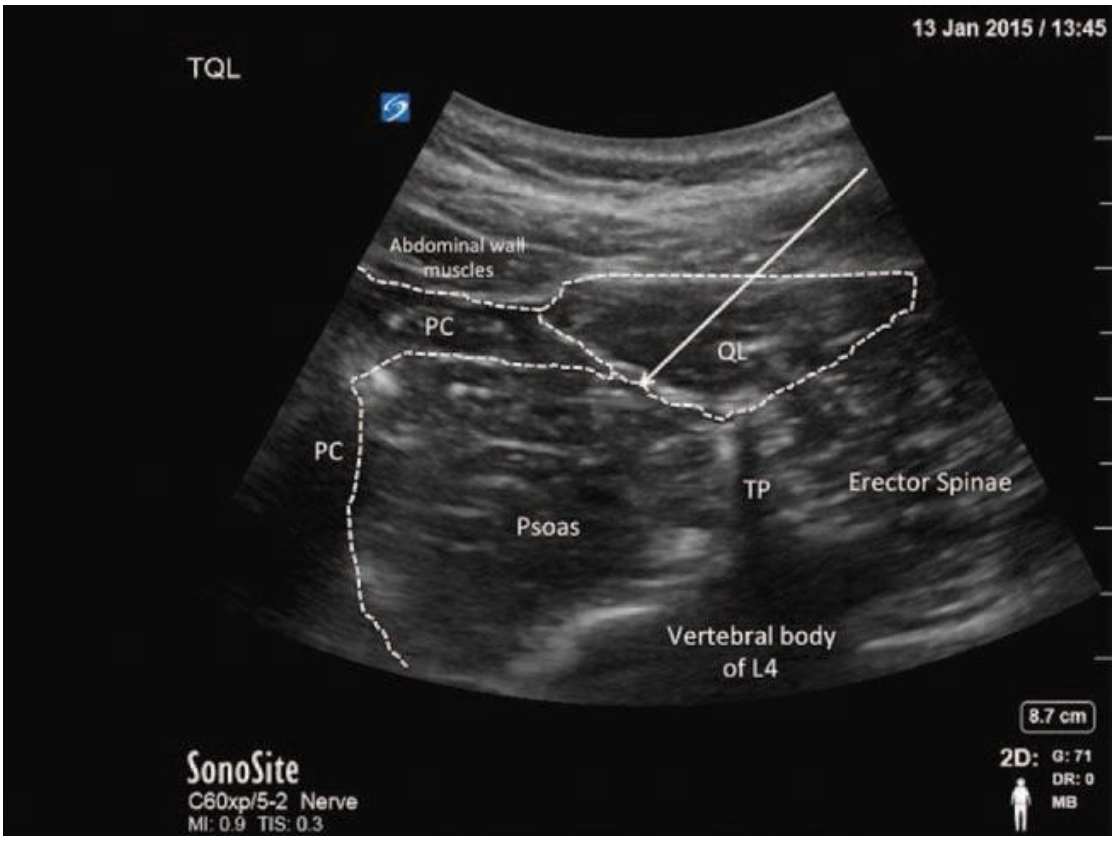

Figure 1: the QLB

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The QL block is performed with the patientin the lateral position. The triangular quadratus lumborum (QL) muscleis adherent to the apex of the transverse process of vertebraL4. Theneedle penetrates the QL muscle with an in-plane approachfrom the posterior side of theultrasound probe. The target point isthe interfascial plane between the QL and the psoas major musclejust deep to the transversalis fascia. Note: A deep recess coveredby peritoneum extends between the abdominal wall muscles andthe psoas major muscle to the anterior side of the QL muscle. Ananterior approach to QL blockade carries a risk of puncture of thisrecess. PC = peritoneal cavity; TP = transverse process.

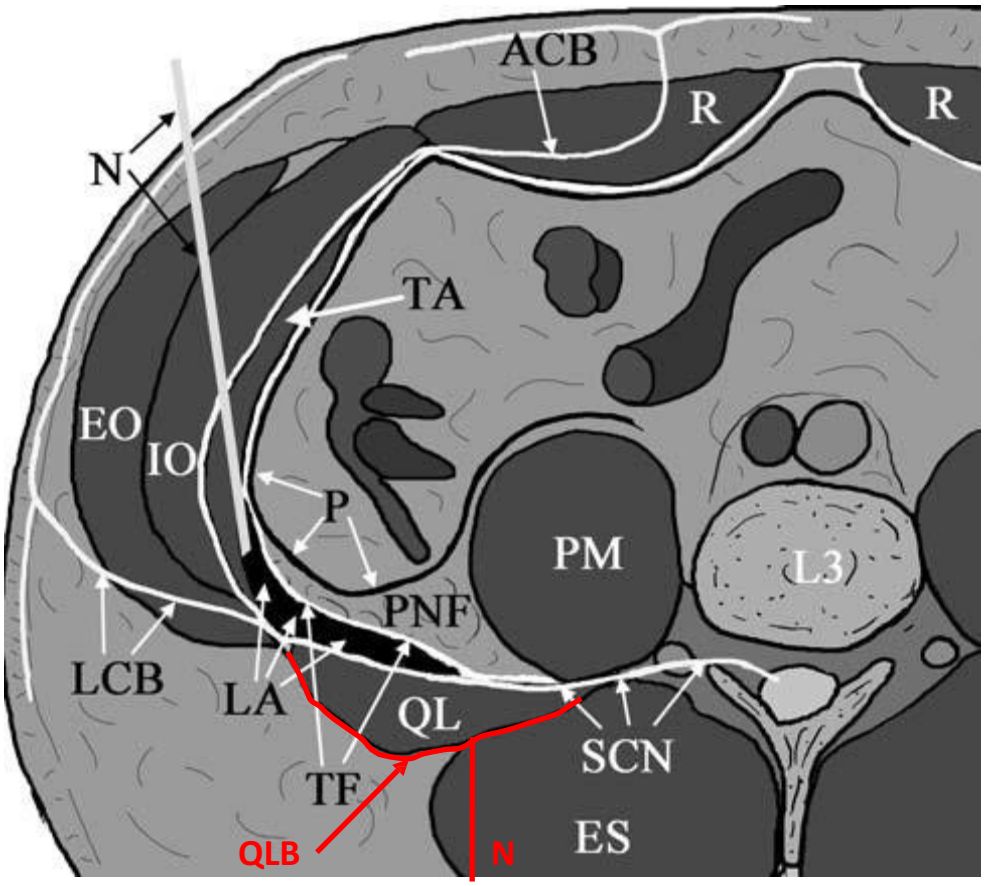

Figure 2: the TFPB

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The red marks and red arrow labeled by this paper's author.

The white marks and white arrow shows transverse diagram through the abdomen above the iliaccrest. The course of the subcostal nerve (SCN) is indicated, includingthe lateral cutaneous branch (LCB) and the anterior cutaneous branch(ACB). The nerve does not actually pass along this transverse plane asit inclines downwards. The location of the local anesthetic (LA)across the anterior surface of the quadratus lumborum (QL) andbehind the transversalis fascia (TF) is shown, and the needle position(N), perinephric fat (PNF), peritoneum (P), and transversalis fascia(TF) are indicated. The following muscles are involved: rectusabdominis (R), erector spinae (ES), psoas (PM), transversus abdominis(TA), internal oblique (IO), and external oblique(EO)

The red marks and red arrow shows QLB(quadratus lumborum block). A needle approach through the quadratus lumborummuscle with the patient placed in the lateral position. The transmuscular approach avoids the risk of unintentionalpenetration of the peritoneal recessbetween the abdominal wall muscles and the psoas major.