Regional anaesthesia and fascial plane blocks for abdominal surgery: a narrative review

Philippa Lindsey May, Thomas Wojcikiewicz

Department of Anaesthetics, Royal Surrey County Hospital, Surrey, UK

Contributions: (I) Conception and design: Both authors; (II) Administrative support: Both authors; (III) Provision of study materials or patients: Both authors; (IV) Collection and assembly of data: Both authors; (V) Data analysis and interpretation: Both authors; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Dr. Philippa Lindsey May. Department of Anaesthetics, Royal Surrey County Hospital, Guildford, Surrey, UK. Email: philippa.may4@nhs.net.

Background and Objective: Major abdominal surgery can cause significant post-operative pain and stress. Thoracic epidural analgesia (TEA) remains the gold-standard in its management. However, it is not without side effects or potential risks. Regional techniques might offer an alternative when TEA is not possible. The aim of this review is to outline the regional anaesthetic options currently in use for pain relief in major abdominal surgery, including their techniques, indications, advantages and potential complications. A brief overview of the anatomy of the abdominal wall is included for context. The current regional techniques used to provide pain relief include the rectus sheath (RS) block, transversus abdominis plane (TAP) block, erector spinae plane (ESP) block and quadratus lumborum (QL) block. The ideal block choice in major abdominal surgery is not currently clear, therefore this narrative review aims to summarise the relevant evidence and aid decision making for anaesthetists.

Methods: A review of the literature was conducted on MEDLINE and PubMed between August and October 2021. Studies were required to be full text in English. Meta-analyses, randomized controlled trials, observational studies (cohort and case-control) and other related review articles were included. A narrative analysis with the evaluation of advantages and disadvantages of each technique was conducted.

Key Content and Findings: This review contains a detailed explanation of the anatomy of the anterior and posterior abdominal walls relevant to abdominal field blocks. It also includes the techniques, indications, advantages and potential complications of the four commonly used blocks: the RS block, TAP block, ESP block and QL block, and relates these back to the gold standard of TEA.

Conclusions: The techniques outlined here provide alternatives to TEA. They are particularly useful for those patients in whom neuraxial techniques are contraindicated, however they may be superior to TEA with regard to opiate consumption and mobilisation post-operatively. QL and ESP blocks show particular promise due to the potential for paravertebral spread and visceral pain relief, however further research is required in this area.

Keywords: Regional anaesthesia; major abdominal surgery; regional field blocks; abdominal field blocks; perioperative pain management

Received: 02 November 2021; Accepted: 09 June 2022; Published: 30 September 2022.

doi: 10.21037/dmr-21-83

View this article at: https://dx.doi.org/10.21037/dmr-21-83

© Digestive Medicine Research. All rights reserved.

Introduction

Post-operative pain can be a significant problem for patients undergoing major abdominal surgery (1). Much of this arises from the abdominal wall incision (2). This results in a significant stress response and post-operative pain (2). If not managed appropriately, patients can suffer poor wound healing (3), excessive post-operative opiate requirements, ileus, urinary retention and delayed rehabilitation (4).

Thoracic epidural analgesia (TEA) remains a keystone in the management of post-operative pain as part of a multimodal analgesic strategy (5). However, whilst TEA provides excellent pain relief, patients can be delayed in their rehabilitation and discharge due to hypotension requiring vasopressor support and motor block impacting on mobilisation and urinary retention. There is also the not insignificant risk of neurological damage (6).

The accessibility of ultrasound has provided an opportunity to develop and expand regional techniques as an alternative to TEA. Field blocks can have a role in major abdominal surgery when attempts at TEA fail or TEA is contraindicated. These include the transversus abdominis plane (TAP) block, erector spinae plane (ESP) block, quadratus lumborum (QL) block and the rectus sheath (RS) block. A catheter can often be inserted to prolong the duration of action of these blocks. Challenges regarding the uptake of these techniques surround lack of clarity of block choice and lack of familiarity with the procedures themselves. We present the following article in accordance with the Narrative Review reporting checklist (available at https://dmr.amegroups.com/article/view/10.21037/dmr-21-83/rc).

Objectives

The goal of this review is to cover the relevant anatomy and explore each regional block in turn. Through analysis of recent literature, potential uses of these blocks are discussed along with their limitations, plus gaps in the literature are highlighted to guide further work in this area.

Methods

A review of the literature was conducted on MEDLINE and PubMed between August and October 2021. Studies were required to be full text in English. Meta-analyses, randomized controlled trials, observational studies (cohort and case-control) and other related review articles were included. A narrative analysis with the evaluation of advantages and disadvantages of each technique was conducted. *Table 1* outlines the search methodology in more detail.

Overview of abdominal wall anatomy

The abdominal wall consists of a number of muscle and soft tissue layers surrounding the peritoneum. The nerves supplying the abdominal wall run between these layers. It can be thought of as two distinct areas; anterior and posterior. The anterior abdominal wall is bound superiorly by the xiphisternum and inferior costal margins, inferiorly by the pelvic bone and inguinal ligament and laterally by the posterior axillary line. It is contained between the subcutaneous tissue of the abdomen and peritoneum and consists of three muscle layers, each contained within a fascial plane. These muscles are the external oblique, internal oblique and transversus abdominis.

The external oblique muscle arises from the 5th–12th ribs and runs inferomedially to the iliac crest and pubic tubercle. It forms an aponeurosis at the midclavicular line and forms the inguinal ligament at its inferior margin. The internal oblique muscle arises from the iliac crest and runs superomedially to the 10th–12th ribs and linea alba. It blends into the aponeurosis of the external oblique muscle to form the RS. The transversus abdominis muscle arises from the 7th–12th costal cartilages, the thoracolumbar fascia and the iliac crest. It runs transversely across the abdomen to insert into the linea alba, also contributing to the RS.

The rectus abdominis muscle also contributes to the abdominal wall. This muscle runs caudocranially from the pubic crest to the xiphoid process and 5th–7th costal cartilages. It is a paired muscle, separated at the midline by the linea alba, and it lies within the RS. Anteriorly, the RS consists of the aponeuroses of the external and internal obliques and attaches to the rectus abdominis by transverse tendons, dividing the rectus abdominis and preventing local anaesthetic spread. Posteriorly, the RS is formed by the internal oblique and transversus abdominis aponeuroses and remains undivided. The posterior RS continues to the arcuate line where it then passes superficially to the rectus muscle.

The nervous supply to the anterior abdominal wall arises from the anterior rami of T6–L1 and runs in between the internal oblique and transversus abdominis muscles within

© Digestive Medicine Research. All rights reserved.

Table 1 Search methodology

Items	Specification
Date of search	August 2021 to October 2021
Databases and other sources	PubMed and MEDLINE
Search Terms used	“Major Abdominal Surgery”, “Abdominal Surgery”, “Post-Operative Pain Relief”, “Regional Anaesthesia”, “Thoracic Epidural Analgesia”, “Fascial Plane Blocks”, “Abdominal Field Blocks”, “Quadratus Lumborum Block”, “Rectus Sheath Block”, “Transversus Abdominis Plane Block”, “Erector Spinae Block”
	Filters: English language, human studies
Timeframe	1989–2021
Inclusion and exclusion criteria	Inclusion criteria: English language, human studies, full text, meta-analyses, randomized controlled trials, observational studies (cohort and case-control) and other related review articles
Selection process	Articles independently selected by Dr. Philippa Lindsey May and corroborated by Dr. Thomas Wojcikiewicz

the TAP. T6–T9 enter medial to the anterior axillary line; T10–L1 entering increasingly laterally. These nerves have numerous interconnections within the TAP which can be thought of as plexi. Three such areas have been described (7). These are the intercostal plexus, the TAP plexus near the deep circumflex artery and the RS plexus near the inferior epigastric artery.

The posterior abdominal wall is bounded superiorly by the diaphragm, inferiorly by the pelvic girdle, laterally by the lateral abdominal wall and medially by the thoracolumbar vertebrae. It consists of the QL, psoas major and thoracolumbar fascia. The QL muscle arises from the iliac crest and runs superiorly to the L1–L4 transverse processes and 12th rib. The psoas major muscle lies anterior to the QL and originates from T12–L5 transverse processes, running inferolaterally to insert onto the lesser trochanter of the femur. The thoracolumbar fascia is a large diamond-shaped area of connective tissue that arises from the spinous processes of the thoracic and lumbar vertebrae. It is an insertion site for a number of muscles and acts to stabilise and transfer load. It splits into three layers; the superficial/posterior and middle layers surround erector spinae, and the middle and deep/anterior layers surround QL and psoas major. The anterior layer is also known as the transversalis fascia.

TEA

The thoracic epidural is typically inserted at the level of T6–T9 for abdominal procedures, after which local anaesthetic and opiates are delivered via bolus or infusion. The benefits of this technique include mitigation of the surgical stress response and reduced post-operative pulmonary complications whilst providing excellent pain relief (8). However, this technique does not come without risks. These relate to the procedure itself, such as epidural haematoma, abscess and nerve damage (9), and to the side effects of the blockade, such as hypotension, urinary retention and impaired motor function. Whilst the risks are potentially catastrophic for the patient, the side effects can also cause significant problems. With the advent of enhanced recovery after surgery (ERAS) protocols, patients are typically expected to mobilise and resume enteral feeding early to improve recovery (10), however the side effects of central neuraxial blockade can often hinder these efforts. A recent Cochrane review (11) comparing TEA with patient-controlled analgesia following intra-abdominal surgery found marginally improved pain relief in the epidural group, however this was accompanied by increased pruritis and hypotension and a not insignificant failure rate. Failure rates as high as 47% (12) have been reported.

© Digestive Medicine Research. All rights reserved.

Given these issues, there has been a growing interest in non-neuraxial regional anaesthesia as an alternative. Whilst failure rates are variable for each block, the use of ultrasound allows for infiltration under direct vision, and the potential for epidural haematoma or abscess is nullified. These regional blocks are also a useful option for patients in whom TEA is contra-indicated, such as patients on anticoagulants, those with coagulopathy or sepsis or those who are uncooperative (13).

RS block

The RS block was first described in 1899 and was initially used for abdominal wall muscle relaxation during laparotomy (14) . It is now commonly used for analgesia after midline surgical incisions.

This technique blocks the terminal branches of T9–T11 which run in between the internal oblique and transversus abdominis muscles to penetrate the posterior wall of the rectus abdominis muscle and end in an anterior cutaneous branch supplying the skin of the umbilical area.

Originally, this block was performed blindly, relying on the sensation of a 'pop' as a blunt needle passes through the fascial layer of the anterior RS. However, such blind techniques lend themselves to complications such as inadequate block, intra-abdominal infiltration and visceral perforation, plus the proximity of the epigastric arteries results in a high risk of vascular injury. Indeed, the correlation between the depth of the posterior sheath and weight, height or body surface area has been shown to be poor (15). The ultrasound guidance allows local anaesthetic infiltration under direct vision and is performed as follows:

With the patient supine, the transducer is placed laterally at the level of the umbilicus in the transverse position. The needle is typically inserted in-plane from lateral to medial to pierce the anterior RS then advanced until the needle tip rests on the posterior RS. Care must be taken not to advance deeper through the transversalis fascia and peritoneum. A minimum 10 mL of local anaesthetic administered per side is usually sufficient for successful blockade in adults.

It is important to note that the RS block provides somatic but not visceral pain relief (16). Therefore, it has been superseded by newer blocks which will be explored below. This is due to the potential for visceral pain relief provided by the newer blocks which is absent in the RS block (17,18).

TAP block

Indications for the TAP block include open and laparoscopic colonic, urological, gynaecological and obstetric surgery (19). It is worth noting that in obstetric surgery it is only used for pain relief if the patient has had a general anaesthetic, as it is not superior to epidural or spinal analgesia (19).

The TAP block was first described in 2001 (20) and aims to block the T6–L1 spinal nerves that lie within the TAP. This was traditionally performed anatomically via the lumbar triangle of Petit (21); the anatomical space bounded by latissimus dorsi, external oblique and the iliac crest (22). However, ultrasound guidance has become the preferred option due to improved efficacy (23,24). There are a number of approaches in current use, the most common being the lateral approach. A high-frequency (5–13 MHz) linear array probe is typically used. With the patient supine, the probe is placed transversely in the mid-axillary line between the 12^{th} rib and iliac crest with in-plane needling from anterior to posterior (25). Local anaesthetic volumes of 20–30 mL are usually sufficient to observe spread between the internal oblique and transversus abdominis. This block is performed bilaterally and covers T10–L1, and is therefore suitable for lower abdominal incisions.

For upper abdominal incisions, a subcostal TAP block can be performed to cover the lower thoracic nerves and T6–T9. These enter more medially than T10–L1, therefore the probe is placed close to the midline on the subcostal margin parallel to the ribs. It is moved along the subcostal margin until the transversus abdominis muscle is identified posterior to the rectus abdominis. Both the subcostal and lateral TAP blocks can be combined to provide extensive abdominal wall coverage, and catheters can be inserted to allow prolonged blockade (26).

There have been questions over the spread of local anaesthetic in TAP blocks and whether it covers the required region (27). Cadaveric studies with the use of methylene blue dye followed by dissection to visualise spread, and human studies involved radio-labelled 0.5% lidocaine followed by CT imaging and sensory testing have shown reliable spread to cover T8–L1 and T7–L1 dermatomes respectively (28,29). The continuous TAP block (with a catheter) has been shown to be non-inferior to TEA. Two studies, which compared pain scores and opioid consumption after laparoscopic and open colorectal surgery respectively, demonstrated similar results in both groups

© Digestive Medicine Research. All rights reserved.

after 24 hours (30,31).

Complications include failure, with a failure rate of 30% reported in one study (32), catheter dislodgement (33) and the need for catheter re-siting (32). Anatomical techniques can result in peritoneal perforation and resulting bowel (34), liver (35) or vascular injury (36). There have also been case reports of femoral nerve block (37,38) thought to be due to misplacement of the needle between the transversus abdominis muscle and the transversalis muscle, resulting in spread of the local anaesthetic to the fascia iliaca.

Despite these issues, TAP blocks remain a useful tool in the management of post-operative pain, particularly for those patients in whom neuraxial blockade is contraindicated.

ESP block

The ESP block is a relatively new technique, first described in 2016 (39). It has been used in a wide variety of situations including acute pain, chronic pain, thoracic and abdominal procedures (40). The erector spinae muscle is a group of muscles that run craniocaudally either side of the vertebral column deep to rhomboid major. Local anaesthetic is introduced deep to erector spinae at the tip of the vertebral transverse process, then spreads craniocaudally by up to four vertebral levels. It is thought to block the ventral and dorsal rami of the spinal nerves. A catheter can be introduced to provide longer term pain relief.

Clinically, ESP blocks have been shown to provide both somatic and visceral pain relief (9,41,42). Visceral pain is dull, poorly localised pain that is transmitted, in part, via the sympathetic chain. This lies within the paravertebral space and is one of the targets of the paravertebral block, alongside somatic fibres. ESP blocks target a different anatomical space when compared to the paravertebral block; therefore, the observation of visceral pain relief is intriguing. The mechanism for this remains unclear, with local paravertebral and epidural spread, lymphatic spread (43) or involvement of the thoracolumbar fascia (44) all described.

A recent review article suggests that the weight of scientific opinion is leaning towards paravertebral spread as the most likely mechanism for the ESP block's clinical effects (45). Of the 16 cadaveric studies of thoracic ESP blocks published to date, 12 have found evidence of paravertebral dye penetration. Cadaveric studies have limitations, as the tissue in living subjects is subject to mechanical forces and fluid shifts that cannot be replicated in preserved tissue. Radiological studies in living subjects have shown spread of contrast into the paravertebral and even epidural spaces (46).

More recently, a meta-analysis looked at 8 randomised controlled trials with 442 patients comparing ESP block and subcostal TAP blocks for pain relief after laparoscopic cholecystectomy (47) and found that patients who underwent ESP block had less opiate use post-operatively, although this was not significant. Opiates are typically used as part of the multi-modal analgesic model to help manage visceral pain (48). Further studies are needed to explore this relationship; however, this could be further evidence for paravertebral involvement in ESP blocks.

QL block

The QL block was first described in 2007 as a variant of the TAP block (49) and is indicated in caesarean section, midline laparotomy, laparoscopic procedures and hip surgery. There are a number of approaches for the QL block; anterior, posterior and lateral (50) and they can be performed with the patient either supine or in the lateral position depending on the preferred approach. The first described approach is the lateral QL block. In this technique the probe is placed on the lateral abdominal wall superior and parallel to the iliac crest. The needle is inserted in plane in the anteroposterior trajectory to deposit local anaesthetic in the fascial plane surrounding the QL muscle. The posterior QL block is carried out in a similar manner but with a steeper needle trajectory to introduce the local anaesthetic deeper into the same fascial plane. The anterior QL block is carried out with the patient in the lateral position. The lumbar vertebral bodies are identified and the needle inserted in plane in a lateral trajectory. The local anaesthetic is introduced in between the QL muscle and psoas major; this is also termed the transmuscular approach.

The QL block is thought to provide somatic and visceral pain relief through local anaesthetic spread to the thoracic sympathetic trunk at T7–L1 depending on the site of injection (50). The transversalis fascia, which lines the transverse abdominal muscle and QL, is continuous with the endothoracic fascia in the thoracic cage, and therefore local anaesthetic can spread posterior to the transversalis fascia and into the thoracic paravertebral space (6,51). More recent studies have explored this further in an attempt to clarify paravertebral spread in the various approaches in current use (52). They have shown that the

© Digestive Medicine Research. All rights reserved.

posterior QL block (also termed the QL block type 2) shows paravertebral spread, but the transmuscular/anterior QL block does not. There has also been a recent flurry of cadaveric studies published with variable findings. The anterior approach has been most studied, with three studies showing paravertebral spread (50,53,54) and one not (55). Only one study has looked into the posterior QL approach in cadaveric specimens, and this documented paravertebral involvement (50).

The QL block has been postulated as a potential alternative to epidural analgesia given the potential for paravertebral spread and visceral pain relief in addition to somatic pain relief.

The ideal outcome for QL to be viewed as superior to TEA would be lower opiate requirements and faster rehabilitation, measured through markers such as removal of urinary catheter and time to discharge, as well as an improved side effect profile. QL blocks already have the advantage shared by all regional techniques in that they are not neuraxial, therefore do not carry the risks of spinal cord damage via direct trauma, infection or haematoma.

A randomised controlled trial published in 2019 compared repeated anterior QL blocks with continuous TEA following laparoscopic nephrectomy (56). The study found that repeated QL blocks had a similar 24-hour cumulative morphine requirement, comparable postoperative pain scores and sensory blockade, higher post-operative mean arterial pressure (MAP), no difference in the incidence of postoperative nausea-vomiting (PONV) and paraesthesia, and shorter urinary catheter usage, compared to the continuous epidural analgesia following transperitoneal laparoscopic nephrectomy.

However, another similar trial comparing anterior QL to TEA for post-operative pain relief after open nephrectomy failed to show any significant difference between morphine requirements or pain scores (57). Further studies are required to clarify this relationship; however, it is promising that QL blocks have not been shown to be inferior to TEA.

Anatomically, the QL block and the TAP block target the same fascial plane, therefore a number of recent studies [2016–2019] have compared the two techniques. These have been neatly summarised in a meta-analysis (58). Eight randomised controlled trials involving 564 patients were included and the results revealed lower pain scores at 2, 4, 6, 12 and 24 postoperative hours, lower postoperative morphine consumption and longer duration of postoperative analgesia in the QL group compared to the TAP group. In addition, there were no differences in PONV. Another large meta-analysis, also published in 2020, compared post-operative pain scores and opiate requirements after caesarean section for patients receiving TAP blocks, neuraxial analgesia or QL blocks (45). Thirty-one trials were included with 2,188 patients. The findings of this meta-analysis were that TAP blocks and QL blocks were provided equivalent pain relief when compared to inactive controls, however there was insufficient data to directly compare the two techniques. This remains an active area of study within the anaesthetic community.

Discussion

Ultrasound-guided fascial plane blocks can be indicated in a wide array of abdominal surgery. With the number of ageing and co-morbid patients undergoing surgery increasing, fascial plane blocks are an increasingly attractive option when TEA is not feasible. The benefit of regional field blocks when compared to central neuraxial blockade lies in the minimisation of the risks, resulting in improved rehabilitation potential whilst still providing excellent pain relief or in cases where neuraxial blockade is contraindicated or not possible (*Table 2*).

Choice of block remains a contentious issue, with no clear technique proving superior analgesia than the others. RS blocks have the advantage of familiarity. However, this provides only somatic pain relief, therefore resulting in a reliance on opiates post-operatively and all their associated side effects. TAP, QL and ESP all have the potential for paravertebral spread given the anatomy of the target fascial plane, however the reliability of this is lacking from the literature. Anatomical studies, both cadaveric and *in vivo*, have provided mixed results.

Block selection will depend on a number of factors; operator ability, operator experience and the infrastructure in place to care for catheter infusions post-operatively.

© Digestive Medicine Research. All rights reserved.

Table 2 Summary of techniques

Technique	Characteristics	Difficulties	Safety	Efficacy
TEA	Local anaesthetic ± opiate or other adjuncts injected into epidural space	Typically a landmark procedure	Risk of neuraxial injury from haematoma, abscess or direct nerve injury	Gold standard post-operative pain relief
	A single catheter can be inserted	Contraindicated in coagulopathy and sepsis	Side effects of hypotension, decreased mobility	Somatic and visceral analgesia
RS	Local anaesthetic injected between rectus abdominus and posterior RS	Requires bilateral blocks to cover abdomen	Risk of peritoneal infiltration or visceral injury	Provides somatic analgesia only
	Catheters can be inserted	High risk of catheter dislodgement		
TAP	Local anaesthetic injected in the plane between the internal oblique and transversus abdominis muscles	Multi-level blocks often required	Blind technique carries risk of peritoneal infiltration, bowel hematoma and transient femoral nerve palsy	Thought to provide somatic and visceral analgesia due to paravertebral spread
	Catheter can be inserted	High risk of catheter dislodgement		
ESP	Local anaesthetic injected deep to erector spinae at the tip of the vertebral transverse process	Simple to perform, well tolerated	Risk of pleural perforation if landmarks not identified	Thought to provide somatic and visceral analgesia due to paravertebral spread
	Catheter can be inserted	Risk of catheter dislodgement		
QL	Local anaesthetic injected deep to QL muscle	Curvilinear probe often required	Needle trauma to kidney due to proximity of psoas muscle	Thought to provide somatic and visceral analgesia due to paravertebral spread
	Catheter can be inserted	Patient might need to be positioned laterally		

TEA, thoracic epidural analgesia; RS, rectus sheath; TAP, transversus abdominis plane; ESP, erector spinae plane; QL, quadratus lumborum.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Chris Jones and Leigh Kelliher) for the series "Current Issues in Analgesia for Major Surgery" published in *Digestive Medicine Research*. The article has undergone external peer review.

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://dmr.amegroups.com/article/view/10.21037/dmr-21-83/rc

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://dmr.amegroups.com/article/view/10.21037/dmr-21-83/coif). The series "Current Issues in Analgesia for Major Surgery" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Open Access Statement: This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with the strict proviso that no changes or edits are made and the original work is properly cited (including links to both the formal publication through the relevant DOI and the license). See: https://creativecommons.org/licenses/by-nc-nd/4.0/.

© Digestive Medicine Research. All rights reserved.

References

1. Cachemaille M, Grass F, Fournier N, et al. Pain Intensity in the First 96 Hours After Abdominal Surgery: A Prospective Cohort Study. Pain Med 2020;21:803-13.
2. McMahon S, Koltzenburg M. editors. Wall and Melzack's Textbook of Pain E-dition. 5th ed. Philadelphia: Churchill Livingstone (Elsevier Health Sciences), 2005.
3. Baratta JL, Schwenk ES, Viscusi ER. Clinical consequences of inadequate pain relief: barriers to optimal pain management. Plast Reconstr Surg 2014;134:15S-21S.
4. Tan M, Law LS, Gan TJ. Optimizing pain management to facilitate Enhanced Recovery After Surgery pathways. Can J Anaesth 2015;62:203-18.
5. Manion SC, Brennan TJ. Thoracic epidural analgesia and acute pain management. Anesthesiology 2011;115:181-8.
6. Onwochei DN, Børglum J, Pawa A. Abdominal wall blocks for intra-abdominal surgery. BJA Educ 2018;18:317-22.
7. Rozen WM, Tran TM, Ashton MW, et al. Refining the course of the thoracolumbar nerves: a new understanding of the innervation of the anterior abdominal wall. Clin Anat 2008;21:325-33.
8. Rigg JR, Jamrozik K, Myles PS, et al. Epidural anaesthesia and analgesia and outcome of major surgery: a randomised trial. Lancet 2002;359:1276-82.
9. Cook TM, Counsell D, Wildsmith JA, et al. Major complications of central neuraxial block: report on the Third National Audit Project of the Royal College of Anaesthetists. Br J Anaesth 2009;102:179-90.
10. Pöpping DM, Elia N, Van Aken HK, et al. Impact of epidural analgesia on mortality and morbidity after surgery: systematic review and meta-analysis of randomized controlled trials. Ann Surg 2014;259:1056-67.
11. Salicath JH, Yeoh EC, Bennett MH. Epidural analgesia versus patient-controlled intravenous analgesia for pain following intra-abdominal surgery in adults. Cochrane Database Syst Rev 2018;8:CD010434.
12. Kooij FO, Schlack WS, Preckel B, et al. Does regional analgesia for major surgery improve outcome? Focus on epidural analgesia. Anesth Analg 2014;119:740-4.
13. Curatolo M. Adding regional analgesia to general anaesthesia: increase of risk or improved outcome? Eur J Anaesthesiol 2010;27:586-91.
14. Schleich D. Schmerzlose Operationen. 4th ed. Berlin: Springer; 1899:240-58.
15. Willschke H, Bösenberg A, Marhofer P, et al. Ultrasonography-guided rectus sheath block in paediatric anaesthesia--a new approach to an old technique. Br J Anaesth 2006;97:244-9.
16. Sviggum HP, Niesen AD, Sites BD, et al. Trunk blocks 101: transversus abdominis plane, ilioinguinal-iliohypogastric, and rectus sheath blocks. Int Anesthesiol Clin 2012;50:74-92.
17. Seidel R, Wree A, Schulze M. Does the approach influence the success rate for ultrasound-guided rectus sheath blocks? An anatomical case series. Local Reg Anesth 2017;10:61-5.
18. Chedgy E, Lowe G, Tang R, et al. Surgical placement of rectus sheath catheters in a cadaveric cystectomy model. Ann R Coll Surg Engl 2018;100:120-4.
19. Baeriswyl M, Kirkham KR, Kern C, et al. The Analgesic Efficacy of Ultrasound-Guided Transversus Abdominis Plane Block in Adult Patients: A Meta-Analysis. Anesth Analg 2015;121:1640-54.
20. Rafi AN. Abdominal field block: a new approach via the lumbar triangle. Anaesthesia 2001;56:1024-6.
21. McDonnell JG, O'Donnell B, Curley G, et al. The analgesic efficacy of transversus abdominis plane block after abdominal surgery: a prospective randomized controlled trial. Anesth Analg 2007;104:193-7.
22. Netter FH. Atlas of Human Anatomy. Summit: CIBA-GEIGY Corporation, 1989.
23. Tsai HC, Yoshida T, Chuang TY, et al. Transversus Abdominis Plane Block: An Updated Review of Anatomy and Techniques. Biomed Res Int 2017;2017:8284363.
24. McDermott G, Korba E, Mata U, et al. Should we stop doing blind transversus abdominis plane blocks? Br J Anaesth 2012;108:499-502.
25. Hebbard P, Fujiwara Y, Shibata Y, et al. Ultrasound-guided transversus abdominis plane (TAP) block. Anaesth Intensive Care 2007;35:616-7.
26. Gómez-Ríos MÁ, Paech MJ. Postoperative analgesia with transversus abdominis plane catheter infusions of levobupivacaine after major gynecological and obstetrical surgery. A case series. Rev Esp Anestesiol Reanim 2015;62:165-9.
27. Webster K. The transversus abdominis plane (TAP) block: abdominal plane regional anaesthesia. Update Anaesth 2008;24:24-9.
28. McDonnell JG, O'Donnell BD, Tuite D, et al. The regional abdominal field infiltration (RAFI) technique: computerised tomographic and anatomical identification of a novel approach to the transversus abdominis neuro-vascular fascial plane. Anesthesiology 2004;101:A899.
29. McDonnell JG, O'Donnell BD, Farrell T, et al. Transversus abdominis plane block: a cadaveric

© Digestive Medicine Research. All rights reserved.

and radiological evaluation. Reg Anesth Pain Med 2007;32:399-404.
30. Niraj G, Kelkar A, Hart E, et al. Comparison of analgesic efficacy of four-quadrant transversus abdominis plane (TAP) block and continuous posterior TAP analgesia with epidural analgesia in patients undergoing laparoscopic colorectal surgery: an open-label, randomised, non-inferiority trial. Anaesthesia 2014;69:348-55.
31. Rao Kadam V, Van Wijk RM, Moran JI, et al. Epidural versus continuous transversus abdominis plane catheter technique for postoperative analgesia after abdominal surgery. Anaesth Intensive Care 2013;41:476-81.
32. Niraj G, Kelkar A, Jeyapalan I, et al. Comparison of analgesic efficacy of subcostal transversus abdominis plane blocks with epidural analgesia following upper abdominal surgery. Anaesthesia 2011;66:465-71.
33. Fiorini F, Sessa F, Congedo E, et al. Transversus Abdominis Plane Block: A New Gold Standard for Abdominal Surgery. J Anesth Crit Care Open Access 2016;4:00145.
34. Frigon C, Mai R, Valois-Gomez T, et al. Bowel hematoma following an iliohypogastric-ilioinguinal nerve block. Paediatr Anaesth 2006;16:993-6.
35. Farooq M, Carey M. A case of liver trauma with a blunt regional anesthesia needle while performing transversus abdominis plane block. Reg Anesth Pain Med 2008;33:274-5.
36. Shirozu K, Kuramoto S, Kido S, et al. Hematoma After Transversus Abdominis Plane Block in a Patient With HELLP Syndrome: A Case Report. A A Case Rep 2017;8:257-60.
37. Salaria ON, Kannan M, Kerner B, et al. A Rare Complication of a TAP Block Performed after Caesarean Delivery. Case Rep Anesthesiol 2017;2017:1072576.
38. Manatakis DK, Stamos N, Agalianos C, et al. Transient femoral nerve palsy complicating "blind" transversus abdominis plane block. Case Rep Anesthesiol 2013;2013:874215.
39. Forero M, Adhikary SD, Lopez H, et al. The Erector Spinae Plane Block: A Novel Analgesic Technique in Thoracic Neuropathic Pain. Reg Anesth Pain Med 2016;41:621-7.
40. Kot P, Rodriguez P, Granell M, et al. The erector spinae plane block: a narrative review. Korean J Anesthesiol 2019;72:209-20.
41. Chin KJ, Malhas L, Perlas A. The Erector Spinae Plane Block Provides Visceral Abdominal Analgesia in Bariatric Surgery: A Report of 3 Cases. Reg Anesth Pain Med 2017;42:372-6.
42. Kwon HM, Kim DH, Jeong SM, et al. Does Erector Spinae Plane Block Have a Visceral Analgesic Effect?: A Randomized Controlled Trial. Sci Rep 2020;10:8389.
43. Otero PE, Fuensalida SE, Russo PC, et al. Mechanism of action of the erector spinae plane block: distribution of dye in a porcine model. Reg Anesth Pain Med 2020;45:198-203.
44. Blanco R, Ansari T, Riad W, et al. Quadratus Lumborum Block Versus Transversus Abdominis Plane Block for Postoperative Pain After Cesarean Delivery: A Randomized Controlled Trial. Reg Anesth Pain Med 2016;41:757-62.
45. El-Boghdadly K, Desai N, Halpern S, et al. Quadratus lumborum block vs. transversus abdominis plane block for caesarean delivery: a systematic review and network meta-analysis. Anaesthesia 2021;76:393-403.
46. Schwartzmann A, Peng P, Maciel MA, et al. Mechanism of the erector spinae plane block: insights from a magnetic resonance imaging study. Can J Anaesth 2018;65:1165-6.
47. Koo CH, Hwang JY, Shin HJ, et al. The Effects of Erector Spinae Plane Block in Terms of Postoperative Analgesia in Patients Undergoing Laparoscopic Cholecystectomy: A Meta-Analysis of Randomized Controlled Trials. J Clin Med 2020;9:2928.
48. Davis MP. Drug management of visceral pain: concepts from basic research. Pain Res Treat 2012;2012:265605.
49. Blanco R. 271. Tap block under ultrasound guidance: the description of a “no pops” technique. Regional Anesthesia & Pain Medicine 2007;32:130.
50. Elsharkawy H, El-Boghdadly K, Barrington M. Quadratus Lumborum Block: Anatomical Concepts, Mechanisms, and Techniques. Anesthesiology 2019;130:322-35.
51. Carney J, Finnerty O, Rauf J, et al. Studies on the spread of local anaesthetic solution in transversus abdominis plane blocks. Anaesthesia 2011;66:1023-30.
52. Tamura T, Kitamura K, Yokota S, et al. Spread of Quadratus Lumborum Block to the Paravertebral Space Via Intramuscular Injection: A Volunteer Study. Reg Anesth Pain Med 2018;43:372-7.
53. Dam M, Moriggl B, Hansen CK, et al. The Pathway of Injectate Spread With the Transmuscular Quadratus Lumborum Block: A Cadaver Study. Anesth Analg 2017;125:303-12.
54. Sondekoppam RV, Ip V, Johnston DF, et al. Ultrasound-guided lateral-medial transmuscular quadratus lumborum block for analgesia following anterior iliac crest bone graft harvesting: a clinical and anatomical study. Can J Anaesth

© Digestive Medicine Research. All rights reserved.

2018;65:178-87.
55. Adhikary SD, El-Boghdadly K, Nasralah Z, et al. A radiologic and anatomic assessment of injectate spread following transmuscular quadratus lumborum block in cadavers. Anaesthesia 2017;72:73-9.
56. Aditianingsih D, Pryambodho, Anasy N, et al. A randomized controlled trial on analgesic effect of repeated Quadratus Lumborum block versus continuous epidural analgesia following laparoscopic nephrectomy. BMC Anesthesiol 2019;19:221.
57. Elsharkawy H, Ahuja S, Sessler DI, et al. Subcostal Anterior Quadratus Lumborum Block Versus Epidural Block for Analgesia in Open Nephrectomy: A Randomized Clinical Trial. Anesth Analg 2021;132:1138-45.
58. Liu X, Song T, Chen X, et al. Quadratus lumborum block versus transversus abdominis plane block for postoperative analgesia in patients undergoing abdominal surgeries: a systematic review and meta-analysis of randomized controlled trials. BMC Anesthesiol 2020;20:53.

doi: 10.21037/dmr-21-83
Cite this article as: May PL, Wojcikiewicz T. Regional anaesthesia and fascial plane blocks for abdominal surgery: a narrative review. Dig Med Res 2022;5:42.

© Digestive Medicine Research. All rights reserved.