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Ultrasound-guided quadratus lumborum block: a powerful way for reducing postoperative pain

Xuechen Long, MBBS[a,*], Yibo Yin, MBBS[b], Wenjun Guo, MBBS[c], Ling Tang, MBBS[a]

Abstract
Ultrasound-guided quadratus lumborum block (QLB) has been gradually carried out in clinical practice. However, some clinical evidence is contradictory, and no studies have summarized and described these results. The authors reviewed the anatomical characteristics of QLB and summarized the advantages and disadvantages of four puncture methods, so as to facilitate the clinical application of QLB.

Keywords: clinical application, quadratus lumborum block, thoracolumbar fascia, ultrasound

Introduction

The quadratus lumborum block (QLB), first proposed by Blanco in 2007[1], is a well-established method for perioperative analgesia. It is an extension method of transversus abdominis plane block (TAPB) and has been shown in previous studies to provide better pain relief and longer duration compared to TAPB by blocking both surface somatic pain and visceral pain[2,3]. While patient-controlled epidural analgesia or patient-controlled intravenous analgesia are commonly used, they carry the risk of postoperative nausea and vomiting, excessive sedation, enteroparalysis, and even respiratory depression[4].

In contrast, nerve blocks are free of these risks, making QLB a promising method for clinical application. With advancements in technology, the proficiency of anesthesiologists in using ultrasound has also increased, making ultrasound-guided nerve blocks more accurate, less invasive, and more beneficial for patients[5]. Because there is no obvious breakthrough sensation, QLB can only be performed using ultrasound-guided puncture techniques. Based on the increasing clinical interest in QLB, we summarize the anatomical structure of QLB and the four techniques of QLB systematically. The application of QLB in different surgical procedures is described in combination with the latest research findings.

[a]Department of Anesthesiology, Northern Jiangsu People's Hospital, Yangzhou, [b]Department of Anesthesiology, Shanghai Chest Hospital, Shanghai and [c]Department of Anesthesiology, The First Affiliated Hospital of Wannan Medical College, Wuhu, China

*Corresponding author. Address: Department of Anesthesiology, Northern Jiangsu People's Hospital, No. 98 Nantong West Road, Yangzhou City, Yangzhou 225009, China.Tel.:+86 18315305065 E-mail: 458844740@qq.com (X. Long).

HIGHLIGHTS

- The anatomy of quadratus lumborum block (QLB) is systematically introduced.
- The advantages and disadvantages of four methods of QLB are summarized.
- The application of QLB in different types of surgery is reported.

Anatomical basis of QLB

The quadratus lumborum (QL) muscle is located in the posterior region of the abdomen, positioned on either side of the spine. It begins at the inferior border of the 12th rib and L1–L4 transverse process, and terminates at the superior border of the iliac crest. The QL is situated medially to the psoas muscle (PM), laterally to the latissimus dorsi, and posterior to the erector spinae (ES)[6]. The primary function of the QL is to provide stability to the spine, while also assisting in respiration and maintaining stability in the thorax. The thoracolumbar fascia (TLF), which is a fusion of tendon and fascia that encases the back muscles extending from the thorax to the lumbar spine, is a crucial anatomical structure for ultrasound-guided puncture as it affects the diffusion and distribution of drugs[7]. The anterior layer of the TLF is positioned anterior to the QL and the PM and is a continuation of the transversus abdominis fascia. It can be divided cephalad into two layers, with the inner layer being continuous with the internal thoracic fascia and the outer layer being fused with the arcuate ligament of the diaphragm. The middle layer of the TLF extends laterally to the lateral side of the QL and anterior to the latissimus dorsi, and joins with the anterior TLF to form the tendon membrane at the beginning of the transversus abdominis muscle. The posterior layer of the TLF covers the back of the ES[7–10]. The drug may diffuse along the TLF, posterior to the arcuate ligament, into the thoracic paravertebral space and intercostal space, thereby blocking the thoracic nerve and thoracic sympathetic trunk. Additionally, the TLF serves as not only a pathway for drug diffusion but also has branches of the spinal nerve and sympathetic nerve and is rich in mechanical stimuli and pain receptors[11,12].

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Four piercing routes of QLB

The four puncture approaches for QLB (QLB1 or lateral QLB, QLB2 or posterior QLB, QLB3 or anterior/transmuscular QLB, and QLB4 or intramuscular QLB) are named according to the position of the needle tip in relation to the QL[13]. QLB1 means that the patient should lie supine with the ultrasound probe placed under the costal margin of the midaxillary line and between the anterior superior iliac spine. After penetrating the transversus abdominia aponeurosis with the tip of the needle under direct vision, the anesthesiologist can push the local anaesthetic between the transversus abdominis and the QL. At this time, the local anaesthetic can spread into the paravertebral space of the thoracic segment[14]. QLB2 means that the patient is in the lateral position and the convex array probe is placed perpendicular to the midaxillary line between the ilium and the costal margin. The probe is moved posteriorly until the QL, the PM and the ES are displayed. Compared with other methods, the injection position of QLB2 is more superficial and the ultrasonic imaging is clearer. The QL is separated from the tip of the needle and the peritoneum, making QLB safer and avoiding the risk of intraperitoneal injection and intestinal injury[15]. QLB3 means that the liquid is injected between the QL and the PM, reaching deep into the anterior layer of the TLF[16]. The patient is placed in the lateral decubitus position, and the convex array probe is placed vertically on the posterior axillary line at the level of the iliac crest, where the cloverleaf pattern can be visualized. The puncture needle is inserted at a 30° angle from the posterior edge of the probe and passes through the QL to reach the space between the QL and the ES, where local anaesthetic can be injected. The rotation of the probe by 90° longitudinally confirms the distribution of the local anaesthetic, which spreads longitudinally from the iliac crest to the 12th rib between the QL and the ES. QLB4 is different from other QLB techniques. It involves the penetration of the QL fascia, where the local anaesthetic is injected[17]. Figure 1 shows the puncture direction of QLB.

Clinical studies and autopsy studies have shown that the block levels of QLB1 are between T7 and L1 and that the drug mainly diffuses in the transversus abdominis plane[18]; the block levels of QLB2 are between T7 and L1 and the drug diffuses in the middle layer of the TIF[18]; the block levels of QLB3 are between T7 and L2, and the drug can spread to the lumbar and thoracic paravertebral spaces[12]. According to the method described by Murouchi, the block levels of QLB4 are between T7 and T12, and this method has some analgesic effect after caesarean section[19]. Table 1 summarizes the characteristics of QLB in the four puncture approaches.

Clinical application of QLB

Currently, ultrasound-guided QLB is commonly used in hip joint and lower limb surgeries, caesarean section surgeries, urological surgeries, paediatric surgeries, gastrointestinal surgeries, and spinal surgeries.

Hip joint and lower limb surgeries

The findings from a meta-analysis indicate that the use of QLB has the potential to decrease postoperative pain and the need for opioid medication in individuals undergoing total hip joint replacement surgery who receive general anaesthesia or spinal
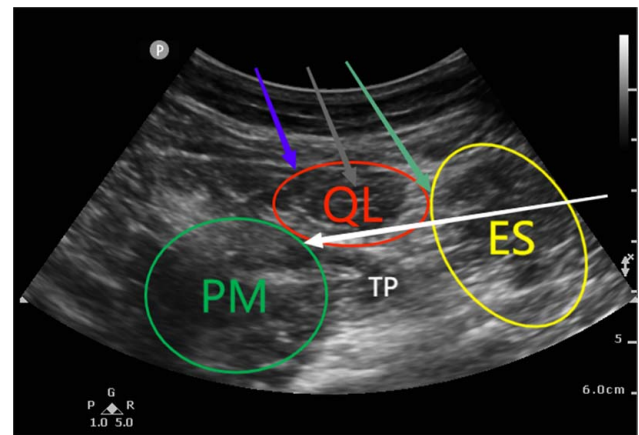

Figure 1. Place the ultrasound probe horizontally above the iliac crest, revealing the three layers of muscles for transversus abdominis plane block. Continue to slide the probe horizontally towards the posterior abdominal wall. Under ultrasound guidance, the "clover" structure formed by the psoas major (PM), erector spinae (ES), and quadratus lumborum (QL) muscles, with the transverse process as the handle, can be seen. The blue, green, white, and grey arrows represent the puncture directions and injection positions for QLB1, QLB2, QLB3, and QLB4, respectively.

anaesthesia[20]. Cadaveric specimens studies have found that QLB3 is different from QLB1 and QLB2, with a more consistent spread of the dye in different specimens, reaching the L1 to L3 nerve roots within the QL and the PM[18]. Therefore, there is currently research exploring the application of QLB3 for postoperative pain management after total hip joint replacement surgery. Altparmak and colleagues reported a case of using a combination of QLB3 and sciatic nerve block as an anaesthetic method for hip surgery in a patient with multiple injuries. This method provided satisfactory anaesthesia for the patient without interfering with their airway and without changing their position[21]. Tulgar et al.[22]. compared the effectiveness of traditional erector spinae plane block (ESPB) and QLB in providing postoperative pain relief for patients undergoing hip joint and proximal femur surgery, and found that compared to the standard intravenous pain control regimen, both ESPB and QLB improved patients' pain quality. Compared to the lumbar plexus block, the QLB injection site is relatively superficial, with advantages such as relatively simple and safe operation, less pain during the procedure, and fewer complications. Research by Kukreja et al.[23]. shows that in patients undergoing total hip joint replacement surgery, QLB3 can provide satisfactory postoperative pain relief, reduce the visual analogue scale pain score in the first 24 h after surgery, decrease the cumulative use of opioids, and improve patient satisfaction. A recent study on total hip replacement surgery indicated that multimodal pain control combined with a posterior lumbar fascia block did not reduce the use of opioid drugs in the 24 h post-surgery. This may be due to the fact that the posterior lumbar fascia block does not block the lumbar plexus[24].

Caesarean section surgeries

The pain after caesarean section surgery includes physical pain caused by the incision in the abdominal wall, inflammatory pain caused by the release of inflammatory substances after trauma,

Comparison of the four puncture approaches for QLB

	QLB1	QLB2	QLB3	QLB4
Block range	T7–L1	T7–L1	T7–L2	T7–T12
Patient position	Supine/lateral position	Supine/lateral position	Lateral position	Supine/lateral position
Injection site	Lateral border of the QL at the junction with the transversus abdominis fascia	Middle layer of the TLF on the posterolateral side of the QL	Anterior layer of the TLF between the PM and the QL	Internal the QL
Operation difficulty	Simple	Simple	Difficult	Simple
Safety	Low risk of puncture	Low risk of puncture	Risk of intraperitoneal organ injury and lower limb muscle weakness	Low risk of puncture
Applicable surgeries	Abdominal operation	The best puncture approach for cesarean section	Hip surgery	Lower abdominal operation

PM, psoas major; QLB, quadratus lumborum block; QLB1, lateral QLB; QLB2, posterior QLB; QLB3, anterior/transmuscular QLB; QLB4, intramuscular QLB; TLF, thoracolumbar fascia.

and strong and persistent uterine contractions caused by the uterine involution after pregnancy and delivery. QLB can block both physical and visceral pain at the same time and is a non-systemic medication without the use of opioid drugs, which is beneficial for breastfeeding. It has unique advantages in post-operative pain relief after caesarean section[12,25,26]. QLB can reduce the consumption of opioid pain relievers after surgery, which helps to reduce the occurrence of adverse reactions such as excessive sedation, respiratory depression, nausea, vomiting, and others caused by opioid pain relievers after caesarean section. It does not affect the care of newborns and breastfeeding by the puerperae[27]. The application of 0.2% ropivacaine for QLB2 with a continuous catheter and combined with non-steroidal anti-inflammatory drugs and acetaminophen for postoperative pain relief can significantly reduce the visual analogue scale pain score of postoperative mothers (0 at rest and 3 during activity). The puerperae can remove the catheter on the third day after surgery, achieving opioid-free pain relief after caesarean section[28]. As previously mentioned, ESPB and QLB have comparable pain-relieving effects after hip joint surgery. There are no significant differences in the pain-relieving effects, complications, and recovery quality of the two in caesarean section surgery[29]. When patients receive intrathecal morphine, QLB only improves the pain score at rest for the first 6 h after surgery (no significant improvement in pain score at other time points within 48 h after surgery), and QLB cannot reduce the consumption of morphine in the first 24 h after surgery[30].

Urological surgeries

Patients with bladder cancer often need to undergo radical cystectomy and have a high mortality rate after surgery. Epidural analgesia has been commonly used in the past, but it may increase the likelihood of low blood pressure, postoperative nausea and vomiting, and the duration of catheterization[31]. A group of authors have found that although epidural analgesia is better than QLB2 for pain relief in bladder cancer patients 2 and 4 h after surgery, there is no significant difference in pain 24 h after surgery, and there is no significant difference in the consumption of opioid drugs in the first 2 days after surgery with both methods[32]. In addition, patients undergoing percutaneous nephrolithotomy, preoperative QLB on the surgical side can reduce the consumption of opioid drugs after surgery and shorten the time from PACU to the first time walking after surgery, reducing the length of hospital stay[33].

Paediatric surgeries

Surgeries often come with pain, which can cause a lot of distress for children. Insufficient pain relief may result in reduced long-term pain tolerance and more pain response[34]. Dexmedetomidine, a highly selective α-2 adrenergic receptor agonist, is becoming increasingly popular in paediatric surgeries due to its ability to produce dose-dependent sedation, anxiolysis, and analgesia without causing respiratory depression[35]. Interfascial administration of dexmedetomidine as an adjuvant to QLB has been found to have a better analgesic effect than intravenous administration, leading to a reduction in the amount of morphine used, lower pain scores, and an extended time to the first request for pain relief[36]. In comparison to TAPB in surgeries such as unilateral inguinal hernia repair or testicular excision, QLB has been shown to reduce the number of patients who require pain relief within 24 h after surgery, extend postoperative pain relief time, and result in higher satisfaction among parents of children[37]. Additionally, QLB reduces the possibility of a prolonged hospital stay, which can be a potential side effect of traditional caudal epidural block[38]. In lower abdominal surgeries, the transmuscular approach of the QL (TQL) may provide a more effective analgesic effect in comparison to the intramuscular approach of the QL. However, it is important to note that the TQL approach may also elevate the likelihood of quadriceps muscle weakness[3].

Gastrointestinal surgeries

Stomach and colon cancers are frequently encountered in surgical procedures for lower abdominal cancers. The main approaches to treatment are open radical surgery and laparoscopic surgery. While laparoscopic surgery is minimally invasive, it can still result in moderate to severe postoperative pain, which can impede the patient's recovery process. Although TAPB has the ability to alleviate postoperative pain and enhance the quality of patient recovery, its scope of coverage is limited and its duration is brief, and it is not effective in mitigating visceral pain[39–41]. On the other hand, QLB has been shown to be more effective in pain management following abdominal surgery compared to TAPB. This could be due to its broader diffusion of local anaesthetic, which might obstruct the pathways of both the abdominal wall nerves and the visceral nerves[42]. A clinical study involving 77 patients demonstrates that QLB is able to significantly decrease the use of morphine by patients in the 24 h following laparoscopic colorectal cancer surgery. Furthermore, the pain scores of patients in the QLB group are lower than those of the TAPB group during periods of rest or activity. In contrast, no significant

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differences are found between QLB and TAPB in regards to other factors, including morphine consumption after 48 h, postoperative nausea and vomiting, sedation scores, time taken for first walking, bowel function recovery time, and hospital stay[43]. A study evaluating the effects of QLB on postoperative pain and recovery in colorectal cancer patients reveals that QLB significantly reduces the consumption of sufentanil during the perioperative period of laparoscopic colorectal surgery and eases postoperative pain[44]. A meta-analysis of eight studies demonstrates that compared to TAPB, QLB significantly improves postoperative pain for abdominal surgery patients in the first 2, 4, 6, 12, and 24 h following surgery, extends the duration of pain relief, and decreases the consumption of morphine after 24 h[45].

Spinal surgeries

Lumbar disc surgery is a frequently performed procedure for alleviating leg and lower back pain; however, it is often accompanied by intense postoperative discomfort. It is crucial for patients to have access to effective postoperative analgesia methods that produce minimal adverse reactions. Adequate postoperative pain management can enhance the patient's ability to be active, decrease the risk of complications like deep vein thrombosis, and increase overall patient satisfaction[46,47]. General anaesthesia is a commonly used anaesthetic regimen, but the use of larger amounts of anaesthetic drugs can result in a slow awakening post-surgery and a higher occurrence of adverse reactions. If the amount of anaesthetic drugs is reduced to ensure anaesthetic safety, it can negatively impact the effectiveness of the anaesthesia[48]. General anaesthesia is a commonly used anaesthetic regimen, but the use of larger amounts of anaesthetic drugs can result in a slow awakening post-surgery and a higher occurrence of adverse reactions. Decreasing the usage of anaesthetic drugs for the purpose of ensuring anaesthetic safety can negatively affect the efficacy of the anaesthesia[48]. Two earlier studies[49,50] indicated that QLB demonstrated favourable results in spinal surgical applications, where local anaesthetic drugs could target the transverse processes and inhibit the posterior branches of the lumbar nerves, resulting in pain relief. Regrettably, both of these studies have since been withdrawn. In a more recent study examining the impact of QLB on postoperative pain management following lumbar disc herniation surgery, it was found that administering QLB after the surgery enhanced the patient's comfort levels both during periods of rest (0 and 2 h postoperatively) and activity (0, 2, 4, 8, and 16 h postoperatively)[51]. Wilton et al.[52]. successfully utilized the continuous QLB to decrease the amount of postoperative morphine needed by patients undergoing lumbar spinal fusion. At present, there are limited reports on the application of QLB in spinal surgery. Other nerve blocking techniques, such as the transversus thoracis muscle block[46] and the thoracolumbar interfascial plane block[53], have demonstrated effectiveness in spinal surgical procedures, but there is not yet a widely agreed upon conclusion regarding their efficacy and safety compared to other methods.

Mechanism of action of QLB under ultrasound guidance

At present, the specific anaesthetic mechanism of QLB is not yet fully understood. The diffusion of local anaesthetics from the TIF

to the paravertebral space may play an important role in paravertebral blockade. The TLF contains mechanoreceptors, nociceptors, and sympathetic nerve fibres. Local anaesthetics can spread along the TIF to the paravertebral space of the thoracic vertebrae, blocking multiple segmental somatic nerves and thoracic sympathetic trunks. Cadaver studies have shown that when performing the TQL at the L4, the dye can spread cranially to the thoracic paravertebral space, staining the thoracic sympathetic trunk and ventral branches of the T9–T10 spinal nerves[12]. Similarly, in cadaver studies of posterior lumbar block at the L3–4, the spread of the dye to the T10 paravertebral space was observed, blocking the T10–L1 nerve roots. When performing subcostal TQL at the L1–2 level, the dye can spread to the T9–T12 paravertebral space, blocking the T9–L1 nerve roots and even reaching the T7 level[54]. However, some studies suggest that the amount of local anaesthetic spreading to the paravertebral space is small, and paravertebral blockade may not play a major role. Instead, the primary mechanism of action of QLB may be the direct action of local anaesthetics on spinal nerve branches, sympathetic nerves, mechanoreceptors, and nociceptors within the TLF[55].

Types, concentrations, dosages, and duration of action for local anaesthetics in ultrasound-guided QLB

At present, there is no clinical consensus on the types, volumes, and concentrations of local anaesthetics for QLB. Ropivacaine, a novel long-acting, pure levorotatory amide local anaesthetic, has lower cardiotoxic and neurotoxic effects compared to bupivacaine and is now widely used in QLB. For unilateral QLB, the recommended local anaesthetic dosage is 0.2–0.4 mL/kg, with the option of using 0.2–0.5% ropivacaine[10]. When performing bilateral blocks, the dosage should be adjusted to ensure that it does not exceed the toxicity threshold; 150 mg of ropivacaine is considered relatively safe for QLB[19]. The increased intra-thoracic and intra-abdominal pressure in pregnant women may lead to a wider range of QLB blockade. Mitchell et al.[56]. reported the use of bupivacaine as a local anaesthetic for QLB, with concentrations of 0.125–0.175% and volumes of 0.2–0.4 mL/kg. The dosages for paediatric patients depend on factors such as weight, age, and the surgical site, and there is currently no uniform dosing regimen. The duration of action for QLB may last for over 24 h[19].

Concurring complications of QLB under ultrasound guidance

Overall, QLB is a relatively safe nerve block technique, and reports of complications associated with QLB are rare. When performing QLB under ultrasound guidance, it is important to ensure that there are no blood vessels in the path of the needle to prevent abdominal organ injury, bleeding, and haematoma. Currently, there have been two reported cases of haematoma after QLB[57]. According to a report by Wikner[58], a patient undergoing gynaecological laparoscopic surgery received QLB1 (0.25% bupivacaine 20 ml). The patient displayed unilateral hip flexion and knee joint extension weakness that lasted for 18 h post-surgery. This adverse effect may have been caused by the spread of the local anaesthetic to the L2 intervertebral space or

the lumbar plexus. The blocking of the sympathetic nerve by QLB can reduce peripheral vascular resistance, leading to a decrease in blood pressure and a compensatory increase in heart rate. According to a report by Sá et al.[59], two patients undergoing gastrointestinal surgery received QLB2. After 30–40 min, the patients exhibited a noticeable decrease in blood pressure and an increase in heart rate. After excluding other factors, it was believed that this adverse reaction may have been related to sympathetic blockade caused by the spread of the local anaesthetic to the intervertebral space and epidural space. This was corrected by administration of atropine and rapid fluid resuscitation.

Conclusion

As perioperative pain management receives increasing attention, multimodal analgesic approaches dominated by regional anaesthesia are widely advocated. QLB is a highly effective regional anaesthesia technique that is known for its wide blocking range, long-lasting pain relief, and excellent pain management results. With a simple and safe administration process and minimal risk of complications, QLB can be effectively utilized as part of a comprehensive pain management plan following surgery. Compared to the conventional TAPB, QLB offers a wider range of pain relief and can extend the duration of pain relief while reducing the amount of pain medication required. QLB is characterized by its ability to block visceral pain, making it a promising approach in abdominal surgical pain management. It is expected to be an effective method for postoperative pain control, reducing the use of opioid medications, promoting gastrointestinal function recovery, shortening time to first ambulation, and accelerating postoperative recovery. In the future, further research is needed to explore the use of QLB for the treatment of chronic pain. Additionally, the mechanism of local anaesthetic diffusion via different techniques of QLB remains unclear, and the optimal administration method, drug concentration, and dose have yet to be determined. Due to the unclear mechanism of local anaesthetic diffusion through various QLB approaches, and as the diffusion of local anaesthetic affects the ultimate clinical outcome, more research is required in the future to investigate diffusion mechanisms and conduct randomized controlled trials on perioperative analgesia. It is expected that the use of QLB in clinical practice will continue to increase in popularity.

Ethical approval

Ethics approval was not required for this Review.

Consent

Informed consent was not required for this Review.

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Author contribution

All authors listed have made contributions to the review. X.C.L. participated in collecting the data, analyzing the data, and drafting the manuscript. X.C.L. designed the study and revised the manuscript.

Conflicts of interest disclosure

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1. Name of the registry: NIL.
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Data availability statement

All data quoted in the paper are extracted from available published literature.

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