NEW REGIONAL ANAESTHESIA FASCIAL BLOCKS: TRANS-MUSCULAR QUADRATUS LUMBORUM BLOCK AND ERECTOR SPINAE BLOCK IN POSTOPERATIVE PAIN MANAGEMENT IN COLONIC SURGERY

A thesis submitted for the degree of

Doctor of Philosophy

In the Discipline of Acute Care Medicine

Adelaide Medical School

Faculty of Health and Medical Sciences

The University of Adelaide

VASANTH RAO KADAM

AUGUST 2022

Table of Contents

Abstract

Post-operative pain management is a key element of enhanced recovery after surgery (ERAS) during elective surgery. This PhD program focused on the new myo-fascial blocks in managing peri-operative pain. The program also focused on simplifying the description of performing the regional block under ultrasound guidance, including illustrated diagrams with coloured images. This thesis is composed of five chapters:

Chapter 1 - Literature search on new fascial plane blocks.

Chapter 2 - Anatomical and ultrasound description of two trans-muscular quadratus lumborum block (TQL) approaches and its application in abdominal surgery, and clinical use of these new techniques at L2 or L4 levels with catheter insertion for post-operative analgesia in open abdominal surgery.

Chapter 3 - A prospective randomized study comparing the ultrasound guided TQL catheter technique with a surgical pre-peritoneal catheter for post-operative analgesia in abdominal surgery. To investigate the incidence of acute kidney injury (AKI) in this surgical population, we retrospectively studied AKI during the peri-operative period.

Chapter 4 - Comparison of ultrasound guided erector spinae plane (ESP) block versus wound infiltration (WI) for post-operative analgesia in laparoscopic colonic surgery in a prospective randomised study. This chapter also includes an observational study of plasma ropivacaine levels after an ESP block.

Chapter 5 - Conclusion and future directions for perioperative pain management strategies in colonic surgery.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

VASANTH RAO KADAM

01/8/2022

Acknowledgments

Firstly, I was fortunate to meet Professor Sanjib Adhikary during my research paper presentation on fascial block in Florida at the American Society of Regional Anaesthesia and World Congress on Regional Anaesthesia and Pain Medicine in New York. He was the first to conduct a cadaveric study of this innovative fascial block. I am fascinated by his pioneering work on cadavers and other clinical research. He kindly agreed to collaborate with our study and formalized protocols on these nerve blocks. I thank Professor Guy Ludbrook, my Principal Supervisor, who has constantly guided me academically and encouraged me to conduct research at the highest standard. He attended my research paper presentations at many international conferences and his supportive feedback was very helpful. I thank A/professor Roelof van Wijk, one of my co-supervisors, and Head of Department of Anaesthesia, Critical Care and Peri-operative Services of the Queen Elizabeth Hospital, who has supported me in facilitating research work after my fellowship. Roelof encouraged me to conduct a regional anaesthesia workshop which was a great success with the support of my colleagues. While supervising Dr Sarika Kumar (a postgraduate student) at the Bezel Hazel Institute, I met Dr Ian Westley in the clinical pharmacology laboratory. His collaboration was essential in providing local anaesthetic plasma level analyses. I am grateful to Professor Peter Hewett, my other co-supervisor, for allowing me to do regional anaesthesia research in a group of colorectal patients and for providing giving me with constant support throughout the clinical work. I am also thankful for his supervision and advise on peri-operative care to help improve the patient outcomes. During this research I worked closely with the colorectal fellows Jacob Abraham, Chris Lauder and Jessy Fisher, obtaining valuable knowledge on surgical wound bed catheters. I would like to thank my colleague and friend A/Professor Venkatesan Thiruvenkatarajan, whose critical comments were a huge help in shaping my manuscripts. I also thank my colleagues at the Anaesthesia Department and Acute Pain Service for understanding the importance of research in peri-operative care. I was fortunate to receive a financial grant from the ANZCA research foundation for the first study by higher degree by research. Finally, I would like to thank my wife Jyotsna and son Vivek for their encouragement in doing academic work and putting up with my many hours spent on research. With the support of my family, I was also able to study and complete my diploma at the European Society of Regional Anaesthesia and Pain Therapy held in 2017 in Lugano Switzerland.

Format of thesis

This thesis is by publication and supplemented by narrative, as per the University of Adelaide guidelines. This thesis has five chapters, each with an introduction, manuscripts, and protocols where relevant. This thesis contains six manuscripts, three protocols, and four original studies. The manuscripts are presented in the form that they were published in UK English and were non-solicited. The references follow each manuscript.

The publications are as follows:

Kadam VR, Ludbrook G, van Wijk RM, Hewett PJ, Moran JL, Thiruvenkatarajan V and Williams PJ. **Comparison of ultrasound-guided trans-muscular quadratus lumborum block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery: a randomised controlled trial.** *Anaesthesia* 2019, Nov; 74 (11): 1381–1388. doi: 10.1111/anae.14794.

Kadam VR, Van Wijk RM, Ludbrook GL, Thiruvenkatarajan V. **Anatomical and ultrasound description of two transmuscular quadratus lumborum block approaches at L2 level and their application in abdominal surgery.** *Anaesth Intensive Care*. 2019 Mar;47(2):141-145. doi: 10.1177/0310057X19839931.

Kadam VR, Loo V, Hewett P, Edwards S. **Incidence of acute kidney ınjury during the perioperative period in the colorectal division of surgery - Retrospective study.** *Indian J Anaesth*. 2020 Oct;64(10):894-897. doi: 10.4103/ija.IJA_276_20.

Kadam VR, Ludbrook G, van Wijk R, Thiruvenkatarajan, J. Moran J, Williams P.

Ultrasound-guided transmuscular quadratus lumborum block catheter technique. a reply. *Anaesthesia* 2020, 75, 414–415, DOI:10.1111/anae.14990.

Rao Kadam V. Ultrasound guided continuous transmuscular quadratus lumborum block and transient femoral nerve palsy. Anaesthesia 2017; 72. Available at: http://www.respond2articles.com/ANA/forums/2363/

Kadam VR, Thiruvenkatarajan V. **ESP block: an evolving technique. Letter of response to: The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair.** Chin K, Adhikary S, Sarwani N, Forero M. *Anaesthesia.* 72(4):452-60, 2017.

Kadam VR. **Ultrasound guided trans-muscular quadratus lumborum block, mid-level safe approach for post-operative analgesia for laparotomy. Letter of response to: A cadaver study comparing spread of dye and nerve involvement after three different quadratus lumborum blocks.** L. Carline G. A. McLeod C. Lamb BJA: *British Journal of Anaesthesia,* Volume 117, Issue 3, 1 September 2016, Pages 387–394,published online 24 July 2017.

Kadam VR, Currie J. **Continuous Erector Spinae plane block for Video Assisted Thoracotomy**. *Anaesth Int Care*. 2018;46:243-44.

Kadam VR, Ludbrook G, van Wijk RM, Hewett P, Thiruvenkatarajan V, Edwards S, Williams P and Adhikary S. **A comparison of ultrasound guided bilateral single injection shot Erector Spinae Plane blocks versus wound infiltration for post-operative analgesia in laparoscopic assisted colonic surgery- a prospective randomised study.** *BMC Anesthesiol* (2021) 21:255 https://doi.org/10.1186/s12871-021-01474-8

Report on Comparison of ultrasound guided trans-muscular quadratus lumborum (TQL) block catheter to surgically placed pre-peritoneal catheter (PPC) for postoperative analgesia in abdominal surgery – a prospective randomised study. ANZCA Foundation Research

Article; ANZCA Bulletin Summer 2020. https://www.anzca.edu.au/getattachment/b251d1bf-6398-49e7-9ea5-e0c97be47524/ANZCA-Bulletin-Summer-2020#page=

Kadam VR, Ludbrook GL, Hewett P, Westley I. **Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery** - An observational study. Indian J Anaesth. 2022;66(3):231-232.

Introduction

Post-operative acute pain can occur due to surgical trauma with a possible inflammatory reaction. Post-operative pain management is one of the key elements of Enhanced Recovery After Surgery (ERAS) in any elective surgery. Having pain management strategies in place may help to minimise pain which could potentially speed postoperative recovery, resulting in a reduced length of patient stay. Shorter hospital admissions may also reduce hospital costs. Pain has traditionally been managed with systemic opioids until regional analgesia was introduced [1]. Inserting a thoracic epidural catheter for analgesia is invasive and has the potential for rare neurological complications [1]. Peripheral nerve blocks such as transversus abdominis plane (TAP) block have gained popularity in peri-operative pain management for reducing opioids allowing early recovery for elective colorectal patients [2]. Over the last five years newer posterior fascial blocks such as the trans-muscular quadratus lumborum (TQL) and erector spinae plane (ESP) blocks have further assisted in reducing opioid use and patient length of stay [3,4]. Further research is warranted on the safety of these local anaesthetic (LA) infiltrations and their mechanism of action. There are descriptions of these new TQL and ESP blocks on cadavers and their use in a few studies [3,5,6]. Nevertheless, there are currently no randomized trials on their use in patients undergoing major colorectal surgery patients. Furthermore, the mechanism of action and the description of the ultrasound technique for the TQL block are not clear.

This PhD program focused on the efficacy and safety of these new fascia blocks for peri-operative pain management, as an important aspect of enhanced recovery after surgery. This program also focused on simplifying the description of the block under ultrasound guidance, including illustrated diagrams with coloured images. We included an assessment of cost-efficacy for the TQL block. ESP block single bolus injection has been proven to be beneficial as a part of multimodal analgesia in surgeries involving the thorax and abdomen [3,6-9]. Levobupivacaine, ropivacaine (ROP), and bupivacaine were used in these case studies at various concentrations and volumes. Information on the pharmacokinetics of local anaesthetic (LA) drugs injected into the ESP space in patients undergoing laparoscopic abdominal surgery is not known. Wound infiltration and preperitoneal block studies have shown the benefits of analgesia in abdominal surgeries [10-14]. Surgeons routinely perform

wound infiltration or pre-peritoneal block and I wanted to compare this to the new fascial blocks. Karmakar et al. reported the pharmacokinetic profile of a thoracic para vertebral injection of local anaesthetic [15] but no studies were reported on the ESP block. Our aim was to study the safety profile of ESP block by analysing ropivacaine levels. The overarching aim of the study was to determine the post-operative pain and safety outcomes of these various techniques for major abdominal surgery in the colorectal population.

References:

1. Cook TM, Counsell D, Wildsmith JA, Royal College of Anaesthetists Third National Audit P. Major complications of central neuraxial block: report on the Third National Audit Project of the Royal College of Anaesthetists. *British Journal of Anaesthesia* 2009; **102:** 179-90.

2. Pirrera B, Alagna V, Lucchi A, et al. Transversus abdominis plane (TAP) block versus thoracic epidural analgesia (TEA) in laparoscopic colon surgery in the ERAS program. *Surgical Endoscopy* 2018; **32:** 376-82.

3. Restrepo-Garces CE, Chin KJ, Suarez P, Diaz A. Bilateral continuous erector spinae plane block contributes to effective postoperative analgesia after major open abdominal surgery: A case report. *A A Case Reports* 2017; **9:** 319-21.

4. Ueshima H, Otake H, Lin JA. Ultrasound-guided quadratus lumborum block: An updated review of anatomy and techniques. *Biomed Research International* 2017; **2017:** 2752876.

5. Akerman M, Pejcic N, Velickovic I. A review of the quadratus lumborum block and eras. *Front Med (Lausanne)* 2018; **5:** 44.

6. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: A novel analgesic technique in thoracic neuropathic pain. *Regional Anesthesia Pain Medicine* 2016; **41:** 621-7.

7. Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia* 2017; **72:** 452-60.

8. Rao Kadam V, Currie J. Ultrasound-guided continuous erector spinae plane block for postoperative analgesia in video-assisted thoracotomy. *Anesthesia Intensive Care* 2018; **46:** 243-5.

9. Tulgar S, Selvi O, Kapakli MS. Erector spinae plane block for different laparoscopic abdominal surgeries: Case series. *Case Reports Anesthesiology* 2018; **2018:** 3947281.

10. Beaussier M, El'Ayoubi H, Schiffer E, et al. Continuous preperitoneal infusion of ropivacaine provides effective analgesia and accelerates recovery after colorectal surgery: a randomized, double-blind, placebo-controlled study. *Anesthesiology* 2007; **107:** 461-8.

11. Bertoglio S, Fabiani F, Negri PD, et al. The postoperative analgesic efficacy of preperitoneal continuous wound infusion compared to epidural continuous infusion with local anesthetics after colorectal cancer surgery: a randomized controlled multicenter study. *Anesthesia Analgesia* 2012; **115:** 1442-50.

12. Fustran N, Dalmau A, Ferreres E, et al. Postoperative analgesia with continuous wound infusion of local anaesthesia vs saline: a double-blind randomized, controlled trial in colorectal surgery. *Colorectal Disease* 2015; **17:** 342-50.

13. Ozer A, Yilmazlar A, Ozturk E, Yilmazlar T. Preperitoneal catheter analgesia is an effective method for pain management after colorectal surgery: the results of 100 consecutive patients. *Local Regional Anesthesia* 2014; **7:** 53-7.

14. Zugasti O, Dufur M, Pavon A, et al. Comparison of analgesic efficacy of preperitoneal continuous infusion catheter with epidural analgesia for upper abdominal surgery with subcostal approach. *Regional Anesthesia Pain Medicine* 2014; **39:** e252.

15. Karmakar MK, Ho AM, Law BK, Wong AS, Shafer SL, Gin T. Arterial and venous pharmacokinetics of ropivacaine with and without epinephrine after thoracic paravertebral block. *Anesthesiology* 2005; **103:** 704-11.

Chapter 1- Literature review on new fascial plane blocks

Purpose: the primary aims of this review are to summarize and critique the state of the science on new fascial plane blocks by analysing previous conducted research studies.

Introduction: Problems noted in the search were: no clinical trials in the colorectal surgery population, including drug dosing and safety of drug. The other issues were complex description of the quadratus lumborum block including ultrasound imaging. The questions focused were: what is the description of the block in terms of imaging, needle technique and sonoanatomy interpretation. Does it have real benefit of pain relief after major surgery? Is it superior to existing analgesic techniques? There is lot of evidence in support of ESPB in thoracic surgery but no such evidence in abdominal surgery. Will it play analgesic role in postoperative period?

At the commencement of this project in 2016-17 available literature on fascial blocks was limited. A literature search was undertaken on new fascial plane blocks including wound infiltration, pre-peritoneal catheter for analgesia and pharmacokinetics of local anaesthetics in erector spinae block.

Methods: The area of search was mainly limited to use of these blocks for post-operative analgesia in abdominal surgery. Eligibility: Surgeries included in TQL were open abdominal and laparoscopic surgeries in erector spinae block. Age limit was for adults above 18 years and surgical population was for abdominal surgery. Data items were: local anaesthetic use and analgesia intervention point post-operative period with outcome for post-operative analgesia.

The literature was searched through PubMed, Web of science ScienceDirect, Scopus, Embase, and Google Scholar using the following combinations of various search terms: Quadratus lumborum, transmuscular, blocks, local anaesthetic, Ultrasonography, Ultrasound, Local Anesthesia, Anesthesia, Local, analgesia, Pain, Post-operative and Nerve Block. All types of publication were searched for the time period January 1974 to current. Peer-reviewed case reports, case series, prospective studies, and letters to the editor in English, French, Swedish, Farsi, Turkish, and Japanese were also retrieved. Reports published and posted between January 2012 and February 2018 were also included.

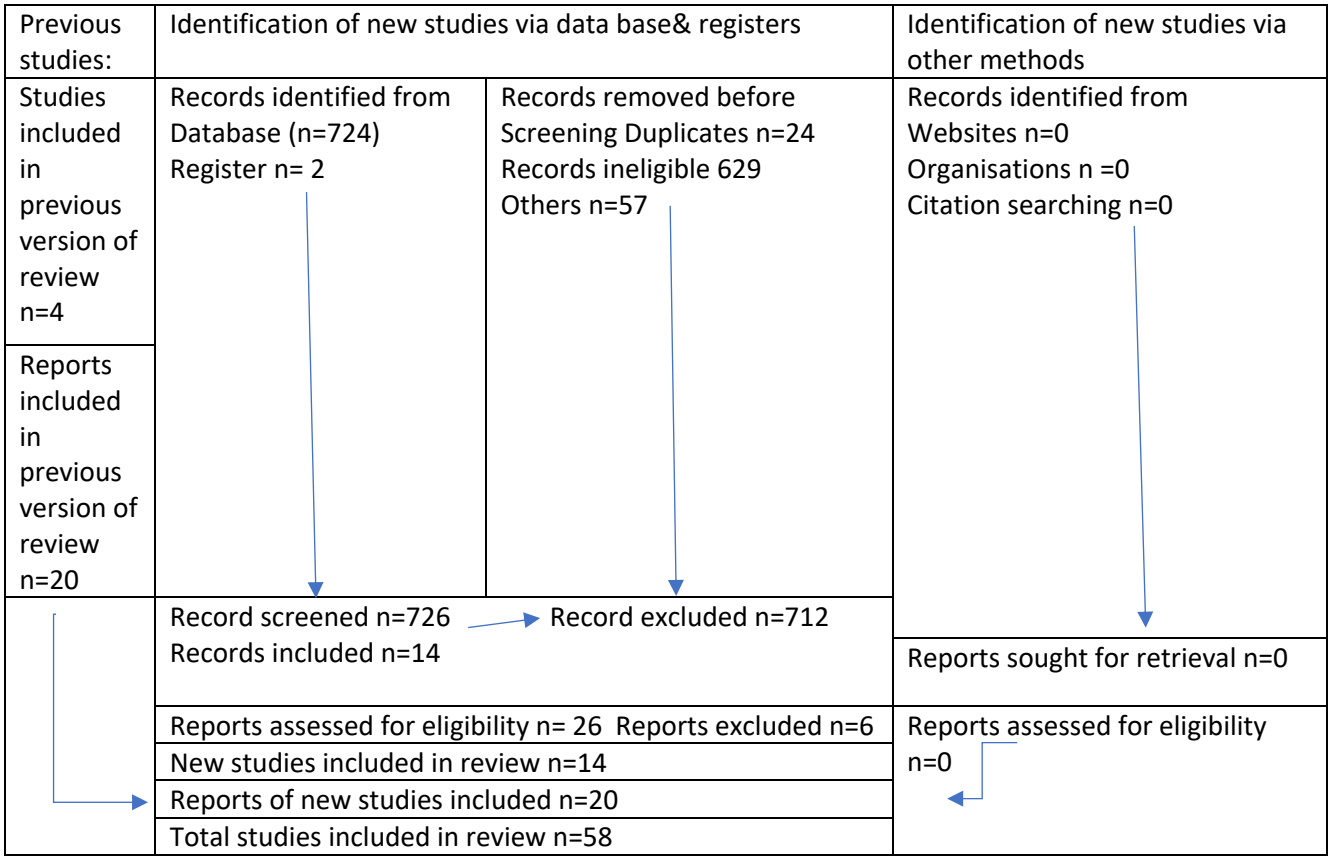
For pre-peritoneal catheter analgesia the literature search was through Embase, Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) <1946 to Present. The search strategy used a combination of various search terms: preperitoneal catheter infusions, continuous preperitoneal, preperitoneal continuous, pre-peritoneal catheter. Similar search was used for wound infiltration techniques for postop -analgesia.

The erector spinae plane (ESP) block literature search was performed using Embase, Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) <2000 to Present. Since this newly developed ultrasound-guided facial block was first discovered in 2016 the contribution to the literature for ESP block was limited when this project was commenced in 2017.

Traditionally systemic opioids were used as analgesics for post-operative pain until neuraxial, spinal and epidural techniques were introduced. As spinal and epidural techniques are in proximity to neurological structures, for safety reasons various peripheral regional analgesic techniques were introduced including fascial plane blocks. This chapter describes the literature on new fascial plane blocks with a short history of older techniques of pain relief compared with current ones.

Results: There were one cadaver study, 14 case reports, and only two randomised controlled trials reporting on the use of TQL block. After the ESPB initial report on novel analgesia technique, under previous studies there were 6 case reports on its use in abdominal surgery, a radiological study, and a cadaveric study. The literature review study details for both blocks shown in flow chart (See fig 1). Since there was minimal literature and block anatomical description was not clear, original authors were contacted at the conference workshop to understand it. This also allowed opportunity to get more skills on the technique of the block. As there were small numbers, no risk bias or quality of evidence grade tool was used.

Fig 1 showing the flow chart of the new fascial blocks review



Systemic use of opioids: The first record of post-operative analgesia was the use of opium in 1784 [1] and later for laparotomy in 1816 [2]. The first use of patient-controlled analgesia (PCA) with an opioid was described by Sechzer in 1967 [3]. Apart from immediate side effects of nausea vomiting, itching, ileus and respiratory depression, opioid misuse and diversion is of major concern [4]. A multimodal approach along with regional analgesia has reduced opioid side effects and improved pain scores [5].

Regional analgesic techniques: Although intravenous, subcutaneous, and intramuscular routes of opioid administration remain important methods of post-operative pain relief, great advances have been made with the introduction of regional techniques such as spinal and epidural injections and infusions.

Spinal analgesia: The first deliberate use of spinal morphine for post-operative analgesia reported in 1909 [6]. In 1973 studies demonstrated opioid receptors in the brain and then in 1977 in the spinal cord [7,8]. Unfortunately, the intrathecal morphine had side effects such as pruritus, nausea, vomiting, urinary retention, and respiratory depression. An intrathecal

mixture of bupivacaine and morphine was associated with less post-operative opioid consumption but has no other advantages over systemic opioids [5].

Epidural: Use of epidural analgesia was described by Jean Sicard [9]. The use of epidural opioids for post-operative pain relief gained acceptance and several studies in the early 1980s confirmed its efficacy [10-14]. There is also concern of rare but serious neurological side effects, hence there is an increasing trend towards peripheral regional nerve blocks [15]. Recent meta-analyses show that the previous benefits of post-operative epidural analgesia may be less promising today when compared to the newer, and less invasive, alternatives [15].

Ultrasound guided regional nerve blocks: The advent of ultrasound has provided real-time visualisation and targeting of major nerves and even the epidural space, where previously these were located with landmark-based "blind" techniques (e.g. loss of resistance, paraesthesia) [15]. Ultrasound is safe and more efficient, and has provided access to newer regional anaesthetic techniques, that are reported to be effective in post-operative pain management in combination with a multimodal analgesic regimen [15]. The emergence of new fascial plane blocks and their use along with multimodal analgesia appears promising in abdominal surgery, but more research is needed.

Transversus Abdominis Plane (TAP) block: TAP was used extensively, but there has been a decline in its use due to its lack of covering visceral pain and therefore being only moderately effective [16]. The current scientific evidence is lacking to definitively identify the surgical procedures, dosing, techniques, and timing that provide optimal analgesia [17]. Meta-analyses have demonstrated the effectiveness of TAP blocks in reducing morphine use and pain in abdominal surgery, despite being limited by a relatively short duration of analgesia [18-21]. A network meta-analysis reported both the efficacy of TAP blocks at 24 hours after surgery, and their reduced efficacy in the longer term, demonstrated by a lack of benefit over the systemic opiate group at 48 hours [22].

Quadratus lumborum and erector spinae plane block: Ultrasound-guided quadratus lumborum (QL) block, a variant of the traditional transversus abdominis plane (TAP) block, may be another option for post-operative pain control. The quadratus lumborum is a deep

muscle of the back that originates from the iliac crest and iliolumbar ligament and inserts onto the 12th rib and transverse processes of the L1–L4 vertebrae.

In 2007, Rafael Blanco et al. described the injection of local anaesthetic (LA) into the QL for postoperative pain management in abdominal surgery [23]. Unlike the TAP block, injection of local anaesthetic occurs more posteriorly at the junction of the external oblique and internal oblique aponeurosis and the QL muscle.

While optimal positioning of the QL block is yet to be fully defined, Blanco et al. have shown that when the injection is performed between the latissimus dorsi and QL muscles, more reliable paravertebral spread occurs [23]. The ability to provide extensive abdominal wall and visceral analgesia (T7–L1) is believed to be the secondary spread of local anaesthetic within the paravertebral space [24,25]. Blanco et al. performed a randomized controlled trial comparing a single shot injection of local anaesthetic versus saline injection in the QL for abdominal surgery and showed a significant decrease in postoperative opioid consumption and dynamic pain scores [24].

Blanco's original approach to QL block suggested deposition of local anaesthetic at the antero-lateral border of the QL, naming this QL block type 1 [23]. However, another potential site of injection, QLB type 2, is posterior to the QL muscle, between the QL and the transversalis fascia [25]. Chakraborty et al. have also performed a successful blockade by inserting a perineural catheter between the QL and the transversalis fascia [26]. Borglum et al. suggested that an ultrasound-guided trans-muscular approach through the QL muscle, and injection of local anaesthetic between the QL and psoas major, may be safer and more efficacious when compared with the initial technique of depositing local anaesthetic into the anterolateral border of the QL muscle [27].

Therefore, we aimed to study the efficacy of the trans-muscular approach. This posterior approach advocated by Borglum also allows for the ability to use the Shamrock sign (Under ultrasound, the QL muscle is seen as a 'superior leaf' of the Shamrock at the apex of the transverse process of L4, erector spinae muscles make up the posterior leaf, psoas major muscle makes the anterior leaf and the transverse process represents the stem connecting the 3 leaves) for a safe and reliable method of injecting local anaesthetic near the paravertebral space. Along with single shot injections of local anaesthetic, catheters have

been placed at various sites for the QL block. Murouchi et al. reported QL Block analgesic effects and pharmacokinetics of LA after Laparoscopic Surgery [28].

Various techniques such as QL blocks (previously described as posterior TAP blocks) have been developed [29] to improve the effectiveness of TAP blocks. This ultrasound-guided technique provides numerous options for the relief of post-operative pain. Among the regional analgesia techniques QL block is one of the most recent and promising peripheral regional nerve blocks [30]. Within the QL block, trans-muscular quadratus lumborum (TQL) block, and erector spinae plane (ESP) block were effective in their initial reports [27,31,32]. Few studies reported an ultrasound-guided trans-muscular approach through the QL muscle, and the injection of local anaesthetic between QL and psoas major may be safer and more efficacious [24,33-35].

A recent systemic meta-analysis reported 27 studies on QL block [36]. Out of the 27, 12 were for laparoscopic procedures and the remainder for open procedures [24,37-61]. TQL block was reported in three trials using ropivacaine [40,42,45]. This review concluded that QL block reduced postoperative opioid consumption with minimal adverse effects, and it was a valid option for post-operative analgesia after abdominal and hip surgeries [36].

A newly developed ultrasound-guided fascial block called erector spinae (ESP) plane block was first discovered in 2016 [32]. The literature on it was limited when this project commenced [62,63]. At that time most of the clinical studies were related to the thoracic region [62,64]. Cadaveric studies were performed to study the extent of LA spread within the ESP [65,66]. The data on its use in abdominal surgery was limited to case reports with no prospective randomised trials [63,67]. Pharmacokinetics studies were undertaken for ultrasound-guided transversus abdominis plane block and in the thoracic paravertebral block [68,69] but plasma ropivacaine level estimation was not performed with this new fascial block. Our aim was to explore the pharmacokinetic profile of local anaesthetics used in the ESP block. Recently, there have been studies on ESP block as a novel method demonstrating promising outcomes in improving enhanced recovery parameters and minimising opioid administration in open abdominal surgery [70-72]. A systemic review published in February 2022 included seven randomised trials (RCT) and 56 other articles [73]. On their analysis opioid requirement and time to first analgesic request was significantly reduced in the ultrasound guided ESP block group, but pain scores, nausea, and vomiting did not differ

significantly after pooling the results of the block and no block studies [74-78]. There were no reports of serious complications related to ESP block. A study reported analgesic benefits in percutaneous nephrolithotomy [77]. A major limitation of this meta-analysis is that there was a limited number of matched clinical trials focused on ESP block in pain control after abdominal surgeries and a heterogeneity of the structure of the published results. Most of the current research has focused on its use in thoracic and trunk surgery.

Preperitoneal and wound infiltration techniques: Colorectal surgery has seen a major shift from open to laparoscopic techniques in recent years. Compared to open surgery, laparoscopic colorectal surgery results in similar visceral acute post-operative pain, whereas the parietal component of post-operative pain is significantly different, resulting in an overall lower pain intensity on mobilization [79,80]. Pain relief with continuous wound infusion was equal to thoracic epidural analgesia for 72 h after open colorectal surgery [81]. However, evidence regarding laparoscopic surgery is lacking. Similarly, pre-peritoneal local anaesthetic infiltration or infusion was effective as an analgesic and minimised the post-operative period opioid requirement in colorectal surgery [82]. Ozer et al. have shown that the catheter is important for the infiltration of LA into the pre-peritoneal space [83]. The LA inhibits the local inflammatory response to the injury, which sensitizes nociceptive receptors and contributes to pain and hyperalgesia [83]. Fustran et al. found similar benefits of continuous wound infusion [84]. Bertoglio compared pre-peritoneal continuous wound infusion to epidural infusion with variables of opioid consumption and pain scores that were non-inferior to epidural analgesia after colorectal surgery [85]. It is comparable to epidural in post-operative analgesia as an alternative method [86]. Paladini, in a narrative review, included 51 trials on abdominal surgery investigating the safety, efficacy, and current perspectives of continuous wound infiltration for post-operative pain management in different surgical settings [87]. Regardless of the heterogeneity of results, a general reduction in pain intensity and in opioid consumption was observed [87]. Another systematic review and meta-analysis by Mungroop et al. [88] analysed 29 RCTsls to explain the different location of wound catheters (i.e., preperitoneal vs subcutaneous). They observed pre-peritoneal wound catheters were superior to subcutaneous and comparable to epidural analgesia [88,89]. Wound Infiltrative techniques are less invasive alternatives as stand-alone or as a part of multimodal regimens. Wound infiltration techniques are simple and safe. A study on peritoneal LA infusion found

reduced opioid consumption, improved pain relief and appeared safe, without any, local or systemic, side effect [90].

References:

1. Bergman NA. *The genesis of surgical anesthesia*: Wood Library-Museum of Anesthesiology, 1998.
2. McDowell E. Three Cases of Extirpation of Diseased Ovaria. *Eclectic Repertory and Analytical Review Medical and Philosphical* 1817; **7:** 242-4.
3. Sechzer P. Objective measures of pain and pain relief following cardiovascular surgery. *Revista Argentina de Angiologia* 1967; **1:** 9-12.
4. Neuman MD, Bateman BT, Wunsch H. Inappropriate opioid prescription after surgery. *Lancet* 2019; **393:** 1547-57.
5. Garimella V, Cellini C. Postoperative pain control. *Clinics in Colon and Rectal Surgery* 2013; **26:** 191-6.
6. McGowan S. Highlights of anaesthesia in Dundee *International Congress and Symposium Series-Royal Society of Medicine*, 1996: 71-3.
7. Kuhar MJ, Pert CB, Snyder SH. Regional distribution of opiate receptor binding in monkey and human brain. *Nature* 1973; **245:** 447-50.
8. Pert CB, Snyder SH. Opiate receptor: Demonstration in nervous tissue. *Science* 1973; **179:** 1011-4.
9. Sicard A. Les injections medicamenteuses extra-durales par voie sacrococcygienne. *Comptes rendus des seances de la Society de biologie et de ses filiales* 1901; **53:** 396-8.
10. Wongyingsinn M, Baldini G, Stein B, Charlebois P, Liberman S, Carli F. Spinal analgesia for laparoscopic colonic resection using an enhanced recovery after surgery programme: better analgesia, but no benefits on postoperative recovery: a randomized controlled trial. *British Journal of Anaesthesia* 2012; **108:** 850-6.
11. Bromage PR, Camporesi E, Chestnut D. Epidural narcotics for postoperative analgesia. *Anesthesia & Analgesia* 1980; **59:** 473-80.
12. Carli F, Trudel JL, Belliveau P. The effect of intraoperative thoracic epidural anesthesia and postoperative analgesia on bowel function after colorectal surgery: a prospective, randomized trial. *Diseases of the Colon & Rectum* 2001; **44:** 1083-9.

13. Rawal N, Sjostrand U, Dahlstrom B. Postoperative pain relief by epidural morphine. *Anesthesia & Analgesia* 1981; **60:** 726-31.
14. Reiz S, Ahlin J, Ahrenfeldt B, Andersson M, Andersson S. Epidural morphine for postoperative pain relief. *Acta Anaesthesiologica Scandinavica* 1981; **25:** 111-4.
15. Curatolo M. Regional anesthesia in pain management. *Current Opinion in Anesthesiology* 2016; **29:** 614-9.
16. Chou R, Gordon DB, de Leon-Casasola OA, et al. Management of postoperative pain: A clinical practice guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. *Journal of Pain Research* 2016; **17:** 131-57.
17. Desai N, El-Boghdadly K, Albrecht E. Epidural vs. transversus abdominis plane block for abdominal surgery - a systematic review, meta-analysis and trial sequential analysis. *Anaesthesia* 2021; **76:** 101-17.
18. Abdallah FW, Halpern SH, Margarido CB. Transversus abdominis plane block for postoperative analgesia after Caesarean delivery performed under spinal anaesthesia? A systematic review and meta-analysis. *British Journal of Anaesthesia* 2012; **109:** 679-87.
19. Albrecht E, Chin KJ. Advances in regional anaesthesia and acute pain management: a narrative review. *Anaesthesia* 2020; **75 Suppl 1:** e101-e10.
20. Baeriswyl M, Kirkham KR, Kern C, Albrecht E. The analgesic efficacy of ultrasound-guided transversus abdominis plane block in adult patients: A meta-analysis. *Anesthesia & Analgesia* 2015; **121:** 1640-54.
21. Siddiqui MR, Sajid MS, Uncles DR, Cheek L, Baig MK. A meta-analysis on the clinical effectiveness of transversus abdominis plane block. *Journal of Clinical Anesthesia* 2011; **23:** 7-14.
22. Johns N, O'Neill S, Ventham NT, Barron F, Brady RR, Daniel T. Clinical effectiveness of transversus abdominis plane (TAP) block in abdominal surgery: a systematic review and meta-analysis. *Colorectal Disease* 2012; **14:** e635-42.
23. Blanco R. 271. Tap block under ultrasound guidance: the description of a “no pops” technique *Regional Anesthesia & Pain Mangement*, 2007: 130.

24. Blanco R, Ansari T, Girgis E. Quadratus lumborum block for postoperative pain after caesarean section: A randomised controlled trial. *European Journal of Anaesthesiology* 2015; **32:** 812-8.

25. Børglum J, Christensen A, Hoegberg L, et al. Bilateral-dual transversus abdominis plane (BD-TAP) block or thoracic paravertebral block (TVPB)? Distribution patterns, dermatomal anaesthesia, and LA pharmacokinetics. *Regional Anesthesia and Pain Medicine* 2012; **37:** E137-E9.

26. Chakraborty A, Goswami J, Patro V. Ultrasound-guided continuous quadratus lumborum block for postoperative analgesia in a pediatric patient. *A & A Case Reports* 2015; **4:** 34-6.

27. Børglum J, Moriggl B, Jensen K, et al. Ultrasound-guided transmuscular quadratus lumborum blockade. *British Journal of Anaesthesia* 2013; **111**.

28. Murouchi T, Iwasaki S, Yamakage M. Quadratus lumborum block: Analgesic effects and chronological ropivacaine concentrations after laparoscopic surgery. *Regional Anesthesia and Pain Medicine* 2016; **41:** 146-50.

29. Abdallah FW, Laffey JG, Halpern SH, Brull R. Duration of analgesic effectiveness after the posterior and lateral transversus abdominis plane block techniques for transverse lower abdominal incisions: a meta-analysis. *British Journal of Anaesthesia* 2013; **111:** 721-35.

30. Borglum J, Gogenur I, Bendtsen TF. Abdominal wall blocks in adults. *Current Opinion in Anesthesiology* 2016; **29:** 638-43.

31. Abrahams M, Derby R, Horn JL. Update on ultrasound for truncal blocks: A review of the evidence. *Regional Anesth & Pain Medicine* 2016; **41:** 275-88.

32. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: A novel analgesic technique in thoracic neuropathic pain. *Regional Anesthesia and Pain Medicine* 2016; **41:** 621-7.

33. Kadam VR. Ultrasound-guided quadratus lumborum block as a postoperative analgesic technique for laparotomy. *Journal of anaesthesiology, clinical pharmacology* 2013; **29:** 550.

34. Zhu M, Qi Y, He H, Lou J, Pei Q, Mei Y. Analgesic effect of the ultrasound-guided subcostal approach to transmuscular quadratus lumborum block in patients

undergoing laparoscopic nephrectomy: a randomized controlled trial. *BMC Anesthesiology* 2019; **19:** 154.

35. Cui XL, Li X, Li MN, et al. Ultrasound-Guided Transmuscular Quadratus Lumbar Block Reduces Opioid Consumption after Laparoscopic Partial Nephrectomy. *Chinese Medical Sciences Journal* 2020; **35:** 289-96.
36. Korgvee A, Junttila E, Koskinen H, Huhtala H, Kalliomaki ML. Ultrasound-guided quadratus lumborum block for postoperative analgesia: A systematic review and meta-analysis. *European Journal of Anaesthesiology* 2021; **38:** 115-29.
37. Aoyama Y, Sakura S, Abe S, Katayama N, Wada M, Saito Y. Quadratus lumborum block and posterior transversus abdominis plane block: a prospective study *ASA Annual Meeting*, 2017.
38. Baytar C, Yilmaz C, Karasu D, Topal S. Comparison of ultrasound-guided subcostal transversus abdominis plane block and quadratus lumborum block in laparoscopic cholecystectomy: A prospective, randomized, controlled clinical study. *Pain Research and Management* 2019; **2019:** 2815301.
39. Bhatti T, Baxendsle L. Quadratus lumborum block(QLB) produces effective or better post operative analgesia than fascia iliaca compartment block (FICB) in patients with fracture femur undergoing hemiarthroplasty. *Regional Anesthesia and Pain Medicine* 2016; **41:** e45.
40. Binzer J, Jensen K, Jørgensen L, Lenz K, Vazin M. Ultrasound-guided (USG) transmuscular quadratus lumborum (TQL) block for elective laparoscopic cholecystectomy. A prospective, randomized double-blind study. *Regional Anesthesia and Pain Medicine* 2013; **38:** E138.
41. Blanco R, Ansari T, Riad W, Shetty N. Quadratus lumborum block versus transversus abdominis plane block for postoperative pain after cesarean delivery: a randomized controlled trial. *Regional Anesthesia & Pain Medicine* 2016; **41:** 757-62.
42. Dam M, Hansen CK, Poulsen TD, et al. Transmuscular quadratus lumborum block for percutaneous nephrolithotomy reduces opioid consumption and speeds ambulation and discharge from hospital: a single centre randomised controlled trial. *British Journal of Anaesthesia* 2019; **123:** e350-e8.
43. Dewinter G, Coppens S, Van de Velde M, et al. Quadratus lumborum block versus perioperative intravenous lidocaine for postoperative pain control in patients

undergoing laparoscopic colorectal surgery: A prospective, randomized, double-blind controlled clinical trial. *Annals of Surgery* 2018; **268:** 769-75.

44. Faiz SHR, Alebouyeh MR, Derakhshan P, Imani F, Rahimzadeh P, Ashtiani MG. Comparison of ultrasound-guided posterior transversus abdominis plane block and lateral transversus abdominis plane block for postoperative pain management in patients undergoing cesarean section: a randomized double-blind clinical trial study. *Journal of Pain Research* 2018; **11:** 5.
45. Hansen CK, Dam M, Steingrimsdottir GE, et al. Ultrasound-guided transmuscular quadratus lumborum block for elective cesarean section significantly reduces postoperative opioid consumption and prolongs time to first opioid request: a double-blind randomized trial. *Regional Anesthesia & Pain Medicine* 2019; **44:** 896-900.
46. Hassan KM, Muhammad DW, Shafeek AM, Gomaa GA, Abd ElMalek FA. A comparative study between ultrasound guided quadratus lumborum block versus ultrasound guided transversus abdominis plane block in laporoscopic bariatric surgery. *The Egyptian Journal of Hospital Medicine* 2018; **70:** 2090-199.
47. He J, Zheng XQ, Luo CH, et al. Effects and safety of quadratus lumborum block in analgesia after hip arthroplasty. *Zhonghua Yi Xue Za Zhi* 2018; **98:** 565-9.
48. Ishio J, Komasawa N, Kido H, Minami T. Evaluation of ultrasound-guided posterior quadratus lumborum block for postoperative analgesia after laparoscopic gynecologic surgery. *Journal of Clinical Anesthesia* 2017; **41:** 1-4.
49. Iwata M, Kuzumoto N, Ogawa Y. The efficacy of ultrasound-guided quadratus lumborum block in the laparoscopic nephrectomy. *Masui* 2018; **67:** 50-3.
50. Kang W, Lu D, Yang X, et al. Postoperative analgesic effects of various quadratus lumborum block approaches following cesarean section: a randomized controlled trial. *Journal of Pain Research* 2019; **12:** 2305.
51. Kilic E, Bulut E. Quadratus lumborum block iii for postoperative pain after percutaneous nephrolithotomy. *Turkish Journal of Anaesthesiology & Reanimation* 2018; **46:** 272-5.
52. Krohg A, Ullensvang K, Rosseland LA, Langesæter E, Sauter AR. The analgesic effect of ultrasound-guided quadratus lumborum block after cesarean delivery: a randomized clinical trial. *Anesthesia & Analgesia* 2018; **126:** 559-65.

53. Kumar GD, Gnanasekar N, Kurhekar P, Prasad TK. A comparative study of transversus abdominis plane block versus quadratus lumborum block for postoperative analgesia following lower abdominal surgeries: A prospective double-blinded study. *Anesthesia Essays and Research* 2018; **12:** 919-23.
54. Mieszkowski MM, Mayzner-Zawadzka E, Tuyakov B, et al. Evaluation of the effectiveness of the quadratus lumborum block type I using ropivacaine in postoperative analgesia after a cesarean section—a controlled clinical study. *Ginekologia polska* 2018; **89:** 89-96.
55. Murouchi T. Quadratus lumborum block intramuscular approach for pediatric surgery. *Acta Anaesthesiologica Taiwan* 2016; **54:** 135-6.
56. Okmen K, Metin Okmen B, Sayan E. Ultrasound-guided lateral versus posterior Quadratus Lumborum Block for postoperative pain after laparoscopic cholecystectomy: a randomized controlled trial. *Turkish Journal of Surgery* 2019; **35:** 23-9.
57. Parras T, Blanco R. Randomised trial comparing the transversus abdominis plane block posterior approach or quadratus lumborum block type I with femoral block for postoperative analgesia in femoral neck fracture, both ultrasound-guided. *Revista Espanola de Anestesiologia y Reanimacion* 2016; **63:** 141-8.
58. Taketa Y, Fujitani T, Irisawa Y, Sudo S, Harada Y, Takaishi K. Comparison of analgesic efficacy between posterior and lateral transversus abdominis plane block techniques for laparoscopic gynecological surgery. *Masui. The Japanese Journal of Anesthesiology* 2015; **64:** 1015-22.
59. Tamura T, Yokota S, Ando M, Kubo Y, Nishiwaki K. A triple-blinded randomized trial comparing spinal morphine with posterior quadratus lumborum block after cesarean section. *International Journal of Obstetric Anesthesia* 2019; **40:** 32-8.
60. Yousef NK. Quadratus kor. *Anesthesia Essays and Research* 2018; **12:** 742-7.
61. Tulgar S, Kose HC, Selvi O, et al. Comparison of ultrasound-guided lumbar erector spinae plane block and transmuscular quadratus lumborum block for postoperative analgesia in hip and proximal femur surgery: A prospective randomized feasibility study. *Anesthesia Essays and Research* 2018; **12:** 825-31.
62. Hamilton D, Manickam B. Erector spinae plane block for pain relief in rib fractures. *British Journal of Anaesthesia* 2017; **118:** 474-5.

63. Restrepo-Garces CE, Chin KJ, Suarez P, Diaz A. Bilateral continuous erector spinae plane block contributes to effective postoperative analgesia after major open abdominal surgery: A case report. *A & A Case Reports* 2017; **9:** 319-21.

64. Scimia P, Basso Ricci E, Droghetti A, Fusco P. The ultrasound-guided continuous erector spinae plane block for postoperative analgesia in video-assisted thoracoscopic lobectomy. *Regional Anesthesia and Pain Medicine* 2017; **42:** 537.

65. Adhikary SD, Bernard S, Lopez H, Chin KJ. Erector spinae plane block versus retrolaminar block: A magnetic resonance imaging and anatomical study. *Regional Anesthesia and Pain Medicine* 2018; **43:** 756-62.

66. Aponte A, Sala-Blanch X, Prats-Galino A, Masdeu J, Moreno LA, Sermeus LA. Anatomical evaluation of the extent of spread in the erector spinae plane block: a cadaveric study. *Canadian Journal of Anesthesia* 2019; **66:** 886-93.

67. Chin K, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia* 2017; **72:** 452-60.

68. Griffiths JD, Barron FA, Grant S, Bjorksten AR, Hebbard P, Royse CF. Plasma ropivacaine concentrations after ultrasound-guided transversus abdominis plane block. *British Journal of Anaesthesia* 2010; **105:** 853-6.

69. Karmakar MK, Ho AM-H, Law BK, Wong AS, Shafer SL, Gin T. Arterial and venous pharmacokinetics of ropivacaine with and without epinephrine after thoracic paravertebral block. *The Journal of the American Society of Anesthesiologists* 2005; **103:** 704-11.

70. Abu Elyazed MM, Mostafa SF, Abdelghany MS, Eid GM. Ultrasound-guided erector spinae plane block in patients undergoing open epigastric hernia repair: A prospective randomized controlled study. *Anesthesia & Analgesia* 2019; **129:** 235-40.

71. Greenbaum A, Wilcox H, Teng CH, et al. Use of erector spinae fascial plane blocks in enhanced recovery for open abdominal surgery. *Journal of Surgical Research* 2021; **268:** 673-80.

72. Hamed MA, Goda AS, Basiony MM, Fargaly OS, Abdelhady MA. Erector spinae plane block for postoperative analgesia in patients undergoing total abdominal hysterectomy: a randomized controlled study original study. *Journal of Pain Research* 2019; **12:** 1393-8.

73. Viderman D, Aubakirova M, Abdildin YG. Erector spinae plane block in abdominal surgery: A meta-analysis. *Frontiers in Medicine (Lausanne)* 2022; **9:** 812531.
74. Abdelhamid BM, Khaled D, Mansour MA, Hassan MM. Comparison between the ultrasound-guided erector spinae block and the subcostal approach to the transversus abdominis plane block in obese patients undergoing sleeve gastrectomy: a randomized controlled trial. *Minerva anestesiologica* 2020; **86:** 816-26.
75. Kamel AAF, Amin OAI, Ibrahem MAM. Bilateral ultrasound-guided erector spinae plane block versus transversus abdominis plane block on postoperative analgesia after total abdominal hysterectomy. *Pain Physician* 2020; **23:** 375-82.
76. Kim D, Kim JM, Choi GS, Heo G, Kim GS, Jeong JS. Ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic liver resection: A prospective, randomised controlled, patient and observer-blinded study. *European Journal of Anaesthesiology* 2021; **38:** S106-S12.
77. Prasad MK, Varshney RK, Jain P, Choudhary AK, Khare A, Jheetay GS. Postoperative analgesic efficacy of fluoroscopy-guided erector spinae plane block after percutaneous nephrolithotomy (PCNL): A randomized controlled study. *Saudi Journal of Anaesthesia* 2020; **14:** 480-6.
78. Tulgar S, Kapakli MS, Senturk O, Selvi O, Serifsoy TE, Ozer Z. Evaluation of ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: A prospective, randomized, controlled clinical trial. *Journal of Clinical Anesthesia* 2018; **49:** 101-6.
79. Stamenkovic DM, Bezmarevic M, Bojic S, et al. Updates on Wound Infiltration Use for Postoperative Pain Management: A Narrative Review. *Journal of Clinical Medicine* 2021; **10:** 4659.
80. Ventham NT, Hughes M, O'Neill S, Johns N, Brady RR, Wigmore SJ. Systematic review and meta-analysis of continuous local anaesthetic wound infiltration versus epidural analgesia for postoperative pain following abdominal surgery. *British Journal of Surgery* 2013; **100:** 1280-9.
81. Li H, Chen R, Yang Z, Nie C, Yang S. Comparison of the postoperative effect between epidural anesthesia and continuous wound infiltration on patients with open surgeries: a meta-analysis. *Journal of Clinical Anesthesia* 2018; **51:** 20-31.

82. Beaussier M, El'Ayoubi H, Schiffer E, et al. Continuous preperitoneal infusion of ropivacaine provides effective analgesia and accelerates recovery after colorectal surgery: a randomized, double-blind, placebo-controlled study. *Anesthesiology* 2007; **107:** 461-8.

83. Ozer A, Yılmazlar A, Oztürk E, Yılmazlar T. Preperitoneal catheter analgesia is an effective method for pain management after colorectal surgery: the results of 100 consecutive patients. *Local and Regional Anesthesia* 2014; **7:** 53.

84. Fustran N, Dalmau A, Ferreres E, et al. Postoperative analgesia with continuous wound infusion of local anaesthesia vs saline: a double-blind randomized, controlled trial in colorectal surgery. *Colorectal Disease* 2015; **17:** 342-50.

85. Bertoglio S, Fabiani F, Negri PD, et al. The postoperative analgesic efficacy of preperitoneal continuous wound infusion compared to epidural continuous infusion with local anesthetics after colorectal cancer surgery: a randomized controlled multicenter study. *Anesthesia & Analgesia* 2012; **115:** 1442-50.

86. Zugasti O, Dufur M, Pavon A, et al. Comparison of analgesic efficacy of preperitoneal continuous infusion catheter with epidural analgesia for upper abdominal surgery with subcostal approach. *Regional Anesthesia and Pain Medicine* 2014; **39:** e252.

87. Paladini G, Di Carlo S, Musella G, et al. Continuous wound infiltration of local anesthetics in postoperative pain management: Safety, efficacy and current perspectives. *Journal of Pain Research* 2020; **13:** 285-94.

88. Mungroop TH, Bond MJ, Lirk P, et al. Preperitoneal or subcutaneous wound catheters as alternative for epidural analgesia in abdominal surgery: a systematic review and meta-analysis. *Annals of Surgery* 2019; **269:** 252-60.

89. Boulind CE, Ewings P, Bulley SH, et al. Feasibility study of analgesia via epidural versus continuous wound infusion after laparoscopic colorectal resection. *British Journal of Surgery* 2013; **100:** 395-402.

90. Konomi I, Vaivai A, Violari M, Kalantzi N, Kalinoglou N, Michaloliakou C. Efficacy of continuous preperitoneal infusion of ropivacaine 0, 5% in postoperative pain after abdominal hysterectomy. A randomized, double-blind, placebo-controlled study. Preliminary data: 14AP5-4. *European Journal of Anaesthesiology* 2012; **29:** 203.

Chapter 2 - Anatomical description and diagrammatic illustration of the new technique and its clinical application

Introduction.

There is limited anatomical and clinical data on ultrasound guided TQL approaches. This makes it difficult for a clinician to interpret ultrasound imaging at the same time as correlating the anatomical structures when performing real time injection or drug dissemination. In addition to this the images of performing blocks at L2 and L4 levels are different. This is particularly important in relation to the proximity of the visceral organs such as the kidneys and perinephric fascia. We endeavoured to produce clear description and imaging as an educational tool and guide to perform this block. Ultrasound guided anatomical details are obtained with high resolution pictures with a professional clinical photographer to demonstrate an innovative approach of the needle placement in this new regional analgesia technique. A professional illustrator was acquired from the Adelaide School of Medicine to illustrate the above technique. This chapter will focus on the anatomical and ultrasound description of two trans-muscular quadratus lumborum block approaches at lumbar level and its application in abdominal surgery.

Anatomical and ultrasound description of two trans-muscular quadratus lumborum block approaches at L2 level and its application in abdominal surgery

Authors

Vasanth Rao Kadam[1,2], Roelof M Van Wijk[1,2], Guy L Ludbrook1[2,3], Venkatesan Thiruvenkatarajan[1,2]

Affiliations

[1]Department of Anaesthesia, The Queen Elizabeth Hospital, Adelaide, Australia

[2]Discipline of Acute Care Medicine, School of Medicine, The University of Adelaide, South Australia, Australia.

[2,3] Department of Anaesthesia Royal Adelaide hospital, Discipline of Acute Care Medicine, School of Medicine, The University of Adelaide, South Australia, Australia.

Keywords

Quadratus lumborum, trans-muscular quadratus lumborum block, thoracolumbar fascia, ultrasound, postoperative analgesia

OFFICIAL

Statement of Authorship

Title of Paper	Anatomical and ultrasound description of two trans-muscular quadratus lumborum block approaches at L2 level and its application in abdominal surgery.
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Kadam VR, Van Wijk RM, Ludbrook GL, Thiruvenkatarajan V. Anatomical and ultrasound description of two transmuscular quadratus lumborum block approaches at L2 level and their application in abdominal surgery. Anaesth Intensive Care. 2019 Mar;47(2):141-145. doi: 10.1177/0310057X19839931. Epub 2019 May 15. PMID: 31088120.

Principal Author

Name of Principal Author (Candidate)	Vasanth Rao Kadam		
Contribution to the Paper	Designed the images conceptualised the work including consenting process and writing manuscript and also corresponding author		
Overall percentage (%)	90		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	29.9.22

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	R. M. Van Wijk		
Contribution to the Paper	Designing, editing, and drafting the manuscript		
Signature		Date	29-9-22

Name of Co-Author	G.L. Ludbrook		
Contribution to the Paper	Designing, editing, and drafting the manuscript		
Signature		Date	4 OCT 2022

OFFICIAL

Name of Co-Author	V. Thiruvenkatarajan		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	29/5/22

Background

Currently there is limited description of imaging of L4 transmuscular quadratus lumborum block to NYSORA web site. The L4 level quadratus lumborum block may not achieve higher segmental analgesia. Having higher lumbar level like L2 may have such advantage and we wanted to utilise this approach developing innovative description of imaging and apply clinically.

Methods/Design

MEDLINE, EMBASE, CINAHL searched for studies that involved any lumbar approaches to trans-muscular quadratus lumborum block.

Discussion

The new imaging will aid in easy understanding and application of needle placement and thus minimise risk of any visceral damage. It may be used as an educational tool in performing regional anaesthesia in lumbar region.

Abstract

The transmuscular quadratus lumborum (TQL) block is one of the recently evolved myofascial blocks utilised in abdominal surgery. It involves injecting local anaesthetic into the fascial plane anterior to the thoracolumbar fascia. This block has previously been described with a transverse oblique paramedian approach at the L2 level in the sitting position. We describe a TQL block at the same level in the lateral position using a transverse posterolateral approach to provide analgesia for patients undergoing abdominal surgery. We elaborate on these two approaches of TQL block at the L2 level, in relation to the anatomy, sonoanatomy and technical aspects.

INTRODUCTION

The trans-muscular quadratus lumborum (TQL) block is one of the recently evolved myofascial blocks utilised in abdominal surgeries. It involves injecting local anaesthetic (LA) into the fascial plane anterior to the thoracolumbar fascia (TLF). Borglum and his colleagues first described the ultrasound-guided TQL block [1] at the level of the fourth Lumbar vertebra (L4).

It is also termed as the anterior quadratus lumborum block because it involves injecting the LA at the anterior aspect of the quadratus lumborum (QL) muscle. In comparison, to achieve sensory block covering the entire abdominal wall, a four-point transversus abdominis plane block would be necessary [2]. Bilateral TQL can provide similar analgesia. Due to presence of surgical drains at the flank level and poor visualization of anatomical structures at this position, Dam and her colleagues later used the transverse oblique paramedian (TOP) approach at L2 level in sitting position [3]. After encountering side effects such as leg paresis with Borglum's L4 approach, we attempted TQL block at a higher level (L2 transverse process) with patients in lateral position, using a transverse posterolateral (TPL) approach in abdominal surgery [4-6]. In this brief review, we elaborate these two approaches of TQL block at L2 level, in relevance to the anatomy, sonoanatomy and technical aspects.

ANATOMY

Myofascial blocks around the QL plane are based on the anatomy of the thoracolumbar fascia (TLF). It is a tubular connective tissue structure formed by the binding aponeuroses and fascia layers, which, by enveloping the back muscles, connects the anterolateral abdominal wall with the lumbar paravertebral region [7] (insert fig 1 here). On its medial side, the TLF is attached to the thoracic and lumbar vertebrae and continues cranially as the endothoracic fascia. The TLF divides into 3 layers (anterior, middle, and posterior) around the muscles of the back. The posterior layer is posterior to the erector spinae muscles; the middle layer is sandwiched between the erector spinae and QL muscle (and is thus posterior to the QL); and the anterior layer is anterior to QL muscle. The anterior layer also blends medially with the fascia of the Psoas Major and blends laterally with the transversalis fascia. Injection between the anterior layer and QL can spread cranially under the lateral arcuate ligament to the endothoracic fascia and reach the lower thoracic paravertebral space posterior to the endothoracic fascia [8].

Technical description

TPL TQL approach: This approach can be performed pre-, intra- and postoperatively. We focus on block performance at the end of the surgical procedure before extubating the patient with the therapeutic aim of enhancing postoperative analgesia [4]. It can be done unilaterally or bilaterally depending on the type of the incision. It is performed in the lateral decubitus

position with the block side upwards. On the lower side a wedge is placed between the rib cage and the iliac crest to make the QL muscle prominent. To improve visualisation, anaesthetic assistants would need to retract the rib cage and the iliac crest to increase the gap. A curved low frequency probe 2-5 Hz is placed transversely between the iliac crest and the costal margin in the posterior axillary line. The structures visualised are the abdominal muscles, psoas muscle, peritoneum, kidney and QL muscle (insert fig 2a here). After identifying the QL an 18 gauge Tuohy needle (with the tip pointing upwards) is introduced in plane and medial to the transducer probe and advanced posterior to anterior through QL muscle. Fig 2b shows the needle pathway view of L2 level ultrasound-guided transmuscular quadratus lumborum block image. Hydro-dissection is carried out while the needle is above the L2 transverse process till it passes through the QL muscle. This will help to identify the muscle plane and reach the anterior TLF. The kidney is very close to the QL muscle, which is separated from it by perinephric adipose tissue and the posterior layer of renal fascia. The LA is injected in the myofascial plane between the QL muscle and the anterior TLF, close to the psoas muscle, where a tactile feel of layer penetration may also be appreciated. The hydro-dissection with the Tuohy needle can avoid entry into the peritoneal cavity or perinephric area. After a test dose of 5ml saline, 20ml of 0.5% ropivacaine is given in 5ml aliquots after aspiration. This is followed by the catheter insertion.

In our view, the risk of puncture of intra-abdominal structures such as the kidney can be minimised by careful tactile feel of fascia, visualisation of the needle tip, the use of a blunt Tuohy needle, and hydro-dissection. We believe the risk is likely to be reduced by taking these measures.

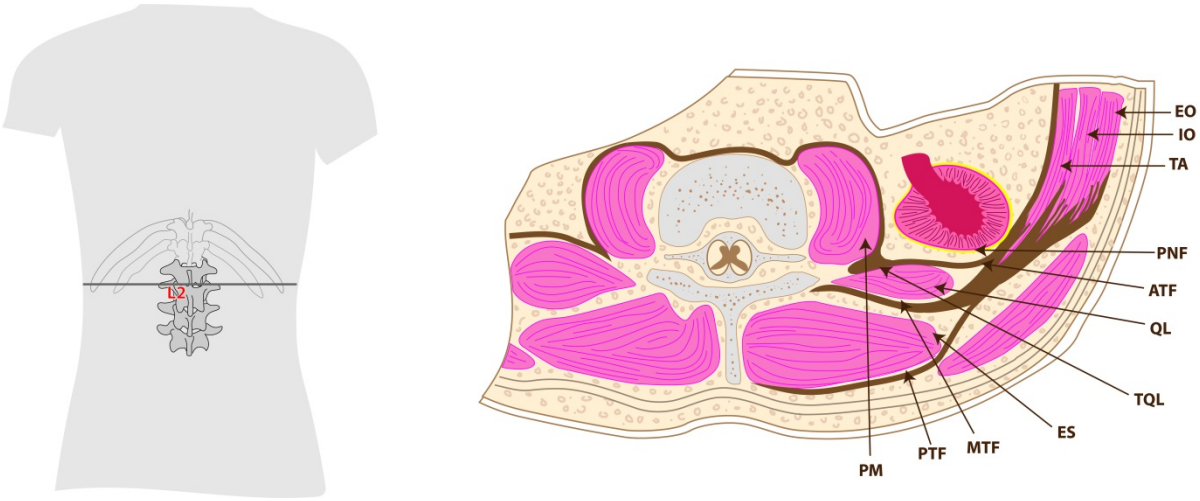
TOP TQL approach: This is a transverse oblique paramedian approach of the TQL block, with the patient in a sitting position. The original sources used the hypo-echoic shadow of the transverse processes as the primary proxy endpoint marker for injection [3]. The cephalad border of the iliac crest and the spinous processes of the lumbar vertebral column are palpated and marked on the skin. A curvilinear transducer 2-5 MHz is placed with a transverse oblique and paramedian orientation approximately 3 cm lateral to the L2 spinous process (insert fig 3 here). The transducer is first shifted cephalad or caudad to identify the L2 transverse process and the adjoining QL muscle. The needle is then inserted in plane from the

medial end of the transducer and advanced in plane laterally to enter the inter fascial plane between the quadratus lumborum and psoas major muscles and LA is injected.

Pearls

- **Performing TQL block at higher level (L2) will minimise the chance of the lower lumbar nerve roots blockade (femoral nerve). These roots are likely to get blocked if the injection point is close to the psoas muscle at L4 level, which is in close proximity where the nerve roots join to form the femoral nerve**
- **Hydro dissection above the L2 transverse process to the anterior thoraco-lumbar fascia can avoid entry into the peritoneal cavity or perinephric area, thus preventing damage to the vital structures in the vicinity**
- **Use of blunt (Tuohy) needle and tactile feel of fascial click may be a safer technique than the use of a sharp needle**

Fig 1 showing the anatomy of Thoraco-lumbar fascia at L2



EO = external oblique, IO = internal oblique, TA = transversus abdominis, PNF= perinephric fascia, ATF = anterior thoracolumbar fascia, QL = quadratus lumborum muscle, TQL = site of Trans-muscular quadratus lumborum block at L2, ES = erector spinae, MTF = middle thoracolumbar fascia, PTF =posterior thoracolumbar fascia, PM = Psoas muscle

Fig 2 a TPL (transverse posterolateral) TQL L2 approach showing transverse probe placement, in plane needle placement and ultrasound image TA = transversus abdominis, QL = quadratus lumborum muscle, ATF = anterior thoracolumbar fascia

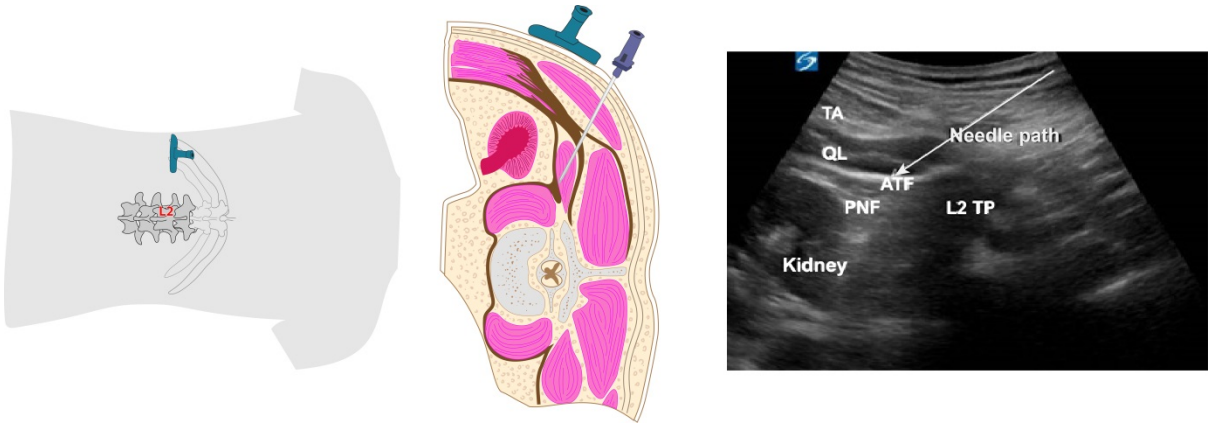


Fig 2 b. Needle pathway view of L2 level ultrasound-guided transmuscular quadratus lumborum block image

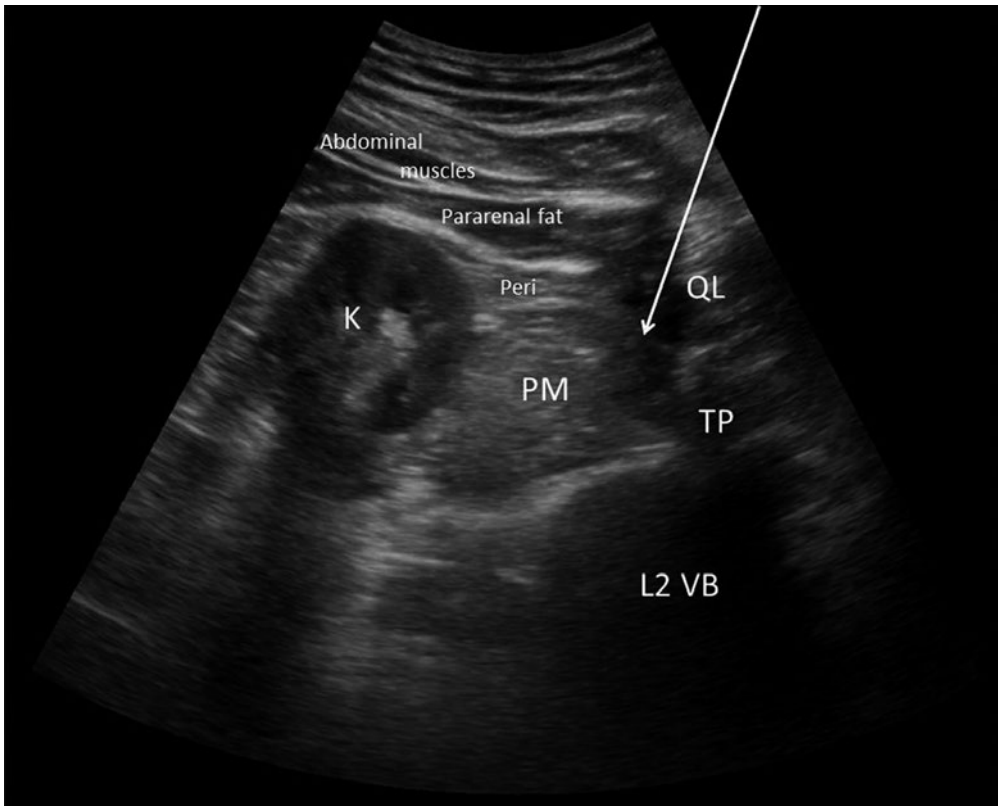
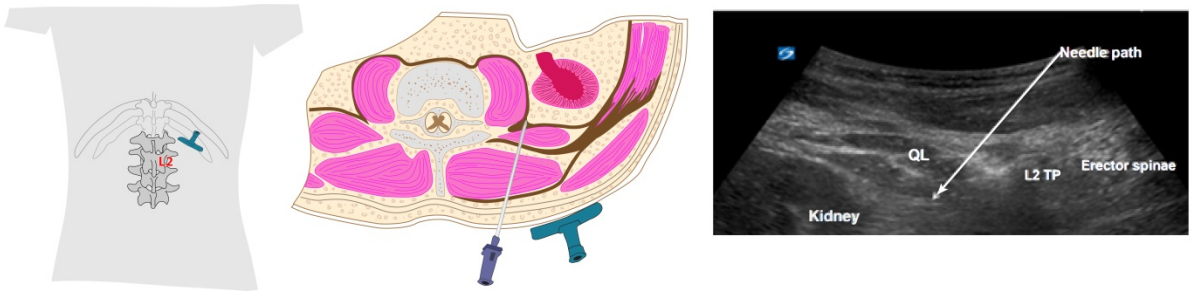


Fig 3 TOP (transverse oblique posteromedial) TQL L2 approach showing transverse oblique Probe placement, in-plane needle placement and ultrasound image



DISCUSSION

This short communication describes two recently developed variations of the TQL approach at the L2 level, with illustrated anatomy and related probe and needle positions to assist in understanding the sonoanatomy and performance of these blocks in abdominal surgery.

A comparison between the TPL and TOP approaches is given in table 1(insert table). It should be noted that the endpoints in both approaches are similar, i.e. the myofascial plane between the QL muscle and the anterior TLF, close to the psoas muscle. Dam et al., using the transverse-oblique posteromedial (TOP) approach in a cadaver model, reported medial spread of dye limited to the lateral part of the psoas fascia and cranial spread into the thoracic paravertebral space [8]. It was noted in this cadaver study that injectate administered at the myofascial QL plane at L2 level could reach lower thoracic up to the T10 thoracic paravertebral space and T9-12 ventral rami. There was no spread of injectate into the psoas major muscle or the lumbar plexus, and a consistent spread of injectate into the thoracic paravertebral space and the thoracic sympathetic trunk was noted. This could possibly reduce both somatic and visceral pain although, as yet data are limited in this regard. This, and the favourable results reported in recent limited case series in major abdominal surgery, demonstrating cranial spread, without the occurrence of lumbar roots blockade [4-6,9], make this approach appropriate in intra- and retroperitoneal abdominal surgery; either as a single sided (e.g. nephrectomy) or double sided (e.g. bowel surgery) block.

The needle skin entry points differ between a more posteromedial (TOP) and posterolateral (TPL) approach. Also, the patient position differs with Dam et al. advocate a sitting position and we suggest a lateral position with a wedge under the patient to enable better access.

Both, in their early publications, suggest applying the block post-operatively. However, from a pain management point of view, having a regional anaesthetic block in situ during surgery will be more advantageous. Other advantages include being able to use the block in patients who are unable to sit up, such as whilst anaesthetised or immediately post-operatively in the post-anaesthesia care unit or intensive care unit.

From a patient comfort and safety perspective, inserting the catheter(s) prior to surgery would be preferable to doing it either with the patient sitting up in PACU or moving the patient in one lateral position, and subsequently in the other, while still anaesthetised.

Unfortunately, no major clinical studies have been reported on this approach.

In a case series of TPL for abdominal surgeries, a dermatomal spread as high as T6 was achieved [6]. It is unclear to what extent this technique covers intra-abdominal visceral pain. A randomised trial is underway in our institution exploring its further benefits in open major abdominal surgery.

Till now, there has been a single case series comparing the needle position at the anterior aspect of the QL muscle, between the L2 and L4 levels approach [6]. Anecdotally we have not observed lower limb weakness, but this was not formally studied. LA spread to the lumbar plexus is a possibility. We found no other adverse events at the L2 level.

However, data is limited as to demonstrate the differences between these approaches [6].Further studies should elaborate the role of TQL in open upper gastrointestinal and colorectal surgeries using TQL at L2 level (higher) and for pelvic surgery at lower (L3 L4) level.

In conclusion, based on anatomical considerations and the limited clinical data available, both ultrasound guided TQL approaches (TPL and TOP) at L2 level have theoretical advantages. However, these would need to be confirmed in prospective studies.

Reference List

1. Børglum J, Moriggl B, Lönnqvist PA, Fogh Christensen A, Sauter A, Bendtsen T. Ultrasound-Guided Transmuscular Quadratus Lumborum Blockade. *British Journal of Anaesthesia* 2013; March.
2. Borglum J, Maschmann C, Belhage B, Jensen K. Ultrasound-guided bilateral dual transversus abdominis plane block: a new four-point approach. *Acta Anaesthesioligica Scandinavica* 2011; **55:** 658-63.
3. Dam M, Hansen CK, Borglum J, Chan V, Bendtsen TF. A transverse oblique approach to the transmuscular Quadratus Lumborum block. *Anaesthesia* 2016; **71:** 603-4.
4. Rao Kadam V, Vanwijk R, Ludbrook G, et al. Ultrasound guided anterior quadratus lumborum block l2 level safe approach for post-operative analgesia for laparotomy-case report. *Regional Anesthesia Pain Medicine* 2017; **42:** e182.

5. Rao Kadam V, Howell S. Ultrasound-guided continuous transmuscular quadratus lumborum block- L4 or L2 level catheter insertion for analgesia in open abdominal surgery: Case series. *Indian J Anaesth* 2018; **62:** 555-7.
6. Rao Kadam V. Ultrasound guided continuous transmuscular quadratus lumborum block and transient femoral nerve palsy [Letter of response to: A radiologic and anatomic assessment of injectate spread following transmuscular quadratus lumborum block in cadavers], 2017. http://www.respond2articles.com/ANA/forums/2363/ShowThread.aspx#2363 (accessed 2018).
7. Willard FH, Vleeming A, Schuenke MD, Danneels L, Schleip R. The thoracolumbar fascia: anatomy, function and clinical considerations. *Journal Anatomy* 2012; **221:** 507-36.
8. Dam M, Moriggl B, Hansen CK, Hoermann R, Bendtsen TF, Borglum J. The Pathway of Injectate Spread With the Transmuscular Quadratus Lumborum Block: A Cadaver Study. *Anesthesia Analgesia* 2017; **125:** 303-12.
9. Rao Kadam V. Ultrasound guided trans-muscular quadratus lumborum block, mid-level safe approach for postoperative analgesia for laparotomy. [Letter of response to: A cadaver study comparing spread of dye and nerve involvement after three different quadratus lumborum blocks]. *British Journal of Anaesthesia* 2017; **7**.

Clinical use of these new techniques of Trans muscular quadratus lumborum block at L4 or L2 levels with catheter insertion for postoperative analgesia in open abdominal surgery.

Authors

Vasanth Rao Kadam[1], Howell S[2]

Affiliations

[1]Department of Anaesthesia, The Queen Elizabeth Hospital, Adelaide, Australia.

[2]School of Public Health, The University of Adelaide, South Australia, Australia.

Keywords

Quadratus lumborum, transmuscular quadratus lumborum block, thoracolumbar fascia, ultrasound, postoperative analgesia

Statement of Authorship

Title of Paper	Ultrasound-guided continuous transmuscular quadratus lumborum block- L4 or L2 level catheter insertion for analgesia in open abdominal surgery: Case series
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Kadam VR, Howell S. Ultrasound-guided continuous transmuscular quadratus lumborum block- L4 or L2 level catheter insertion for analgesia in open abdominal surgery: Case series. Indian J Anaesth 2018; 62:555-7.

Principal Author

Name of Principal Author (Candidate)	Vasanth Rao Kadam		
Contribution to the Paper	Designed the images conceptualised the work including consenting process and writing manuscript and also corresponding author		
Overall percentage (%)	90		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	29.9.22

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publicaton in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Howell S.		
Contribution to the Paper	Statistical support, editing and drafting the manuscript		
Signature		Date	3/10/22

Introduction:

Quadratus Lumborum Block (QLB) is a technique of injecting local anaesthetics around quadratus lumborum muscle to achieve pain relief after abdominal surgeries. This block can be performed injecting at either the lateral, posterior, anterior or intramuscular aspects of the Quadratus Lumborum (QL) muscle for post-operative analgesia. Nomenclature on types of QLB keeps changing [1]. An ultrasound guided Transmuscular Quadratus Lumborum (TQL) block, which involves needle passing through the Quadratus Lumborum (QL) muscle and injecting the LA into the anterior aspect of fascia; interspace between the QL and psoas muscle. It's also called the QLB3 [2]. There have been case reports on the use of single and continuous QLB block in abdominal surgery as an alternative analgesic technique in paediatric and adult patients [3-5]. There is a general paucity of literature on continuous use of TQL block in adults for major abdominal surgery [6,7]. We have previously reported on the effectiveness of the anterior approach or TQL block performed at L4 resulting in transient paraesthesia of the leg in one case [6]. In view of this issue, we performed the same block at higher level (L2) without adverse effect. So far, no studies examined the analgesic effect of TQL catheters placed at different levels utilising anterior approach for major abdominal surgery. The aim of this study was to evaluate the efficacy of these blocks at two levels in open midline incision surgery. The primary objectives were to assess analgesic use and dynamic pain scores in recovery on day one and two. The secondary objectives were to assess dermatomes and any adverse effects related to catheter use.

Methods:

Ten consecutive patients (7 males, 3 females) undergoing elective open abdominal surgery with any midline incision were recruited in 2016 at The Queen Elizabeth Hospital. Patients unable to provide consent and allergic to fentanyl, Ropivacaine and oral opioids were excluded. Human Research Ethics Committee approval was obtained. All patients underwent a standard general anaesthetic with endotracheal intubation and were administered intermittent doses of Fentanyl for analgesia. The patients were placed in a lateral position following the surgical procedure and prior to extubation to insert the QLB catheters under ultrasound guidance using a 2-5 MHz frequency curved probe (SonoSite X-Porte, Sonosite Inc, Bothell, Washington, USA). A lower approach (L4) was used in five patients, where the probe was placed transversely in the posterior axillary line and moved towards L4 transverse process (iliac crest level). In the remaining five patients the probe was placed close to L2 level of the transverse process (see Fig1). After identifying the QL muscle above the transverse process, an 18gauge Touhy's needle was introduced at the respective transverse process, in a posterior to anterior direction, in plane through the QL muscle by saline hydro dissection to reach the anterior thoracolumbar fascia (Fig 2 and 3 show the sonoanatomy). A bolus of 20ml of Ropivacaine 0.5% was administered followed by bilateral catheter insertion directing cephalad to the depth of 3-4cm, to infuse, Ropivacaine 0.2% at 5ml-8 ml/ hr each side for 48 hrs. Patients were also administered multi-modal analgesia with 1 gm Paracetamol 6hrly, Dexamethasone 8mg and Fentanyl PCA. Parameters measured by acute pain service were dermatomal levels, pain scores on cough and total analgesia used in the 48 hours post-surgery.

Results:

Table 1 provides demographic details along with the level of the block performed, dermatomal levels, analgesia used and pain scores (NRS) on cough in PACU until day two post-operatively. The majority of patients had bowel surgery; none required ICU admission for ventilation. Mean pain score during recovery was slightly higher amongst patients who had the block at L2 when compared those at L4 (L2 v L4: 4.20 v 1.20). However, group differences were negligible at both time points (24 hours: L2 v L4: 5.4 v 5.0) (48 hours: L2 v L4: 5.6 v 5.6).

Mean fentanyl consumption over the 48 hours was 1024 and 1277 mcg for block performed at L2 and L4, respectively. Femoral nerve palsy and hypotension occurred when blocks were performed at L4; however, there were no adverse events at L2. There were no complications relating to catheter, infections, or systemic side effects to Ropivacaine during the study period.

Discussion:

In our study, continuous infusion of TQL block in abdominal open surgery had reduced pain scores; the higher-level (L2) approach resulted in fewer adverse effects such as hypotension and nerve palsy. This nerve palsy is possibly from the LA tracking to the lower lumbar roots and its close proximity to the lumbar plexus in psoas muscle. Unanticipated femoral nerve palsy was also reported after transversalis fascia block and QLB [8,9] and unexplained hypotension following this block has also been reported [10]. We chose to perform the QL3 block based on Borglum's study reporting anaesthesia from T7 to L1. This was supported by Carney et al study, which reported traces of contrast in the thoracic paravertebral space [11]. There are no such LA studies performed at L2 level.

Ueshima reported, a single shot technique was found to be effective for almost 24 hours with dermatomes level up to T7 [12]. We achieved dermatomal level up to T8 but there is need for a technique that achieves cephalad block with catheters providing prolonged analgesia in open procedures. However, since T6 is ideal for an incision close to xiphoid, there may be room for improvement on cephalad spread in terms of bolus dosing and infusions. There are no specific guidelines on the bolus dosage to be given before catheter insertion, the precise catheter length to be inserted, nor whether a multi-holed catheter would provide more LA spread. However, the management of TAP block catheters has provided some insights since the transversalis fascia is an extension of TAP which is continuous with the QL muscle.

TQL catheters have the advantage of analgesic benefit for both upper and lower abdominal surgery. With regards to injection technique, the lower iliac crest level at L4 and higher near L1 spine, near the 12th rib have been established as approaches to TQL block [2,13]. At the L2 level we would qualify for the in between (mid-level) TQL block. At this stage we are unsure whether high [13], mid or low level TQL technique is optimal, however, this series suggests that L2 (mid-level Rao's technique) may have an advantage over the techniques at L4 in

preventing adverse effects. Larger studies and randomised control trials are warranted to establish the efficacy and safety of these techniques. This study is limited by the small case series.

Conclusion:

A TQL catheter placed either at L4 and L2 levels reduced postoperative pain scores and analgesic use after major abdominal surgeries. Absence of neurological adverse events in the L2 group may suggest its possible safety. More Controlled clinical trials are required to authenticate our results.

References:

1. El-Boghdadly K, Elsharkawy H, Short A, Chin KJ. Quadratus lumborum block nomenclature and anatomical considerations. *Regional Anesthesia Pain Medicine* 2016; **41:** 548-9.
2. Børglum J, Moriggl B, Jensen K, et al. Ultrasound-guided transmuscular quadratus lumborum blockade. *British Journal of Anaesthesia* 2013; **111**.
3. Baidya DK, Maitra S, Arora MK, Agarwal A. Quadratus lumborum block: an effective method of perioperative analgesia in children undergoing pyeloplasty. *Journal of Clinical Anesthesia* 2015; **27:** 694-6.
4. Chakraborty A, Goswami J, Patro V. Ultrasound-guided continuous quadratus lumborum block for postoperative analgesia in a pediatric patient. *A A Case Reports* 2015; **4:** 34-6.
5. Shaaban M, Esa WA, Maheshwari K, Elsharkawy H, Soliman LM. Bilateral Continuous Quadratus Lumborum Block for Acute Postoperative Abdominal Pain as a Rescue After Opioid-Induced Respiratory Depression. *A A Case Reports* 2015; **5:** 107-11.
6. Rao Kadam V, Taylor L, Tong M. Continuous transmuscular quadratus lumborum block catheter technique for post-operative pain relief in upper abdominal surgery-case report. *Journal of Anesthesia & Pain Medicine* 2016; **1:** 1-2.

7. Warusawitharana C, Basar S, Jackson BL, Niraj G. Ultrasound guided continuous transmuscular quadratus lumborum analgesia for open renal surgery: A case series. *Journal of Clinical Anesthesia* 2017; **42:** 100-1.
8. Lee S, Goetz T, Gharapetian A. Unanticipated Motor Weakness with Ultrasound-Guided Transversalis Fascia Plane Block. *A A Case Reports* 2015; **5:** 124-5.
9. Wikner M. Unexpected motor weakness following quadratus lumborum block for gynaecological laparoscopy. *Anaesthesia* 2017; **72:** 230-2.
10. Sá M, Cardoso JM, Reis H, et al. Quadratus lumborum block: are we aware of its side effects? A report of 2 cases. *Brazilian journal of anesthesiology* 2018; **68:** 396-9.
11. Carney J, Finnerty O, Rauf J, Bergin D, Laffey JG, Mc Donnell JG. Studies on the spread of local anaesthetic solution in transversus abdominis plane blocks. *Anaesthesia* 2011; **66:** 1023-30.
12. Ueshima H, Yoshiyama S, Otake H. The ultrasound-guided continuous transmuscular quadratus lumborum block is an effective analgesia for total hip arthroplasty. *Journal of Clinical Anesthesia* 2016; **31:** 35.
13. Elsharkawy H. Quadratus lumborum block with paramedian sagittal oblique (subcostal) approach. *Anaesthesia* 2016; **71:** 241-2.

Acknowledgement:

We thank Dr Venkatesan Thiruvenkatarajan for his editing, Patricia Williams and Karen Taylor for spell check.

Table 1 showing the demographics, dermatomes, pain scores and analgesia used.

	Age	Sex	ASA*	TQL† block level	Dermatomal level	Pain scores PACU ‡ (0-10)	Analgesia in PACU (fentanyl in mcg)	Pain scores Day 1 (0-10)	Pain scores Day 2 0-10	Total Fentanyl Used 48hrs (mcg)	Type of surgeries
1	69	Male	2	L4	T8-L1	0	0	5	4	310	Subtotal Gastrectomy
2	77	Female	3	L4	T6-L1	1	160	5	5	1800	Reversal of Hartmann's
3	63	Female	3	L4	T8-L1	5	80	2	4	2300	Ext hemi colectomy
4	42	Female	3	L4	T8-L1	0	0	7	6	900	Ext hemi colectomy
5	68	Male	2	L4	T8-L1	1	60	5	8	1075	Right hemicolectomy
6	60	Male	2	L2	T8-L1	0	0	5	5	500	Anterior resection
7	62	Male	2	L2	T8-L1	7	100	5	5	170	Reversal of ileostomy
8	50	Male	2	L2	T8-10	6	100	6	8	800	Left hemicolectomy
9	62	Male	3	L2	T8-10	0	0	6	7	3000	Laparotomy bowel resection
10	65	Male	3	L2	T8-L1	2	80	5	3	650	Low anterior resection

*ASA=American society of anaesthesiologist, †TQL= Trans-muscular Quadratus lumborum
‡PACU=Post anaesthesia care unit, mcg=microgram

Figure1 showing the Lumbar level skin markings with needle approached under ultrasound probe to perform TQL at L2 level

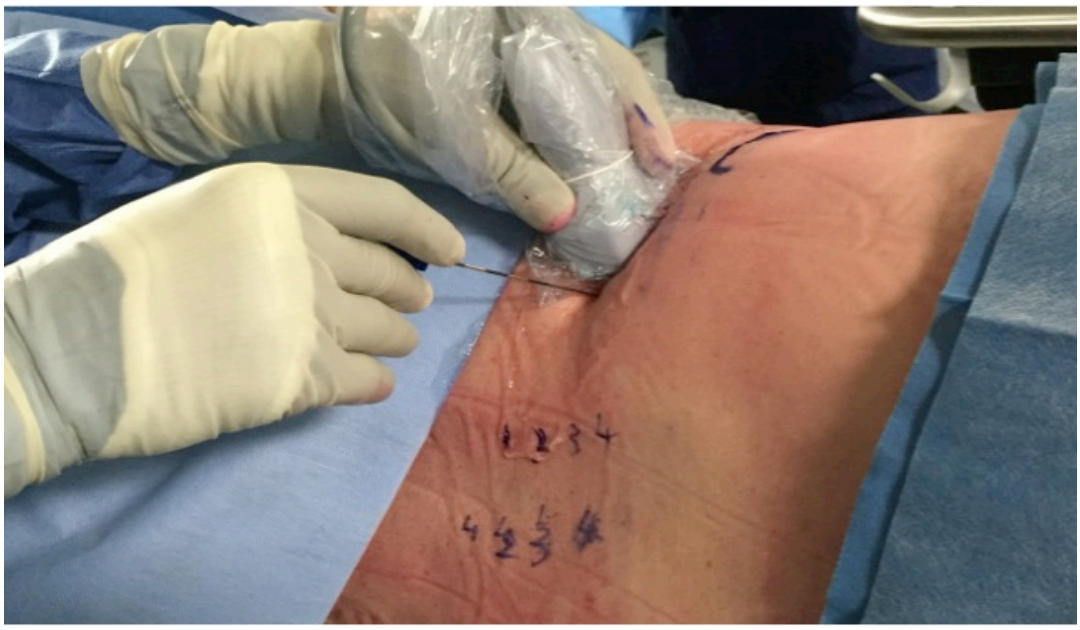
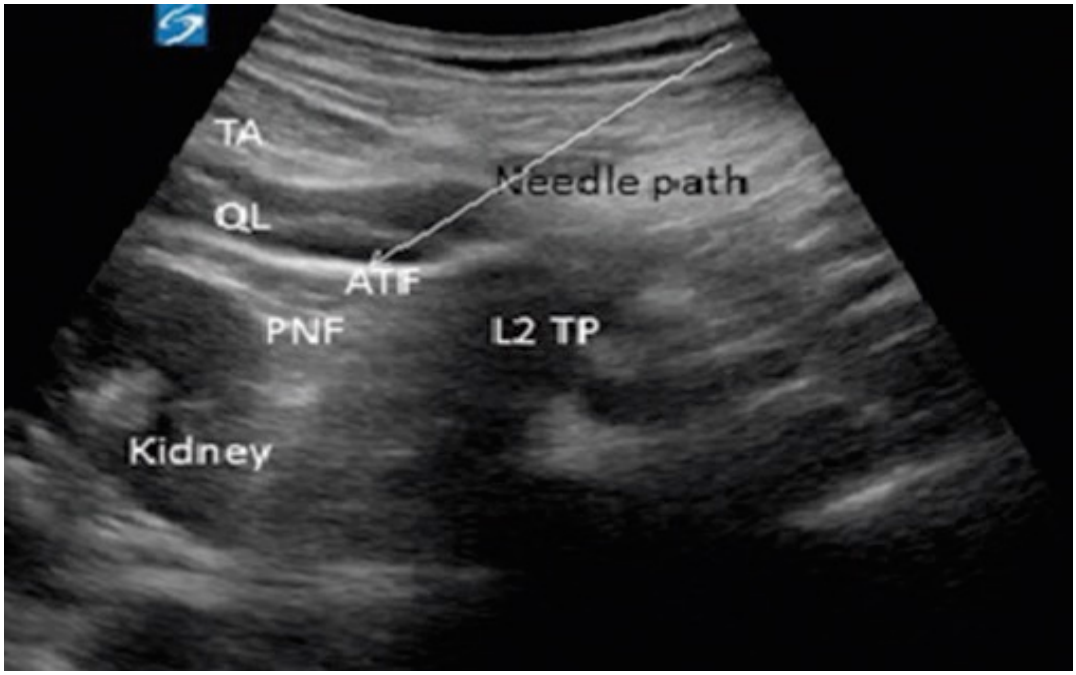
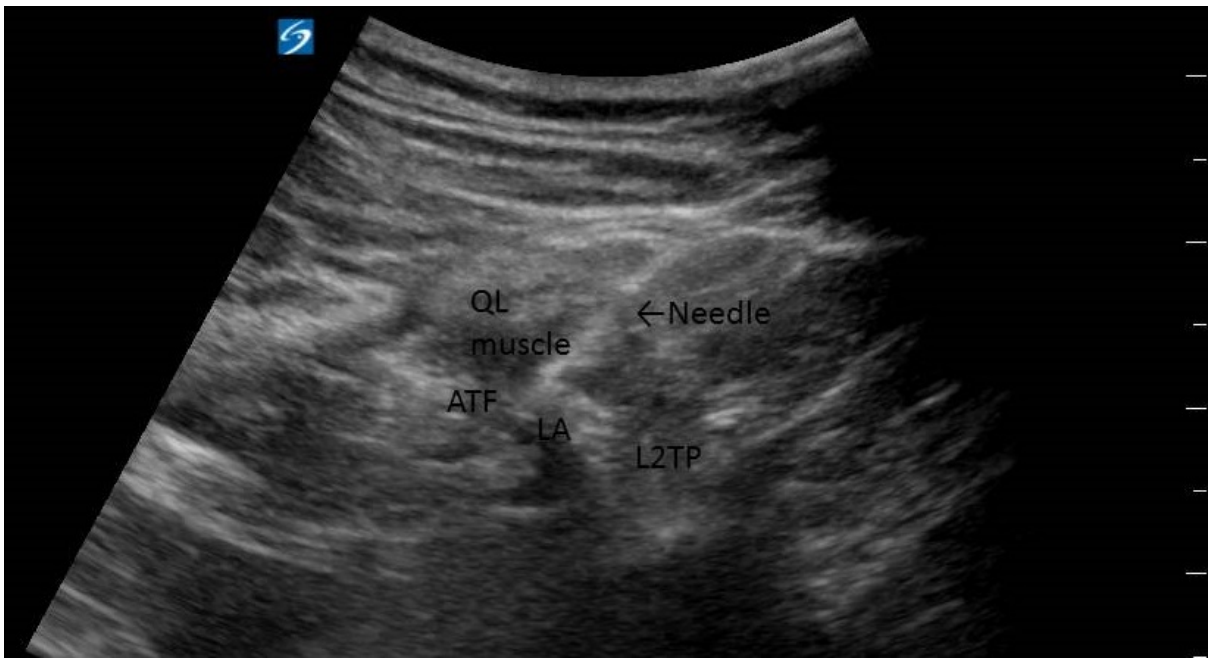


Fig 2 showing the sonoanatomy of TQL block at L2



Legends: TA= transversus abdominis, QL= quadratus lumborum muscle, ATF= anterior thoracolumbar fascia, PNF= perinephric fascia, TP= transverse process

Fig 3 showing the ultrasound guided TQL with LA injected at L2 level



Legends: TA= transversus abdominis, QL= quadratus lumborum muscle, ATF= anterior thoracolumbar fascia, PNF= perinephric fascia, TP= transverse process

Chapter 3 - Evaluation of the new ultrasound guided trans-muscular quadratus lumborum block

Comparison of ultrasound guided trans-muscular quadratus lumborum (TQL) block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery - Prospective randomized study.

Authors

V. Rao Kadam[1,2], G. Ludbrook[3], R.M.A.W. van Wijk[1,2], P. Hewett[4,5], J.L. Moran[6,7], V. Thiruvenkatarajan [1,2], P. Williams[6,8,9]

Affiliations

[1]Department of Anaesthesia, The Queen Elizabeth Hospital, South Australia, Australia, [2] A/Professor, Acute Care Medicine, The University of Adelaide, South Australia, Australia, [3] Professor, Acute Care Medicine. The University of Adelaide, South Australia, Australia, [4]Department of Surgery, The Queen Elizabeth Hospital, South Australia, Australia, [5]Professor, Department of Surgery, The University of Adelaide, South Australia, Australia, [6]Department of Intensive Care Medicine, The Queen Elizabeth Hospital, South Australia, Australia, [7]A/Professor, The University of Adelaide, South Australia, Australia, [8] Affiliate Lecturer, Acute Care Medicine, The University of Adelaide, South Australia, Australia, [9] Adjunct Research Fellow, Department of Epidemiology and Preventative Medicine, Monash University, Victoria, Australia.

Keywords

Quadratus lumborum, transmuscular quadratus lumborum block, thoracolumbar fascia, ultrasound, post-operative analgesia

Statement of Authorship

Title of Paper	Comparison of ultrasound guided transmuscular Quadratus Lumborum (TQL) block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery - Prospective randomized study
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Kadam VR, Van Wijk RM, Ludbrook GL, P. Hewett, J. L. Moran, Thiruvenkatarajan V. P. Williams. Comparison of ultrasound-guided trans-muscular quadratus lumborum block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery: a randomised controlled trial. Anaesthesia 2019, 74, 1381–1388.

Principal Author

Name of Principal Author (Candidate)	Vasanth Rao Kadam		
Contribution to the Paper	Designed the images conceptualsed the work including consenting process and writing manuscript and also corresponding author		
Overall percentage (%)	90		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	29.9.22

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	R. M. Van Wijk		
Contribution to the Paper	Designing, editing, and drafting the manuscript		
Signature		Date	05.10.22

Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	4 OCT 22
Name of Co-Author	P. Hewett		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	12/10/22
Name of Co-Author	J. L. Moran		
Contribution to the Paper	Statistical analysis, editing and drafting the manuscript		
Signature		Date	
Name of Co-Author	V. Thiruvenkatarajan		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	29/9/22
Name of Co-Author	P. Williams		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	29.9.2022

Abstract

Following abdominal surgery both continuous local anaesthetic infusion through preperitoneal catheter (PPC) and Trans-muscular Quadratus Lumborum (TQL) block have been described for post-operative analgesia. This study compared the efficacy of continuous TQL block versus PPC for post-operative analgesia following laparotomy.

Eighty-two patients between 18 and 85 years of age undergoing elective surgery were randomised to receive either PPC or TQL block. In the PPC group after 20mls bolus of 0.375% ropivacaine infiltration at subcutaneous, sub-fascial and preperitoneal plane catheters were placed bilaterally. In TQL group, under ultrasound guidance, an 18-gauge Tuohy's needle was passed through QL muscle to reach its anterior aspect. A 20ml bolus of 0.375% ropivacaine was administered and catheters placed bilaterally. Both groups received an infusion of 0.2% ropivacaine at 5ml/h continued up to 48hrs along with a multimodal regime including regular paracetamol and a patient-controlled analgesia with fentanyl. The primary end point was post-operative pain score on a Numerical Rating Score (NRS, 0-10) on coughing. Secondary outcomes measured were NRS at rest, fentanyl usage until 48hrs, satisfaction scores and costs.

There was no difference in NRS at cough (p=0.24). In TQL group there was reduction in NRS at rest (p=0.036) and satisfaction scores on days 1 and 30 (p=0.004 p=0.006), nonetheless, fentanyl usage was similar. The TQL technique incurred 574.64AUD more per patient than the PPC. In TQL group, the highest and lowest blocks observed in the recovery area were T4 and L1, respectively. The TQL group achieved reduced pain scores at rest but at cough there was no difference.

Introduction

Myofascial blocks (ultrasound guided as well as under direct vision) such as the transversus abdominis plane (TAP) block have been advocated for post-operative analgesia for over a decade [1,2]. Although TAP blocks have been shown to provide somatic analgesia and reduced opioid consumption, two level TAP blocks are required to achieve analgesia for longer abdominal incisions [3] . A surgical infiltration technique has been reported to provide

superior pain relief at rest and on coughing with reduced opioid consumption compared with a TAP block [4]. Preperitoneal catheter (PPC) analgesia compared to saline has been demonstrated to be effective in reducing opiate consumption and pain scores at rest and cough; and same variables were non-inferior to epidural analgesia after colorectal surgery [5-9]. The mechanism of action is presumably blocking the nociceptive afferents of peritoneum [8].

The ease of the PPC technique and the reduced complexity involved in managing the catheters postoperatively have been a great attraction, and many surgical protocols have incorporated this as a standard practice [9]. Trans-muscular Quadratus Lumborum (TQL) block is a recently described myofascial plane technique where the local anaesthetic is deposited adjacent to the QL muscle aiming to anaesthetise the thoracolumbar nerves via the mechanism of LA reaching the paravertebral space [10]. It has been shown to provide visceral analgesia in abdominal surgery with any type of incision, covering higher dermatomal levels (T7-L1) [10]. There are both paediatric and adult case reports of single and continuous TQL block for post-operative analgesia [11-14].

To date, there have been no studies examining the continuous TQL technique for post-operative analgesia after major open abdominal surgery in adults. This study aimed to investigate whether continuous TQL had an analgesic advantage over the continuous PPC. We hypothesized that ultrasound-guided TQL block provide superior analgesia as reflected by improved Verbal Numerical Rating Score (NRS) for pain on movement and reduced opioid requirement in comparison with surgically guided continuous pre-peritoneal block. The primary outcome examined was postoperative dynamic pain scores, Verbal NRS (0-10) on cough. Secondary outcomes were rest pain, opioid usage, procedure related technical issues in relation to anatomy, time taken for catheter insertion, incidence of motor weakness, and overall satisfaction.

Methods

Human Research Ethics Committee (The Queen Elizabeth Hospital) approval was obtained (reference number HREC/16/TQEH/176). This was a single centre trial conducted at The Queen Elizabeth Hospital with the main flow of patients recruited from the colorectal division of surgery from November 2016 to November 2018.

Patients undergoing elective abdominal surgery with a midline incision (above and below umbilicus), between 18 and 85 years of age, with ASA grade 1-3, who had adequate English language skills were included after obtaining informed consent. Patients were identified in pre-admission clinic by the anaesthetist. Exclusion criteria were emergency surgery, allergy to local anaesthetic, pregnancy, chronic opioid medication of >30mg/day (morphine equivalent), mental handicap or psychiatric condition precluding adequate communication.

The group allocation was by a simple randomization table using the user written Stata module "ralloc" [15]. This allocation was concealed by a sealed opaque envelope. The proceduralist could not be blinded; however, the patients were blinded to group allocation. On arrival in theatre, the chief investigator handed the box of envelopes to the attending nurse or anaesthetic colleague to assign participants for intervention. During the surgical procedure patients had standard monitoring with standardized general anaesthetic technique comprising propofol, rocuronium, oxygen, air, and sevoflurane. For intra-operative analgesia, fentanyl was used via intermittent bolus.

Patients randomized to the pre-peritoneal catheter group received infiltration with ropivacaine (Naropin, AstraZeneca Pty Ltd, Sydney, NSW, Australia), which was performed by the surgeon. At the end of the surgery, all layers of the surgical incision were infiltrated with a 22-gauge, 40-mm needle under direct visualization. Ropivacaine (3mg/mg.kg-1 maximum up to 225 mg) was diluted with 40 ml of normal saline to a total volume of 60 ml, of which 20 ml was infiltrated in the preperitoneal plane (see figure 1), 20 ml in the sub-fascial plane, and 20 ml into the subcutaneous plane. Thereafter, the surgeon placed the catheter on the superior aspect of the incision in the pre-peritoneal region under direct vision. This was to facilitate the continuous infusion of 0.2% ropivacaine in the recovery room and ward until 48 hours.

In the TQL group, at the end of the surgery, in a lateral position the chief investigator, under ultrasound guidance visualised the QL muscle with a curved transducer probe (Sonosite X-Porte, SonoSite Inc. Bothell, WA). Under aseptic precautions, an 18-gauge Tuohy's needle was used in plane, posterior to anterior, through QL muscle to reach the anterior aspect of the QL muscle and below the anterior thoraco-lumbar fascia, (near the peri-nephric fascia) see figure 2. This was confirmed by injecting saline, followed by a bolus dose of 20 ml of 0.375% ropivacaine, and a catheter was placed in the plane. The same technique was repeated on the other side.

The time taken from the needle entry to the catheter insertion was noted in both groups by either an anaesthetic colleague or a nursing staff member. Each group of participants had one catheter on each side of the abdomen and each was connected to a continuous infusion device. A continuous infusion of 0.2% ropivacaine at 5 ml/h was delivered by an elastomeric infusion device ('On Q pain relief system' Kimberly Clark, CA, USA.) in both groups for 48 hrs. Once the patients were stable enough to leave the PACU, they were discharged to the surgical ward. The dermatomal segments of TQL block were assessed by ice by the recovery staff after one hour in the post anaesthesia care unit (PACU), and the rest of the study duration did not involve dermatomal assessment. Patients in both groups received paracetamol 1-gram QID (orally or IV) and a fentanyl PCA device (bolus 20 to 40 mcg; lockout time 5 min; no back-ground infusion) as part of a multi-modal analgesic approach.

Acute Pain Service (APS) personnel independently assessed post-operative pain scores and analgesia used in recovery and on days one and two. The APS team was not blinded as it was not possible to perform catheter care without this information. During the daily morning post-surgery visit they assessed pain scores, followed up any side effects related to fentanyl or local anaesthetics and cared for the catheters. All results were recorded prospectively on a purpose-built data collection sheet and subsequently entered into a protected database.

Postoperative pain was assessed using the 10 point self-report Numerical Rating Score (NRS) in PACU (0 and 1 hour) and at first and second postoperative days. The primary outcome was dynamic pain score, on coughing at the predetermined time points.

Secondary end points were: rest pain scores, rescue analgesia fentanyl use, procedure related technical issues, duration of catheter insertions, and complications such as motor weakness

were noted. A 4 point 'Likert'-scale for satisfaction of how well the pain managed on the scale of 4 (1. completely relieved; 2. relieved; 3. somewhat relieved; and 4. not relieved). This was used on post-operative day 2 and during a follow-up telephone call at one month by a research assistant to assess patient satisfaction with the analgesic technique used and any adverse events experienced. The first flatus or bowel opening times and hospital discharge times were also recorded from electronically recorded surgical progress notes. Personnel and material costs were analysed for cost-benefit analysis. Financial information was obtained from pharmacy and nurse/business managers.

Continuous data was analysed by the *t*-test (unequal variances) for normally distributed data (identified by moment analysis; skewness and kurtosis). Non-normally distributed data were analysed by the rank-sum test; categorical data by the Fisher exact test. As the numerical rating pain scores were repeated over time, a linear mixed model analysis (patient as random intercept, patient-time as random slope; unstructured covariance) was undertaken to identify any treatment differences [16]. Model specification was assured by residual analysis. Model based estimates and treatment contrasts were undertaken using the "margins" procedure of Stata™ [17]. The statistical analysis was blinded to group allocation.

Based on our previous report [18], the peak cough pain score (Numerical Rating Scores for Pain; NRS-P; 0-10) was noted to be 5.0 (standard deviation, 3.0). As appropriate RCT's for the use of QL blocks catheters have not been published, an approximate scenario was established for patient number: the total patient number (at 80% power) for a 2 point (40%) mean decrease in NRS-P was 72. On this basis, it was proposed to randomize 82 patients to the two treatment arms allowing for dropout.

Results

Only one patient had a breach of protocol (did not receive TQL) and none were lost to follow up (see Consort flow diagram Figure 3). Both the groups were comparable with respect to pre-operative status. Baseline and operative specifications are shown in Table 1. Pain scores, fentanyl usage and Likert satisfaction scores by treatment group, are shown in Table 2. There was no difference between the groups in terms of pain on coughing over time (p= 0.242) and

no interaction between therapy and time was noted (p=0.32). The TQL group showed a slight efficacy for pain at rest over time (p=0.036; two periods in PACU and at two time points in the ward) compared with PPC group. Satisfaction scores were lower in the TQL group on days 2 and 30, p=0.006 and 0.004 respectively. The cost analysis showed, a 574.64 Australian dollars (AUD) difference in cost in favour of the PPC technique; the difference being in the additional material for TQL as well as the extra theatre utilisation time. No block related complications, such as vascular/visceral puncture or local anaesthetic toxicity were recorded. Catheter leaks were found in two patients in each group, and two patchy blocks (no uniform dermatomes distribution) were reported. Hypotension was comparable between the groups (Table 3), it was mild necessitating only fluid therapy without ICU admission. In the TQL group the highest and lowest block observed was T4- and L1 respectively in the PACU. In 20 patients there was clear dermatomal spread; in the other patients it was not well defined. Ketamine was used for pain relief in one patient in each group.

Discussion

TQL-block provided a small but significant reduction in pain scores at rest both at PACU and postoperative day one and day two compared with the PPC group. Although dynamic pain scores may be a more important patient outcome than rest pain relief, these was similar in both groups.

One possible reason for better analgesia at rest in the immediate postoperative period with TQL block may be the quicker onset with bolus injection and intra operative opioid effect. Although improvement in dynamic pain scores is vital for recovery of respiratory function, the small reduction in rest pain in the TQL group compared with the PPC group would also have offered a clinical benefit. Both somatic and visceral analgesia may be achieved by PPC and TQL which may reflect the modest amount of rescue analgesia used. The sympatholytic effects such as hypotension were mild and the frequency of this outcome and ileus was similar between the groups. We did not observe a profound sympathetic effect implying that the visceral component was probably spared. The moderate-high frequency of ileus, 29% with PPC and 18% with TQL (Table 1), is difficult to explain, as both groups were comparable with regard to rescue opioid used. It is likely therefore that LA agents injected through a catheter

into the pre-peritoneal space are able to act locally to block nociceptive afferents of the fascia of the abdominal muscles and the peritoneum. Both the fascia of the abdominal muscles and peritoneum are injured during laparotomy and contribute to postoperative pain and primary mechanical hyperalgesia [19,20]. The current mechanism of TQL is LA spread to the paravertebral space. Even though a cadaveric study reported dye spread to the thoracic paravertebral space and sympathetic chain, we did not observe any profound clinical effects related to this effect such as exaggerated hypotension [21]. However, the dermatomal cover observed from T4-L1 in the immediate postoperative period may indicate the possibility of LA reaching the paravertebral space and blocking the dorsal and ventral rami. Only one case had right leg weakness; this was temporary, and it was difficult to ascertain whether it was block related or procedure related with a prolonged duration in the lithotomy position. Even though no demonstrable dermatomal spread was evident in 50% of patients, they were clinically comfortable as evidenced by lower resting pain scores and opioid use.

PPC was more cost effective in relation to consumables and medical assistance requirements. It was also technically simple and easier to perform without the requirement of ultrasound. The time taken from the needle entry to the catheter's insertion was similar in both groups. Previous PPC practice included preperitoneal bolus and wound infiltration; in the PPC group this was modified to use an additional precise LA bolus injection into the sub fascial layers followed by continuous infusion. This minor change could be incorporated into our routine practice.

There were several limitations of our trial. It was conducted in a single centre, was single blinded and our costings and current practice of PPC catheter insertion may not be applicable in other settings. Our optimistic postulate of a 40% mean decrease in NRS may have resulted in a Type 2 (false negative) error. Within the constraints of a postoperative analgesia study involving catheter intervention, attempts were made to reduce bias as much as possible. The proceduralist could obviously not be blinded. Allocation concealment was ensured by only assigning computer-generated group allocation after induction of the patient in the operating theatre. Given the different catheter positions between the groups, patient blinding existed only until arrival on the ward, as it was considered undesirable to place sham catheters. The acute pain team who assessed pain scores on the ward also could not be blinded, as it would not be possible to perform catheter assessment and care otherwise. Except for the two

catheter techniques, postoperative care and analgesia were standardised between the groups to reduce performance bias. We also ensured that statistical analysis was blinded to group allocation. Although we could not disprove our null hypothesis, true to academic principles we still pursued publication of this paper and thus helped to reduce reporting bias.

In conclusion this prospective, single centre, randomised, open label study revealed a slight analgesic benefit (at rest) of the TQL group in the immediate post-operative period over the PPC technique. Both techniques were comparable in terms of pain scores during cough and rescue opioid requirement. No differences in complications were observed between the two techniques. In the TQL group, the highest and lowest block observed was T4 and L1, respectively (in the recovery area). Considering the invasiveness and expertise required for the TQL block, the PPC technique may be a cost-effective viable alternative for postoperative pain management after abdominal surgery.

Acknowledgments

This study was partially funded by The Australian and New Zealand College of Anaesthetists Research Foundation (No. N18/002). Clinical trial registry: Australian and New Zealand Clinical Trial Registry (reference no: ANZCTR: 12616000915459. 09/08/2016

Competing Interests

No Financial disclosures or conflicts of interest.

Table 1 Patient Demographics and Details by Technique. Data are presented as mean (SD) or median (IQR [range]) for continuous measures, and n (%) for categorical measures. PPC denotes preperitoneal catheter; TQL, Trans-muscular Quadratus Lumborum; cm, centimetres; PACU, post anaesthetic care unit; mins, minutes; LOS, length of stay.

	PPC N=41	TQL N=40	p-value
Age (years)	66.4 (14.1)	64.2 (15.0)	0.50
Gender			0.91
Female	21 (51%)	21 (53%)	
Male	20 (49%)	19 (48%)	
ASA status	3.0 (2.0-3.0)	3.0 (2.0-3.0)	0.66
Operation			0.56
Upper GI surgery	3 (7%)	1 (3%)	
Colorectal surgery	33 (80%)	35 (88%)	
Laparotomy	5 (12%)	4 (10%)	
Incision length (cm)	21.0 (5.4)	22.6 (5.9)	0.20
Surgical duration (mins)	170.0 (135.0-210.0)	173.0 (140.0-262.5)	0.42
Anaesthetic duration (mins)	205.0 (153.0-240.0)	207.5 (180.0-302.5)	0.12
Catheter insertion (mins)	10.0 (7.0-11.0)	9.0 (7.0-11.5)	0.77
Insertion difficulties			0.051
No	31 (76%)	22 (55%)	
Yes	10 (24%)	18 (45%)	
PACU time (mins)	75.0 (63.0-105.0)	90.0 (57.5-120.0)	0.80
Post-operative ileus			0.21
No	29 (71%)	33 (83%)	
Yes	12 (29%)	7 (18%)	
Post-operative hypotension			0.62
No	39 (95%)	37 (93%)	
Yes	2 (5%)	3 (8%)	
Flatus time (mins)	72.0 (48.0-96.0)	72.0 (48.0-74.0)	0.94
Bowel motion time (mins)	88.0 (62.0-144.0)	75.0 (72.0-126.0)	0.95
Hospital LOS (days)	9.0 (7.0-13.0)	8.0 (5.5-11.0)	0.15

Table 2 Numerical Rating Scores for Pain (at rest and cough), Fentanyl use (μg) and Likert scores. Data are presented as mean (SD) or median (IQR).

PPC denotes pre-peritoneal catheter; TQL, Trans-muscular Quadratus Lumborum; PACU, post anaesthetic care unit; μg, microgram.

	PPC **N=41**	**TQL** **N=40**	**p-value**
Intraoperative fentanyl use	500.0 (375.0-600.0)	600.0 (500.0-700.0)	0.027
PACU cough pain 0hr	4.0 (2.0-7.0)	2.0 (0.0-7.0)	
PACU rest pain 1hr	3.3 (2.1)	3.1 (2.4)	
PACU cough pain 1hr	4.5 (2.0)	4.4 (2.6)	
PACU cumulative fentanyl (μg)	100.0 (0.0-120.0)	35.0 (0.0-160.0)	0.52
Ward rest pain day1	2.0 (1.0-4.0)	2.0 (0.0-4.5)	
Ward cough pain day1	6.0 (5.0-8.0)	6.5 (5.0-8.0)	
Cumulative fentanyl D1 (μg)	887.6 (646.5)	901.1 (704.1)	0.93
Ward rest pain day2	2.0 (1.0-4.0)	2.0 (0.0-3.0)	
Ward cough pain day2	6.0 (4.0-8.0)	5.5 (3.0-7.0)	
Cumulative fentanyl D2 (μg)	350.0 (190.0-900.0)	515.0 (160.0-1210.0)	0.73
Total fentanyl (μg)	1195.0 (825.0-1840.0)	1372.5 (692.5-2580.0)	0.91
Likert score day2	2.2 (0.5)	1.8 (0.6)	0.006
Likert score day30	2.3 (0.8)	1.8 (0.7)	0.004

Table 3 Complications. PPC denotes preperitoneal catheter; TQL, Trans-muscular Quadratus Lumborum

	PPC **N=41**	**TQL** **N=40**
Ileus	12	7
Nausea	10	11
Failed block	0	1
Catheter leak	left (1) right (1)	left (2)
Hypotension	2	2
Patchy block	not assessed	3
Weakness in right leg (temporary)	0	1
Aspiration pneumonia	2	1
Tachycardia	2	2

Figure 1

Identification: showing the pre peritoneal bolus infiltration under vision

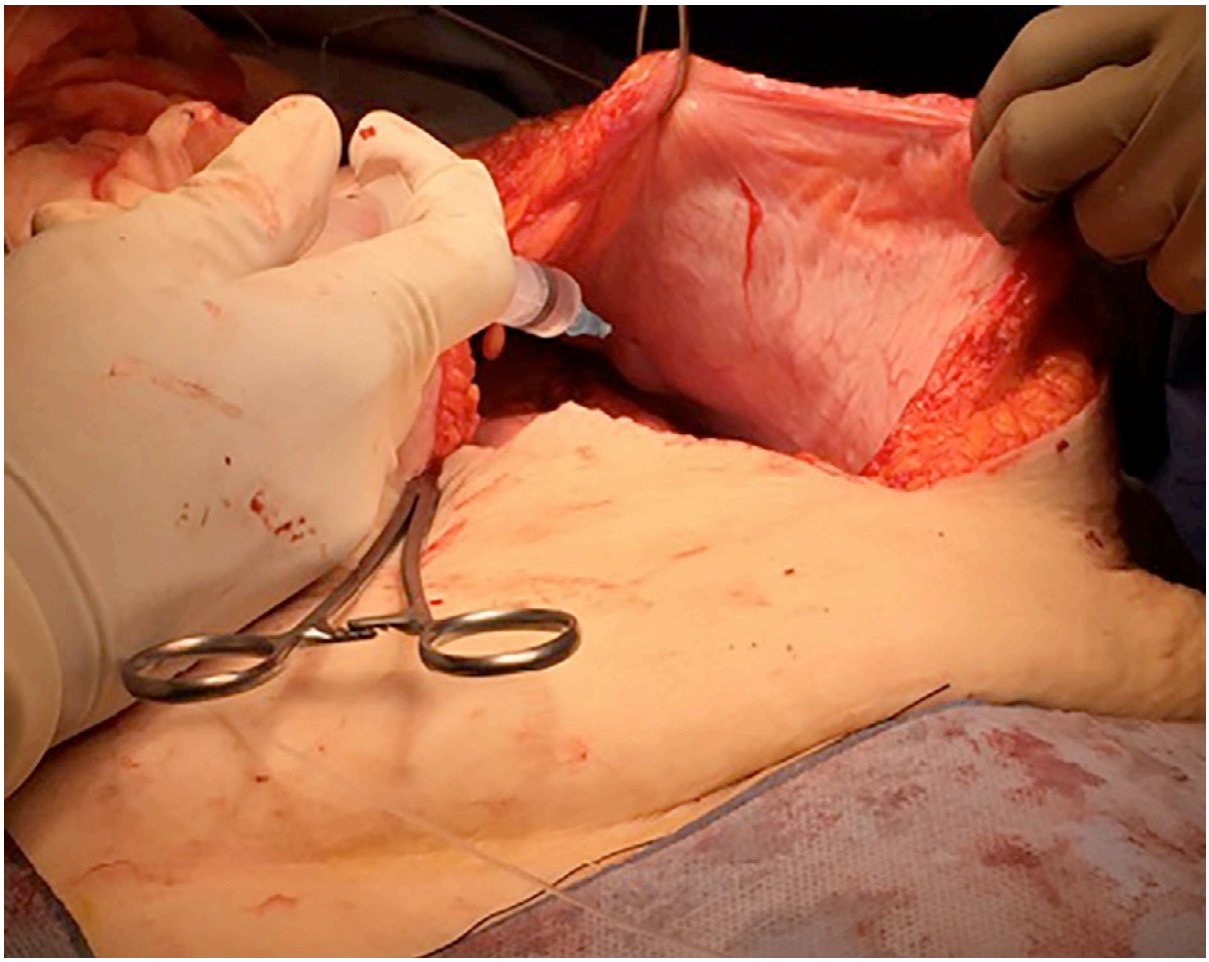
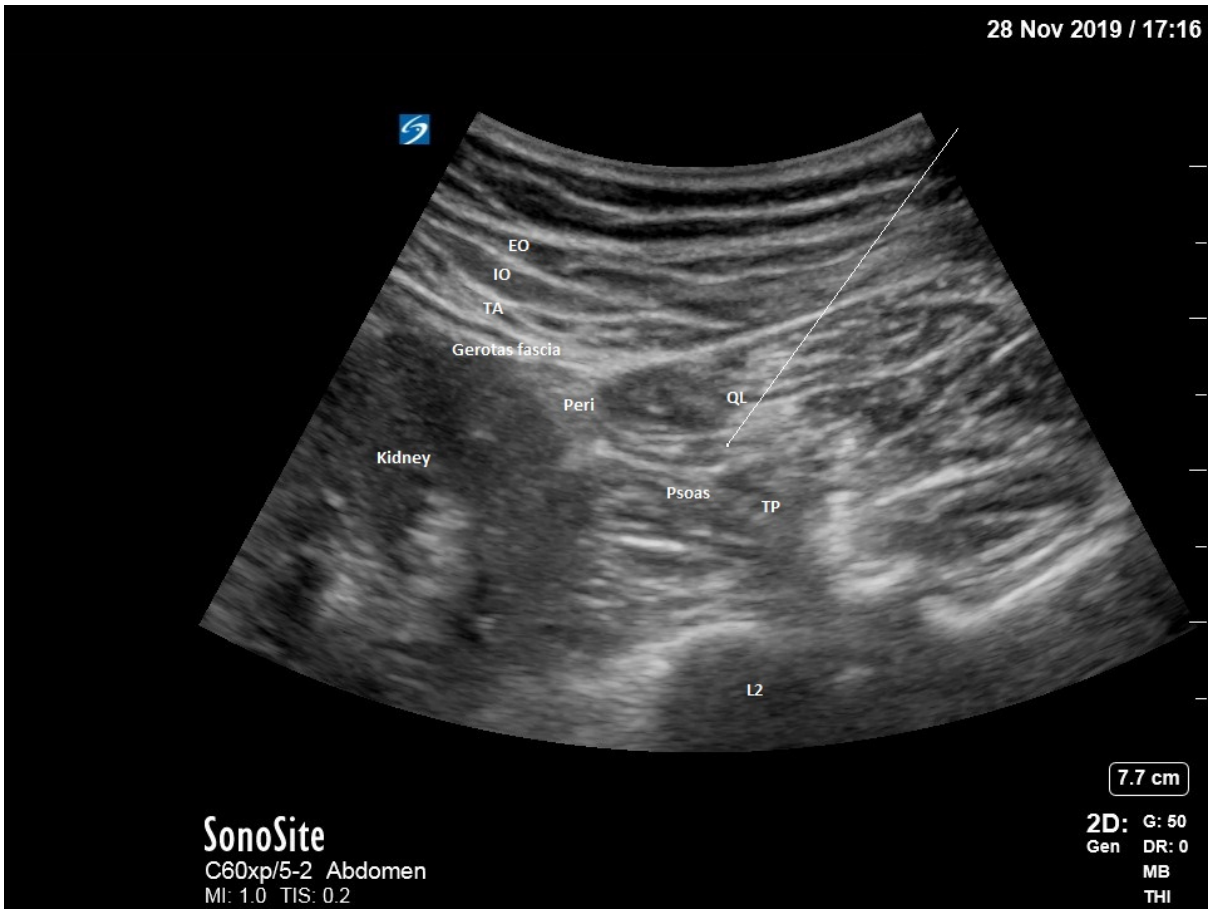


Figure 2

Identification: showing the lateral position with illustrate anatomy and sono anatomy with simulated needle path



Abbreviations: TA - transversus abdominis

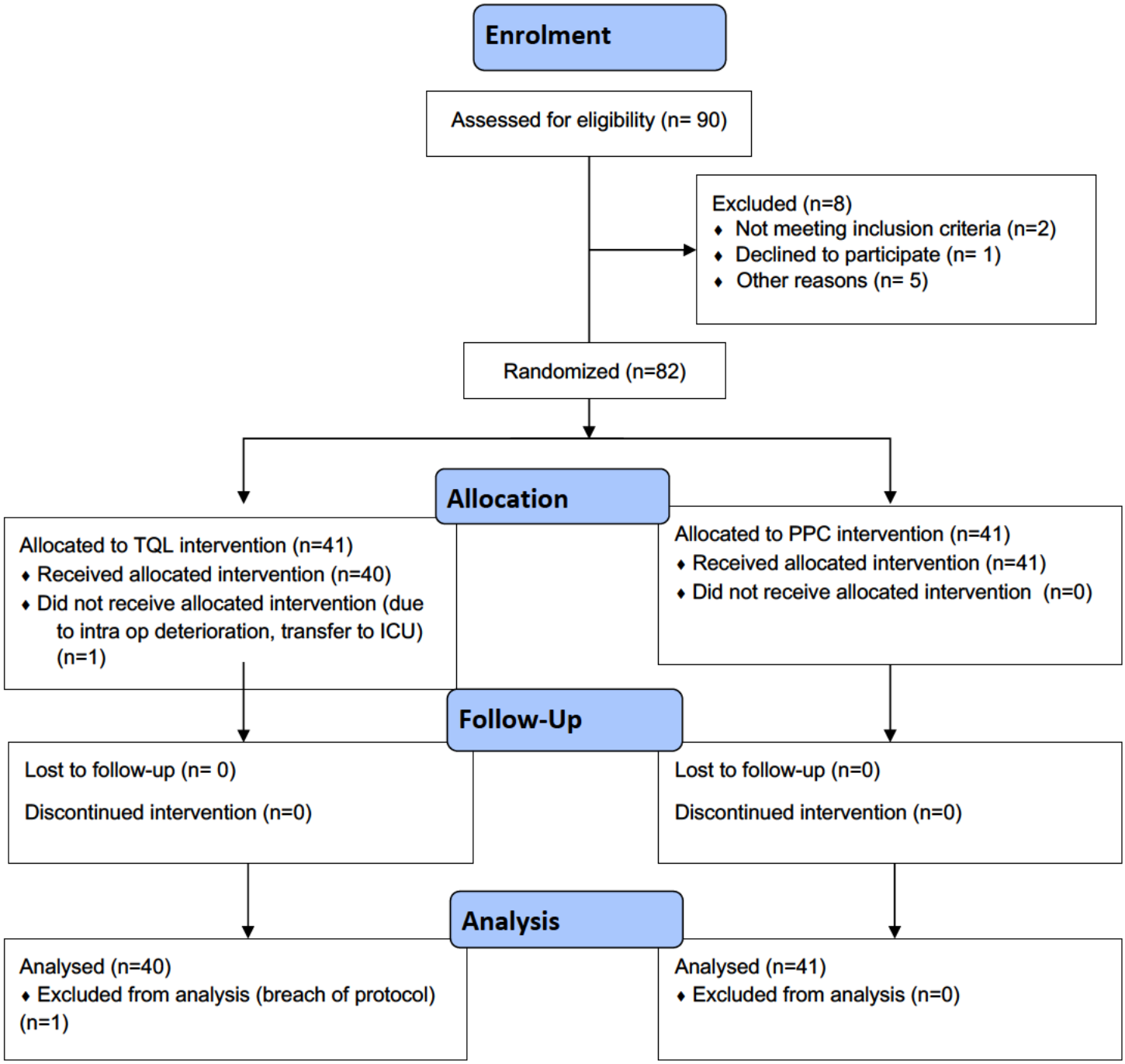
QL - Quadratus lumborum muscle

ATF - anterior thoraco-lumbar fascia

PNF - perinephric fascia

L2 TP - 2nd lumbar transverse process

Figure 3 CONSORT Flow Diagram



References:

1. Brady RR, Ventham NT, Roberts DM, Graham C, Daniel T. Open transversus abdominis plane block and analgesic requirements in patients following right hemicolectomy. *Annals Royal College Surgeons England* 2012; **94:** 327-30.
2. Petersen P, Mathiesen O, Torup H, Dahl J. The transversus abdominis plane block: a valuable option for postoperative analgesia? A topical review. *Acta Anaesthesiologica Scandinavica* 2010; **54:** 529-35.
3. Borglum J, Maschmann C, Belhage B, Jensen K. Ultrasound-guided bilateral dual transversus abdominis plane block: a new four-point approach. *Acta Anaesthesioligica Scandinavica* 2011; **55:** 658-63.
4. Gasanova I, Alexander J, Ogunnaike B, et al. Transversus Abdominis Plane Block Versus Surgical Site Infiltration for Pain Management After Open Total Abdominal Hysterectomy. *Anesthesia Analgesia* 2015; **121:** 1383-8.
5. Beaussier M, El'Ayoubi H, Schiffer E, et al. Continuous preperitoneal infusion of ropivacaine provides effective analgesia and accelerates recovery after colorectal surgery: a randomized, double-blind, placebo-controlled study. *Anesthesiology* 2007; **107:** 461-8.
6. Bertoglio S, Fabiani F, De Negri P, et al. The postoperative analgesic efficacy of preperitoneal continuous wound infusion compared to epidural continuous infusion with local anesthetics after colorectal cancer surgery: a randomized controlled multicenter study. *Anesthesia Analgesia* 2012; **115:** 1442-50.
7. Fustran N, Dalmau A, Ferreres E, et al. Postoperative analgesia with continuous wound infusion of local anaesthesia vs saline: a double-blind randomized, controlled trial in colorectal surgery. *Colorectal Disease* 2015; **17:** 342-50.
8. Krishnan S, Morris RG, Hewett PJ, et al. A randomized double-blind clinical trial of a continuous 96-hour levobupivacaine infiltration after open or laparoscopic colorectal surgery for postoperative pain management--including clinically important changes in protein binding. *Therapeutic Drug Monitoring* 2014; **36:** 202-10.
9. Ozer A, Yılmazlar A, Oztürk E, Yılmazlar T. Preperitoneal catheter analgesia is an effective method for pain management after colorectal surgery: the results of 100 consecutive patients. *Local and Regional Anesthesia* 2014; **7:** 53.

10. Børglum J, Moriggl B, Jensen K, et al. Ultrasound-guided transmuscular quadratus lumborum blockade. *British Journal of Anaesthesia* 2013; **111**.
11. Baidya DK, Maitra S, Arora MK, Agarwal A. Quadratus lumborum block: an effective method of perioperative analgesia in children undergoing pyeloplasty. *Journal of Clinical Anesthesia* 2015; **27:** 694-6.
12. Corso RM, Piraccini E, Sorbello M, Bellantonio D, Tedesco M. Ultrasound-guided transmuscular quadratus lumborum block for perioperative analgesia in open nephrectomy. *Minerva Anestesiol* 2017; **83:** 1334-5.
13. Mænchen N, Hansen C, Dam M, Børglum J. Ultrasound-guided transmuscular quadratus lumborum (TQL) block for pain management after caesarean section. *Int J Anesth Anesthesiol* 2016; **3:** 23937.
14. Warusawitharana C, Basar S, Jackson BL, Niraj G. Ultrasound guided continuous transmuscular quadratus lumborum analgesia for open renal surgery: A case series. *Journal of Clinical Anesthesia* 2017; **42:** 100-1.
15. Ralloc R. Allocation of treatments in controlled trials using random permuted blocks. *Stata Technical Bulletin* 2000; **54:** 49-53.
16. Mallinckrod CH, Lane PW, Schnell D, Peng Y, Mancuso JP. Recommendations for the primary analysis of continuous endpoints in longitudinal clinical trials. *Drug Information Journal* 2008; **42:** 303-19.
17. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. *The Stata Journal* 2012; **12:** 308-31.
18. Kadam VR, Moran JL. Epidural infusions versus transversus abdominis plane (TAP) block infusions: retrospective study. *Journal of Anesthesia* 2011; **25:** 786-7.
19. Ventham NT, O'Neill S, Johns N, Brady RR, Fearon KC. Evaluation of novel local anesthetic wound infiltration techniques for postoperative pain following colorectal resection surgery: a meta-analysis. *Diseases of the Colon & Rectum* 2014; **57:** 237-50.
20. Zahn PK, Brennan TJ. Incision-induced changes in receptive field properties of rat dorsal horn neurons. *Anesthesiology* 1999; **91:** 772-85.
21. Dam M, Moriggl B, Hansen CK, Hoermann R, Bendtsen TF, Borglum J. The Pathway of Injectate Spread With the Transmuscular Quadratus Lumborum Block: A Cadaver Study. *Anesthesia Analgesia* 2017; **125:** 303-12.

Incidence of acute kidney injury during the perioperative period in the colorectal division of surgery - Retrospective study.

Colonic surgery: perioperative evaluation of the acute kidney injury

During the above colorectal surgery trial, there was incidental finding of few cases with worsening of pre-existing renal impairment and acute renal failure in the immediate postoperative period. This prompted us to investigate and procure data of this patient group for possible improvement in practice or prevention. After ethics approval, under the supervision of Prof Hewett a retrospective audit was conducted.

Authors

V. Rao Kadam[1,2], V. Loo[3], S. Edwards[4], P. Hewett[5]

[1]Department of Anaesthesia, The Queen Elizabeth Hospital, South Australia, Australia, [2] A/Professor, Acute Care Medicine, The University of Adelaide, South Australia, Australia,

[3] The University of Adelaide, South Australia, Australia,

[4] School of Public Health, The University of Adelaide, South Australia, Australia

[5]Professor, Department of Surgery, The University of Adelaide, South Australia, Australia,

Statement of Authorship

Title of Paper	Incidence of acute kidney injury during the perioperative period in the colorectal division of surgery - Retrospective study.
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Rao Kadam V, Loo V, Edwards S, Hewett P. Incidence of acute kidney injury during the perioperative period in the colorectal division of surgery - Retrospective study. I J A 2020; 64:894-7.

Principal Author

Name of Principal Author (Candidate)	Vasanth Rao Kadam		
Contribution to the Paper	Designing, conceptualisation, recruitment, data collection, co-ordinating and writing manuscript. Also corresponding author.		
Overall percentage (%)	80		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	29.9.22

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

I. the candidate's stated contribution to the publication is accurate (as detailed above);

II. permission is granted for the candidate to include the publication in the thesis; and

III. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Loo V		
Contribution to the Paper	Co-designing, data collection, editing, and drafting the manuscript		
Signature		Date	04/10/2022

Name of Co-Author	Edwards S		
Contribution to the Paper	Statistics, editing and drafting the manuscript		
Signature		Date	29 September 2022
Name of Co-Author	P. Hewett		
Contribution to the Paper	Co-designing, editing and drafting the manuscript		

SIGNATURE

DATE 12/10/22

Introduction and background

Acute kidney injury (AKI) commonly occurs following cardiac surgery but is also seen in colorectal surgeries [1]. This may have a detrimental impact on cost, length of hospital stay and mortality. Kidney Disease Improving Global Outcomes (KDIGO) defines AKI by an absolute increase in creatinine, ≥0.3mg/dL within 48 hours or by a 50% increase in creatinine from a baseline within 7 days, or a urine volume <0.5mL/kg/h minimum duration of 6 hours [1]. There have been several studies on AKI during the hospital stay in major abdominal surgery [2-4]. However, studies on AKI developed after colorectal surgery are limited [5-7]. The incidence is 4.8-11.8% [7].

The study aims to assess the kidney function from preoperative to postoperative period. In addition, it also evaluates the incidence and risk factors of AKI in the first 7days after surgery in a cohort of patients undergoing major colorectal surgery. Notable secondary outcomes include hypotension and reduced urinary output in the post-anaesthetic care unit (PACU), medical complications in hospital, in-hospital mortality, and time until discharge.

Methods

Ethics approval was obtained from Central Adelaide Local Health Network Human Research Ethics Committee (Ref no HREC/18/CALHN/510). This retrospective single Centre study involved all open/laparoscopic colorectal procedures performed at The Queen Elizabeth Hospital from June 2016 to June 2018. The biochemical and patient data was collected from the hospital electronic system during this period.

The patients who enrolled in this study were patients who had general anaesthesia with propofol, fentanyl and rocuronium with endotracheal intubation. They were aged 18 and above undergoing elective/emergency or laparoscopic/open procedures. Patients with no renal parameters, chronic kidney disease, transplanted kidney, renal replacement therapy, multiple surgeries in the same admission were excluded.

Acquired kidney Injury (AKI) was defined as having a post-op to pre-op creatinine ratio≥1.5 or a glomerular filtration rate (GFR)≤0.8 at either Day 1 or Day 7 post-op. Medical complications were defined as cardiopulmonary compromise during hospital stay requiring ICU admission.

Statistical Analysis Plan: Sample size analysis was not performed at commencement of study. A Table 1 was constructed with descriptive statistics as appropriate. Univariate binary logistic regressions were performed for AKI at Day 1 or Day 7 versus various potential predictors. Those potential predictors with P value<0.2 were included in an initial multivariable model, and backwards elimination was performed until all P values were less than 0.05. Cross tabulations were then performed for AKI versus operation variables, with associated Fisher's Exact Tests or Chi Square Tests. The statistical software used was SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Out of 779 patients 25 did not satisfy the inclusion criteria. Descriptive statistics of patient demographics and perioperative variables are demonstrated in Tables 1 and 2. The incidence of AKI in our retrospective study was 6.9%. Odds Ratios (OR), 95% Cl, comparison and P values are presented in Table 3 and final multivariable binary logistic regression model in Table 4. There is a significant association between AKI at Day 1 or Day 7 and ASA category, adjusting for PACU decreased urine output (P value<0.0001). For every one unit increase in ASA category, the odds of developing AKI are multiplied by 2.7 (OR=2.7, 95% CI: 1.8, 4.0). If the patient has decreased urine output in PACU, their odds of developing AKI are 2.7 times that of patients with adequate urine output (OR=2.7, 95% CI: 1.1, 6.5).

There is a significant association between AKI and diabetes (P= 0.0120). Similarly, this was also observed between AKI and hypertension (P=0.0200).

Patients with diabetes and hypertension were almost twice more likely to develop an AKI as compared to non-diabetics and non-hypertensive with occurrence of AKI being (15% vs 7.4%) and (12.1% vs 6.6%) respectively.

The 30-day mortality rate in patients with associated AKI was 7.7% compared with 2.2% in patients with no AKI. The median discharge time was found to be 3 days longer in patients with AKI (Median Interquartile range (IQR))=10 (5, 19.5) for patients with AKI and 7 (4,12) for patients without AKI) .

Discussion

This retrospective study showed significant association between AKI at Day 1 or Day 7 and PACU decreased urine output. AKI is associated with medical morbidity and mortality, prolonged hospital stay, and higher hospital costs [7].

Hypertension was deemed a major risk factor evidential by the Kheterpal study [4]. Thirty-day mortality after colorectal cancer (CRC) surgery ranged from 6.7% to 42% [4,8]. In our database, the 30-day patient mortality was 7.7% with AKI versus with 2.2% with no AKI. There was no difference in incidence of AKI in patients with heart failure, ischemic heart disease, hypercholesterolemia, chronic pulmonary airway disease or reflux disorders.

The incidence of AKI in our study was 6.9% as compared the 11.9% reported in Causey et al. [6]. Although there is difference in the rate of AKI in elective surgery (3.38%), emergency surgery (12.99%) was associated with 3.8 times higher rate of AKI [5]. We did not find any difference in rates of AKI in elective vs emergency surgery.

Prolonged duration of surgery together with vasopressors use can potentially affect renal blood flow, however there was no increase in AKI rates in longer surgeries or with the use of vasopressors in our study. Preoperative dehydration is associated with increased rates of postoperative AKI [9]. The preoperative use of concentrated glucose solutions in these patients has been reported to decrease postoperative complications in colorectal surgery [9]. Solanki et al. guidelines recommend the use of balanced salt solutions or albumin with the goal of adequate urine output for patients undergoing cytoreductive surgery [10]. Our study has not shown a difference in incidence of AKI based on the amount and type of fluids used however, our study was retrospective with no strict protocol on liberal or restrictive use of fluids. Myles et al. reported the restrictive fluids regimen was associated with a higher rate of AKI [11].

The pathogenesis of postoperative AKI is complex and is affected by patient, anaesthetic and surgical factors. Patients with mechanical ventilation can constitute an additional mechanism for increased fluid loss. Surgery increases catabolic hormones and cytokines, leading to increased antidiuretic hormone secretion, which results in water retention, impairing fluid electrolyte homeostasis [12]. Patients on long-term ACE inhibitor therapy are at a higher risk

of developing post-operative renal dysfunction due to the loss of ability of the renin–angiotensin system to compensate for the decrease in renal perfusion [12]. Though renal blood flow may be decreased during pneumo-peritoneum, in our study there was no difference between laparoscopic and laparotomy incidence of AKI.

Limitations

Due to this being a retrospective study, there are many confounding factors such as the lack of data on antibiotic usage, NSAIDs and contrast during inpatient stay. Future research on this topic should be encouraged to consolidate the data on AKI and to find ways to improve outcomes in this patient population.

Conclusion

Patients undergoing colorectal surgery are at significant risk of developing AKI in the immediate postoperative period. Presence of medical complications is associated with AKI, including in-hospital mortality. Hence, monitoring during the intraoperative and immediate postoperative period to detect early signs of renal insufficiency is recommended.

References:

1. Group KDIGOKAKIW. KDIGO clinical practice guideline for acute kidney injury. *Kidney Int Suppl* 2012; **2:** 1-138.
2. Abelha FJ, Botelho M, Fernandes V, Barros H. Determinants of postoperative acute kidney injury. *Critical Care* 2009; **13:** R79.
3. Cho A, Lee JE, Kwon G-Y, et al. Post-operative acute kidney injury in patients with renal cell carcinoma is a potent risk factor for new-onset chronic kidney disease after radical nephrectomy. *Nephrology Dialysis Transplantation* 2011; **26:** 3496-501.
4. Kheterpal S, Tremper KK, Heung M, et al. Development and validation of an acute kidney injury risk index for patients undergoing general surgery: results from a national data set. *Anesthesiology* 2009; **110:** 505-15.

5. Balakrishnan KP, Survesan S. Anaesthetic management and perioperative outcomes of cytoreductive surgery with hyperthermic intraperitoneal chemotherapy: A retrospective analysis. *Indian Jornal of Anaesthesia* 2018; **62:** 188-96.
6. Causey MW, Maykel JA, Hatch Q, Miller S, Steele SR. Identifying risk factors for renal failure and myocardial infarction following colorectal surgery. *Journal of Surgical Research* 2011; **170:** 32-7.
7. Masoomi H, Carmichael JC, Dolich M, et al. Predictive factors of acute renal failure in colon and rectal surgery. *American Surgeon* 2012; **78:** 1019-23.
8. Morris EJA, Taylor EF, Thomas JD, et al. Thirty-day postoperative mortality after colorectal cancer surgery in England. *Gut* 2011; **60:** 806-13.
9. Moghadamyeghaneh Z, Phelan MJ, Carmichael JC, et al. Preoperative dehydration increases risk of postoperative acute renal failure in colon and rectal surgery. *Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract* 2014; **18:** 2178-85.
10. Solanki SL, Mukherjee S, Agarwal V, et al. Society of Onco-Anaesthesia and Perioperative Care consensus guidelines for perioperative management of patients for cytoreductive surgery and hyperthermic intraperitoneal chemotherapy (CRS-HIPEC). *Indian Jornal of Anaesthesia* 2019; **63:** 972-87.
11. Myles PS, Bellomo R, Corcoran T, et al. Restrictive versus liberal fluid therapy for major abdominal surgery. *The New England Journal of Medicine* 2018; **378:** 2263-74.
12. Sear JW. Kidney dysfunction in the postoperative period. *British Journal of Anaesthesia* 2005; **95:** 20-32.

Conflicts of Interest: there are no conflicts of interest**.**

Table 1. Demographic patient characteristics

Patient Characteristics	Frequency (%)
Age – mean (SD)	56.8 (19.7)
Female	395 (52.4)
Weight – mean (SD)	78.2 (20.6)
Comorbidities	
Hypertension	251 (33.3)
Diabetes	117 (15.5)
IHD	55 (7.3)
Hypercholesterolemia	90 (11.9)
Hyperlipidaemia	31 (4.1)
COPD	41 (5.4)
GORD	137 (18.2)
Heart failure	9 (1.2)
ASA category	
1	140 (18.6)
2	303 (40.3)
3	261 (34.7)
4	46 (6.1)
5	2 (0.3)
Pre-existing kidney disease	123 (16.6)
Operation Type	
Laparoscopy	410 (54.4)
Laparotomy	339 (45.0)
Lap to Laparotomy	5 (0.7)
Operation Elective/Emergency	
Elective	492 (65.3)
Emergency	262 (34.8)

*IQR = Interquartile Range

Table 2 showing the biochemical, perioperative variables with complications and mortality

Preop creatinine – Median (IQR*)	75 (63, 90)
Postop D1 creatinine – Median (IQR)	70 (55, 88)
Postop D7 creatinine – Median (IQR)	68 (53, 87)
Preop GFR – Median (IQR)	88 (70, 90)
Postop D1 GFR – Median (IQR)	90 (70, 90)
Postop D7 GFR – Median (IQR)	90 (70, 90)
Acquired Kidney Injury	52 (6.9)
Intraoperative variables	
Intraoperative hypotension	331 (43.9)
Vasoactive drug use	438 (58.1)
Bloods used	41 (5.4)
Intraop urine output – Median (IQR)	245 (140, 550)
Intraop urine output - adequate	208 (81.3)
Intraop urine output - low	48 (18.8)
Fluids used	
Colloid	3 (0.4)
Crystalloid	598 (79.7)
Crystalloid and colloid	148 (19.7)
None	1 (0.1)
Volume of fluid used	
0	6 (0.8)
1	357 (47.4)
2	220 (29.2)
3	114 (15.1)
4	27 (3.6)
5	14 (1.9)
6	7 (0.9)
7	5 (0.7)
8	1 (0.1)
9	3 (0.4)
Volume of albumin used – Median (IQR)	1000 (500, 1000)
PACU hypotension	48 (6.4)
PACU decreased urine output	33 (4.4)
Duration of surgery in Minutes – Median (IQR)	157 (97, 239)
Postoperative complications	253 (33.6)
Medical complications	289 (38.3)
In Hospital mortality	22 (2.9)
Discharge time in Days – Median (IQR)	6 (2, 11)

*IQR = Interquartile Range

Table 4. Final Multivariable binary logistic model of AKI at Day 1 or Day 7 versus significant predictors

Predictor	*Comparison*	*Odds Ratio (95% CI)*	*Global P value*
ASA category (continuous)		2.71 (1.82, 4.03)	<.0001
PACU decreased urine output	Yes versus No	2.65 (1.08, 6.50)	0.0334

Table 3 Univariate binary logistic regression results for AKI at 1 Day or 7 Days versus various predictors

Predictor	*Comparison*	*Odds Ratio (95% CI)**	*Comparison value*	*Global P value*
Pre-ex st ng k dney d sease	Yes vs No	1.41 (0.72, 2.73)		0.3128
Sex	Ma es vs Fema es	1.02 (0.58, 1.81)		0.9381
Hypertens on	Yes vs No	1.95 (1.10, 3.46)		0.0218
D abetes	Yes vs No	2.21 (1.18, 4.15)		0.0138
IHD	Yes vs No	1.81 (0.77, 4.25)		0.1743
Hypercho estero em a	Yes vs No	1.39 (0.65, 2.98)		0.3946
Hyper p dem a	Yes vs No	0.87 (0.20, 3.77)		0.8468
COPD	Yes vs No	2.48 (1.04, 5.95)		0.0410
GORD	Yes vs No	0.97 (0.47, 2.00)		0.9344
Heart fa ure	Yes vs No	5.48 (1.33, 22.59)		0.0186
Operat on type	Laparotomy vs Laparoscopy	2.09 (1.12, 3.90)		0.0205
E ect ve emergency	Emergency vs E ect ve	1.20 (0.66, 2.21)		0.5482
Intraop ur ne output	Low vs Adequate	0.95 (0.31, 2.95)		0.9330
Intraop hypotens on_	Yes vs No	1.48 (0.83, 2.62)		0.1814
Vasoact ve drug use	Yes vs No	2.30 (1.13, 4.68)		0.0220
F u ds used	Co o d vs Crysta o d/Co o d	3.82 (0.33, 44.45)	0.2839	0.1243
	Co o d vs Crysta o d	6.20 (0.55, 70.15)	0.1407	
	Crysta o d/Co o d vs Crysta o d	1.62 (0.87, 3.01)	0.1254	
B oods used	Yes vs No	1.17 (0.40, 3.44)		0.7703
PACU hypotens on	Yes vs No	2.35 (1.03, 5.34)		0.0413
PACU decreased ur ne	Yes vs No	3.93 (1.67, 9.27)		0.0017
Postoperat ve comp cat ons	Yes vs No	2.38 (1.33, 4.25)		0.0034
Med ca comp cat on	Yes vs No	2.56 (1.40, 4.68)		0.0023
In Hosp ta morta ty	Yes vs No	7.41 (2.92, 18.84)		<.0001
Age		1.04 (1.02, 1.06)		0.0003
We ght		1.00 (0.98, 1.01)		0.8549
ASA category		2.84 (1.92, 4.22)		<.0001
Durat on of surgery		1.00 (1.00, 1.00)		0.5871
Durat on of anaesthes a		1.00 (1.00, 1.00)		0.5470
Vo ume f u d used		1.11 (0.91, 1.36)		0.2847
Intraop ur ne output		1.00 (1.00, 1.00)		0.6794
Vo ume a bum n used_		1.00 (1.00, 1.00)		0.1111
D scharge t me		1.04 (1.02, 1.07)		0.0015

*Mode ng the probab ty that AKI = “Yes”

Chapter 4- Efficacy and safety of the ultrasound guided Erector Spinae Plane block in abdominal surgery

Comparison of Ultrasound guided Erector Spinae Plane block (ESPB) versus wound infiltration (WI) for postoperative analgesia and estimation of blood levels of ropivacaine in laparoscopic colonic surgery- Prospective randomized study.

A comparison of ultrasound guided bilateral single injection shot Erector Spinae Plane blocks versus wound infiltration for post-operative analgesia in laparoscopic assisted colonic surgery- a prospective randomised study.

V. Rao Kadam1,2*, G. Ludbrook3, R. M. van Wijk1,2, P. Hewett4, V. Thiruvenkatarajan1,2, S. Edwards5, P. Williams1 and S. Adhikary6

[1]Department of Anaesthesia, The Queen Elizabeth Hospital, South Australia, Australia, [2]A/Professor, Acute Care Medicine, The University of Adelaide, South Australia, Australia, [3]Professor, Acute Care Medicine. The University of Adelaide, South Australia, Australia, [4]Department of Surgery, The Queen Elizabeth Hospital, South Australia, Australia, , [5] School of Public Health

The University of Adelaide, South Australia, Australia, [7] SA pathology Flinders medical centre, South Australia, Australia, [1] Affiliate Lecturer, Acute Care Medicine, The University of Adelaide, South Australia, Australia, [6] Professor, Department of Anaesthesiology and Perioperative Medicine, Penn State Hershey Medical Center, Penn State College of Medicine, Pennsylvania, United States of America

Statement of Authorship

Title of Paper	A comparison of ultrasound guided bilateral single injection shot Erector Spinae Plane blocks versus wound infiltration for post-operative analgesia in laparoscopic assisted colonic surgery- a prospective randomised study
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	V. Rao Kadam, G. Ludbrook, R. M. van Wijk, P. Hewett, V. Thiruvenkatarajan, S. Edwards, P. Williams and S. Adhikary A comparison of ultrasound guided bilateral single injection shot Erector Spinae Pane blocks versus wound infiltration for post-operative analgesia in laparoscopic assisted colonic surgery- a prospective randomised study. BMC Anesthesiol (2021) 21:255.

Principal Author

Name of Principal Author (Candidate)	Vasanth Rao Kadam		
Contribution to the Paper	Designing, conceptualisation, recruitment, performance of the block, co-ordinating and writing manuscript. Also corresponding author.		
Overall percentage (%)	90		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	29.9.22

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	G.L. Ludbrook

Contribution to the Paper	Designing, editing, and drafting the manuscript		
Signature		Date	04/10/2022
Name of Co-Author	R. M. Van W		
Contribution to the Paper	Designing, e drafting the manuscript		
Signature		Date	25-9-22
Name of Co-Author	P. Hewett		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	14/10/22
Name of Co-Author	S. Edwards		
Contribution to the Paper	Statistical analysis, editing and drafting the manuscript		
Signature		Date	29.9.2022
Name of Co-Author	V. Thiruvenkatarajan		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	29/9/22
Name of Co-Author	P. Williams		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	29.9.2022
Name of Co-Author	S. Adhikary		
Contribution to the Paper	Editing, and drafting the manuscript		
Signature		Date	29/9/2022

Abstract

Background: both wound infiltration (WI) with local anaesthetic and erector spinae plane block (ESPB) have been described for post-operative analgesia after abdominal surgery. This study compared the efficacy of WI versus ESPB for post-operative analgesia after laparoscopic assisted colonic surgery.

Methods: Seventy-two patients between 18 and 85 years of age undergoing elective surgery were randomised to receive either WI or ESPB. In the WI group a 40 ml bolus of 0.5% Ropivacaine, infiltrated at the ports and minimally invasive wound at subcutaneous and fascia layers. In the ESPB group at T8 level, under ultrasound guidance, a 22-gauge nerve block needle was passed through the Erector Spinae muscle to reach its fascia. Similar dose, divided into two equal volumes, was injected at each side. Both groups had a multimodal analgesic regime, including regular Paracetamol, dexamethasone, and patient-controlled analgesia (PCA) with Fentanyl. The primary end point was a post-operative pain score utilising a verbal Numerical Rating Score (NRS, 0–10) on rest and coughing in the post anaesthetic care unit (PACU) and in the first 24 h. Secondary outcomes measured were: opioid usage, length of stay and any adverse events.

Results: There was no significant treatment difference in PACU NRS at rest and coughing (p-values 0. 382 and 0.595respectively). Similarly, there were no significant differences in first 24 h NRS at rest and coughing (p-values 0.285 and 0.431 respectively). There was no significant difference in Fentanyl use in PACU or in the first 24 h (p- values 0.900 and 0.783 respectively). No difference found in mean total Fentanyl use between ESPB and WI groups (p-value 0.787).

Conclusion: Our observations found both interventions had an overall similar efficacy.

Trial registration: The study was registered with the Australian New Zealand Clinical Trial Registry (ACTRN: 12619 00011 3156).

Keywords: Ultrasound, Erector Spinae Plane, Post-operative analgesia, Local anaesthetic

Background

The Erector Spinae Plane block (ESPB) was first described by Forero, in 2016 [1]. Initially, the block was performed for thoracic and breast surgery and its use has now been reported for abdominal surgery [2-4]. This block has gained popularity in the last 5 years, as one of the options for post-operative pain relief after abdominal surgery [2-4]. Both single bolus injection and catheter technique has proven to be beneficial as a part of multimodal analgesia in surgeries involving the thorax and abdomen [5-8]. The technique involves injecting local anaesthetic (LA) into the myofascial plane beneath the fascia covering the Erector Spinae muscle using real time ultrasound guidance. This approach is gaining popularity mainly due to its simplicity in performance. It is simple to visualise the para spinal muscles at the mid thoracic, about 3 cm lateral to the midline. Clinical trials reported to be effective in use of ESPB in laparoscopic cholecystectomy [9-11] but not in laparoscopic colonic surgery.

The purpose of this study was to assess the efficacy of single injection ESPB performed for post-operative analgesia in laparoscopic assisted colonic surgery. Efficiency was assessed by comparing pain scores. We hypothesized that ultrasound guided ESPB is superior to wound infiltration performed at the end of surgery in providing superior pain relief without major side effects.

Methods

The study was conducted at The Queen Elizabeth Hospital (TQEH), part of Central Adelaide Local Health Network (CALHN) between January 2019 and September 2020. The study was registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12619000113156 date 24/01/2019). Institutional Human Ethics and Research Committee (HREC/18/ CALHN/456) approval was obtained, and all patients provided prior informed consent for their participation in the study.

The primary end point was post-operative pain score utilising a verbal Numerical Rating Score (NRS, 0–10) on rest and coughing in PACU and during the first 24 h (worst NRS on rest and coughing). Secondary outcomes measured were opioid usage until 24 h post-operatively, length of stay (days) and clinical determinants of adverse effects.

Patients with an American Society of Anesthesiologists Physical Status 1–3, greater than 18 years of age, and undergoing elective laparoscopic colonic surgery, were recruited for the study to receive either ESPB or WI at the end of surgery and before extubation. Patients were excluded if they had communication barriers, sensitivity, or allergy to local anaesthetics, were pregnant, had a preoperative daily use of opioids equivalent to 10 mg/day of morphine or above or if the procedure could not be performed laparoscopically. The study was designed with the groups randomised to the intervention allocation based on a computer-generated sequence.

All patients received a standardized general anaesthetic technique and monitoring. They were administered intermittent intravenous fentanyl as intra-operative opioid analgesia. At the end of procedure, before extubation, an ESPB was performed by an experienced anaesthetist, or the WI was performed by the surgical fellow/ consultant.

An in-plane approach in the lateral position was used under ultrasound guidance for the ESPB. T8 level was confirmed by counting the spinous process from T1 down to T8. Using a 6- to 15-MHz high-frequency linear probe (Sonosite X-Porte, SonoSite Inc. Bothell, WA, USA), the 2 muscle layers of the posterior spine anatomy, namely trapezius and erector spinae (ES)

muscles, were visualized slightly cephalad to the T8 transverse process. The 22-gauge Stimuplex (Pajunk, Geisingen, Germany) nerve block needle tip was placed deep to the ES muscle, beneath the fascia in a cephalad to caudal direction. Needle position was confirmed by a 3 ml normal saline test dose under ultrasound guidance to observe linear spread lifting the ES muscle. Ropivacaine (AstraZeneca Pty Ltd., Sydney, NSW, Australia) dissemination was confirmed lifting the ES muscle in real time under ultrasound guidance from start to completion of injection. A dose of 40 ml of 0.5% Ropivacaine (200 mg), divided into two equal volumes, was injected at each side. In the WI group 40 ml of 0.5% Ropivacaine was injected at the surgical ports and into the minimally invasive wound. In the PACU and subsequently in the wards for 24 h (time from PACU), patients were observed and questioned for signs and symptoms of local anaesthetic systemic toxicity (LAST), such as perioral numbness, tingling sensation, tinnitus, metallic taste, muscle twitching, and convulsions. Sensory block was assessed by recovery staff after surgery in PACU using a cold test on either side of the anterior abdomen between xiphi-sternum and pubic symphysis (dermatomes T6-L1).

All patients had a pre-operative electrocardiogram (ECG) and a repeat ECG was to be performed if any signs and symptoms of LA toxicity were observed. Patients were administered Paracetamol 1 g QID (orally or IV) and received a single dose of Dexamethasone 8 mg intra-operatively as part of a multimodal analgesic approach. A Fentanyl PCA device (bolus 10 to 40 mcg based on age; lockout time 5 min; no background infusion) was provided as rescue analgesia. The difference in PCA usage was used as an indication of efficacy of the analgesic techniques. The primary endpoints measured were NRS for Pain at rest and on coughing in PACU at 0 and I hour and in the postoperative ward at 24 h. Other end points were Fentanyl use in PACU and first 24 h, any rescue medication used, procedure related technical issues, potential side effects or complications in relation to the technique used and length of stay (days). Data was entered in excel by the research assistant at the trial centre, who has blinded the statistician for group allocation.

Statistical analysis

Continuous measures are presented as means with standard deviations and medians with interquartile ranges, based on the normality of their distribution. Categorical measures are presented as frequencies and percentages. Group comparisons on baseline characteristics

were assessed using Student's T-test, a Wilcoxon Rank Sum test, Pearson's Chi-square statistic or Fisher's Exact Test as required, and linear mixed-effects models were used to compare pain and fentanyl use between ESP and WI groups, across time periods, adjusting for repeated measurements over time. Linear regressions were also used for two fentanyl outcomes. All tests are two-tailed and assessed at the 5% alpha-level. The statistical software used was SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

Sample size

As RCTs for the use of ESPB in laparoscopic colonic surgery have not been published, an approximate scenario was established to obtain the required patient numbers. Calculations were based on the primary outcome (pain scores) and it was determined that a clinically meaningful difference between groups would be 2.5 points on the NRS. Assuming constant variance and a standard deviation of 3 points, a sample of 24 patients per group was required. The sample was inflated to 36 patients per group to account for intra-patient correlations arising from repeated measures. Thus, a total of 72 patients were required.

Randomisation

The randomisation schedule was generated by the Clinical Trials Division of the Pharmacy Department at The Queen Elizabeth Hospital. To ensure equal distribution of the intervention arm, randomisation was done in specific blocks to pre-determined numbers known only to the clinical trials division. A simple randomisation table was created by computer software (computerised sequence generation). This allocation was concealed by a sealed opaque envelope. The proceduralist was unable to be blinded; however, the patients were blinded to group allocation. The person analysing the data was also blinded.

Results

Seventy-two patients were recruited. Five patients did not complete the study and 67 were included in the analysis. These five patients excluded from analysis had a breach of protocol and none were lost to follow up (see Consort flow diagram Fig. 1). Table 1 shows the patient demographics in each group. Wound infiltration time was significantly lower than ESPB ($p = < 0.01$), otherwise both the groups were comparable with respect to pre-operative status and

operative specifications are shown in Table 1. No block related complications, such as vascular/visceral puncture or local anaesthetic toxicity were recorded. None of the patients had well defined dermatomal spread in the ESPB group in PACU. Only one patient had patchy spread. Table 2 shows the pain scores and fentanyl use with mean and standard deviation by technique and time period, mean differences, 95% confidence intervals (CI) and comparison and global P values. There were no significant differences between the groups on intra-operative fentanyl use or total fentanyl use. There were also no significant differences between the groups for rest or cough pain scores or cumulative fentanyl use in PACU or on day one (refer to Table 2). The mean differences between ESPB and WI groups for rest and cough pain ranged from − 0.6 to − 0.3 were not significant. Table 3 shows the complications. There was no difference in the complication incidences between the groups. Technically, we did not have any failures but had slight difficulty in three obese participants in the ESPB group requiring 120 mm needles to reach the plane. None of the patients had any sign or symptoms of LAST in the 24- h study period. However, 3 patients developed tachycardia after 48hrs which was related to low haemoglobin requiring transfusion and anastomotic leak requiring intervention. One patient developed bradycardia (50/ min) in the ESP group at 24 h on the ward, but remained stable. The average theatre time for (LA loading and checking/positioning/setup ultrasound equipment) was 20 min for ESP group compared to 10 min in WI group.

Discussion

The main outcome of the study was that we found no treatment- related differences in NRS pain scores at rest and coughing in PACU or day one between the groups. There was no statistically significant difference found in mean total fentanyl use between ESPB and WI groups. There were no differences in adverse events or length of stay between the groups. Though we hypothesised that ultrasound-guided ESP block is superior to wound infiltration in providing superior pain relief, this was not confirmed by our findings. Technically, we did not have any failures but had slight difficulty in three obese participants in the ESPB group requiring 120 mm needles to reach the plane. Complications related to LAST were not observed. Only one patient in the ESPB group had bradycardia at 24 h on the ward but remained haemodynamically stable with unremarkable ECG. Tulgar et al. found 3 mild cases of LAST in ESPB patients [12]. However, as stated, the patients in our study did not show any such symptoms. There were two patients in WI group who developed bradycardia, one in the PACU and the other outside the 24 h study period, both with unremarkable ECGs.

We performed ESPB at T8 level, however we did not observe any clinical effects on dermatome sensory distribution on the anterior aspect of the chest. We used 20 ml of 0.5% ropivacaine each side and it is possible that this may be an inadequate volume leading to poor sensory block. The optimal volume may range from 20 to 30 ml [13]. Tulgar et al. in their case series performed ESPB at T8 level for laparoscopic surgeries and reported its analgesic benefits but failed to report sensory block [8].

Similarly Chin et al. performed ESPB at T7 level in four patients undergoing laparoscopic ventral hernia repair and reported reduced pain scores in the first 24 h and oral morphine consumption [5]. They reported dermatome spread from T6 to T12 in one of their patients. In our study, though patients achieved analgesia, we did not observe any dermatomal sensory block. We are unable to explain this finding. Peng et al., described that the ESPB has characteristics of differential blockade [14]. Analgesia without motor block along discernible cutaneous sensory block has been described [14]. A review on dermatomal analysis of case

reports revealed variable results of ESPB dermatomal spread [15]. Due to its unpredictable dermatomal spread more clinical trials are required to assess this. A recent narrative review reports that the mechanism of ESPB is from the direct effect of LA via physical spread and diffusion to ESP and adjacent tissue compartments [16,17]. It also highlights the unpredictability and variability that result from myriad factors [16,17]. This limited LA spread may be due to the mechanical barrier of the intertransverse ligament, intertransversalis muscle, and/or superior costotransverse ligaments in the thoracic paravertebral space [18]. Only intertransverse and superior costotransverse ligaments are found in the thoracic region posing a possible obstacle [19]. Some authors reported benefits of technical refinements of ESPB such as double injection technique, multiple level injections and injecting near the costotransverse ligament in breast procedures, to improve LA diffusion into the paravertebral space [20-22]. There are no published trials on these new approaches for performing ESPB in abdominal surgery. Future clinical trials on this should be considered. A metanalysis on ESP found reduction in postoperative opioid consumption compared to control [23]. However, this study had significant heterogeneity.

There were a few limitations of our trial: It was conducted in a single centre, was single blinded and practice of WI may not be applicable in other settings. As there were no RCTs, sample size calculation was not possible prior to commencement of this study. We were optimistic in requiring a 2.5 points difference in pain scores between the groups. Nevertheless, given our findings, even using a minimally clinically important difference (MCID) of only 1 point as suggested by Myles et al. [24] may not have changed our overall outcomes. However, a substantially lower MCID would have made our study with current numbers underpowered. The volume we used (20 ml) may be low, higher volumes may produce more extensive physical spread.

In conclusion, this prospective, single centre, randomised, open label study revealed that both WI and ESPB techniques were comparable in terms of pain scores and rescue opioid requirement during the first 24 h post-operatively. There were no differences in complications observed between the two techniques. As the ESPB appears to be more invasive, and requires expertise, local anaesthetic wound infiltration remains a more practical and relatively simple technique in laparoscopic colonic surgery.

Competing Interests

No Financial disclosures or conflicts of interest.

List of Abbreviations:

WI: wound infiltration

ESPB: Erector Spinae Plane Block

PACU: post anaesthetic care unit

LA: local anaesthetic

LAST: local anaesthetic systemic toxicity

NRS: Numerical Rating Score

PCA: patient controlled analgesia

Declarations:

Ethics approval and consent to participate:

Institutional Human Ethics and Research Committee (HREC/18/CALHN/456),

Central Adelaide Local Health Network approval obtained. Informed consent for participation was obtained from all participants prior to participation in the study.

The research meets ethical and scientific requirements in accordance with the NHMRC and relevant legislative policy and requirements.

Consent for publication: Not applicable

Availability of data and materials: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: No Financial disclosures or conflicts of interest

Funding: Not applicable

References:

1. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: A novel analgesic technique in thoracic neuropathic pain. *Regional Anesthesia Pain Medicine* 2016; **41:** 621-7.
2. Hamed MA, Goda AS, Basiony MM, Fargaly OS, Abdelhady MA. Erector spinae plane block for postoperative analgesia in patients undergoing total abdominal hysterectomy: A randomized controlled study original study. *Journal of Pain Research* 2019; **12:** 1393-8.
3. Hamed MA, Yassin HM, Botros JM, Abdelhady MA. Analgesic efficacy of erector spinae plane block compared with intrathecal morphine after elective cesarean section: A prospective randomized controlled study. *Journal of Pain Research* 2020; **13:** 597-604.
4. Ibrahim M, Elnabtity AM. Analgesic efficacy of erector spinae plane block in percutaneous nephrolithotomy: A randomized controlled trial. *Anaesthesist* 2019; **68:** 755-61.
5. Chin K, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia* 2017; **72:** 452-60.
6. Rao Kadam V, Currie J. Ultrasound-guided continuous erector spinae plane block for postoperative analgesia in video-assisted thoracotomy. *Anaesthesia Intensive Care* 2018; **46:** 243-5.
7. Restrepo-Garces CE, Chin KJ, Suarez P, Diaz A. Bilateral Continuous Erector Spinae Plane Block Contributes to Effective Postoperative Analgesia After Major Open Abdominal Surgery: A Case Report. *A & A Case Reports* 2017; **9:** 319-21.
8. Tulgar S, Selvi O, Kapakli MS. Erector spinae plane block for different laparoscopic abdominal surgeries: case series. *Case Reports in Anesthesiology* 2018; **2018**.
9. Aksu C, Gurkan Y. Ultrasound-guided bilateral erector spinae plane block could provide effective postoperative analgesia in laparoscopic cholecystectomy in paediatric patients. *Anaesthesia Critical Care and Pain Medicine* 2019; **38:** 87-8.
10. Altiparmak B, Korkmaz Toker M, Uysal AI, Kuscu Y, Gumus Demirbilek S. Ultrasound-guided erector spinae plane block versus oblique subcostal transversus abdominis

plane block for postoperative analgesia of adult patients undergoing laparoscopic cholecystectomy: Randomized, controlled trial. *Journal of Clinical Anesthesia* 2019; **57:** 31-6.

11. Tulgar S, Kapakli MS, Senturk O, Selvi O, Serifsoy TE, Ozer Z. Evaluation of ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: A prospective, randomized, controlled clinical trial. *Journal Clinical Anesthesia* 2018; **49:** 101-6.
12. Tulgar S, Selvi O, Senturk O, Serifsoy TE, Thomas DT. Ultrasound-guided erector spinae plane block: indications, complications, and effects on acute and chronic pain based on a single-center experience. *Cureus* 2019; **11:** e3815.
13. Choi YJ, Kwon HJ, Jehoon O, et al. Influence of injectate volume on paravertebral spread in erector spinae plane block: An endoscopic and anatomical evaluation. *PloS one* 2019; **14:** e0224487.
14. Forero M, Roqués V, Trujillo-Uribe NJ. Erector Spinae Plane Block (ESP Block). In: Peng P, Finlayson R, Lee SH , Bhatia A, eds. *Ultrasound for Interventional Pain Management: An Illustrated Procedural Guide.* Cham: Springer International Publishing, 2020: 131-48.
15. Tulgar S, Ahiskalioglu A, De Cassai A, Gurkan Y. Efficacy of bilateral erector spinae plane block in the management of pain: Current insights. *Journal of Pain Research* 2019; **12:** 2597-613.
16. Chin KJ, El-Boghdadly K. Mechanisms of action of the erector spinae plane (ESP) block: a narrative review. *Canadian Journal of Anesthesia* 2021; **68:** 387-408.
17. Chin KJ, Lirk P, Hollmann MW, Schwarz SKW. Mechanisms of action of fascial plane blocks: A narrative review. *Regional Anesthesia Pain Medicine* 2021; **46:** 618-28.
18. Agur AM, Dalley AF. *Grant's atlas of anatomy*: Lippincott Williams & Wilkins, 2009.
19. Saadawi M, Layera S, Aliste J, Bravo D, Leurcharusmee P, Tran DQ. Erector spinae plane block: A narrative review with systematic analysis of the evidence pertaining to clinical indications and alternative truncal blocks. *Journal of Clinical Anesthesia* 2021; **68:** 110063.
20. Aksu C, Kus A, Yorukoglu HU, Tor Kilic C, Gurkan Y. Analgesic effect of the bi-level injection erector spinae plane block after breast surgery: A randomized controlled trial. *The Journal of the Turkish Society of Algology: Agri Derg* 2019; **31:** 132-7.

21. Cosarcan SK, Doan AT, Ercelen O, Gurkan Y. Superior costotransverse ligament is the main actor in permeability between the layers? Target-specific modification of erector spinae plane block. *Reg Anesth Pain Med* 2020; **45:** 674-5.
22. Sahin A, Gültekin A, Yildirım I, Baran O, Arar C. Ultrasound guided erector Spinae Block with costotransverse ligament puncture is more effective than erector Spinae Block alone; eight cases for oncologic breast surgery; a brief technical report. *Open Journal of Anesthesiology* 2020; **10:** 179-89.
23. Kendall MC, Alves L, Traill LL, De Oliveira GS. The effect of ultrasound-guided erector spinae plane block on postsurgical pain: a meta-analysis of randomized controlled trials. *BMC Anesthesiology* 2020; **20:** 1-11.
24. Myles PS, Myles DB, Galagher W, et al. Measuring acute postoperative pain using the visual analog scale: The minimal clinically important difference and patient acceptable symptom state. *British Journal of Anaesthesia* 2017; **118:** 424-9.

Table1 Patient demographics and details by technique.

	ESPB group	WI group	p-value*
	N=33	N=34	
Age (years) mean (SD)	60.5 (17.8)	61.2 (13.3)	0.86
Gender			
Female	14 (52%)	13 (48%)	0.73
Male	19 (48%)	21 (52%)	
Weight (kg) mean (SD)	84.3 (14.6)	77.2 (17.5)	0.078
BMI (kg/ht^2)	29.4 (5.4)	26.8 (5.7)	0.059
ASA status			
1	2 (50%)	2 (50%)	0.85
2	15 (54%)	13 (46%)	
3	16 (46%)	19 (54%)	
Operations			0.35
Hemicolectomy	14 (47%)	16 (53%)	0.70
Anterior resection	10 (50%)	10 (50%)	0.94
Hartmann's	2 (100%)	0 (0%)	0.15
Reversal of Hartmann's	1 (33%)	2 (67%)	0.57
Ultra-low anterior resection	2 (50%)	2 (50%)	0.97
Ileocecal resection	1 (100%)	0 (0%)	0.31
Small bowel resection	0 (0%)	2 (100%)	0.16
Others	3 (60%)	2 (40%)	0.62
PACU time (mins) median (IQR)	60 (60, 105)	62 (45, 90)	0.61
Flatus time (mins) median (IQR)	48 (48, 72)	48 (48,72)	0.43
Bowel motion time (mins) median (IQR)	77 (72, 96)	72 (60, 120)	0.84
Hospital LOS (days) median (IQR)	5 (4, 7)	4 (4, 8)	0.92

Data are presented as mean (SD) or median (IQR) for continuous measures, and n (%) for categorical measures. ESP denotes Erector Spinae Plane; WI denotes wound infiltration; PACU: post anaesthetic care unit; mins: minutes; LOS: length of stay.

*independent t-test P value, Wilcoxon Rank Sum Test P value, Chi-Square P value or Fisher's Exact Test P value as appropriate.

Table 2. Results for linear mixed-effects and linear models of pain variables versus interaction of technique and time period, adjusting for repeated measurements over time.

Outcome	*Interaction/ Predictor*	*Period - hours*	***ESPB** N=33 mean (SD)*	***WI** N=34 mean (SD)*	*Mean difference* (95% CI)*	*Comparison P value*	*Interaction/Global P value*
Intraoperative fentanyl use	Technique		469.7 (198.4)	491.3 (265.4)	-21.6 (-136.2, 93.0)		0.708
Rest pain	Period*Technique	0	1.6 (2.5)	1.9 (3.1)	-0.3 (-1.5, 0.9)	0.606	0.892
		1	3.3 (2.2)	3.8 (2.4)	-0.5 (-1.7, 0.7)	0.382	
		24	2.4 (2.0)	3.0 (2.2)	-0.6 (-1.8, 0.5)	0.285	
Cough pain	Period*Technique	0	2.3 (3.3)	2.9 (3.5)	-0.6 (-2.0, 0.8)	0.375	0.953
		1	4.4 (2.4)	4.8 (2.8)	-0.4 (-1.7, 1.0)	0.595	
		24	5.3 (2.3)	5.9 (2.5)	-0.5 (-1.9, 0.8)	0.431	
Cumulative Fentanyl use	Period*Technique	1	117.6 (107.8)	104.1 (111.4)	13.5 (-200.0, 226.8)	0.900	0.911
		24	760.3 (682.1)	730.7 (527.3)	29.6 (-183.8, 242.9)	0.783	
Total fentanyl used**	Technique		877.9 (731.9)	834.9 (557.0)	43.0 (-273.7, 359.8)		0.787

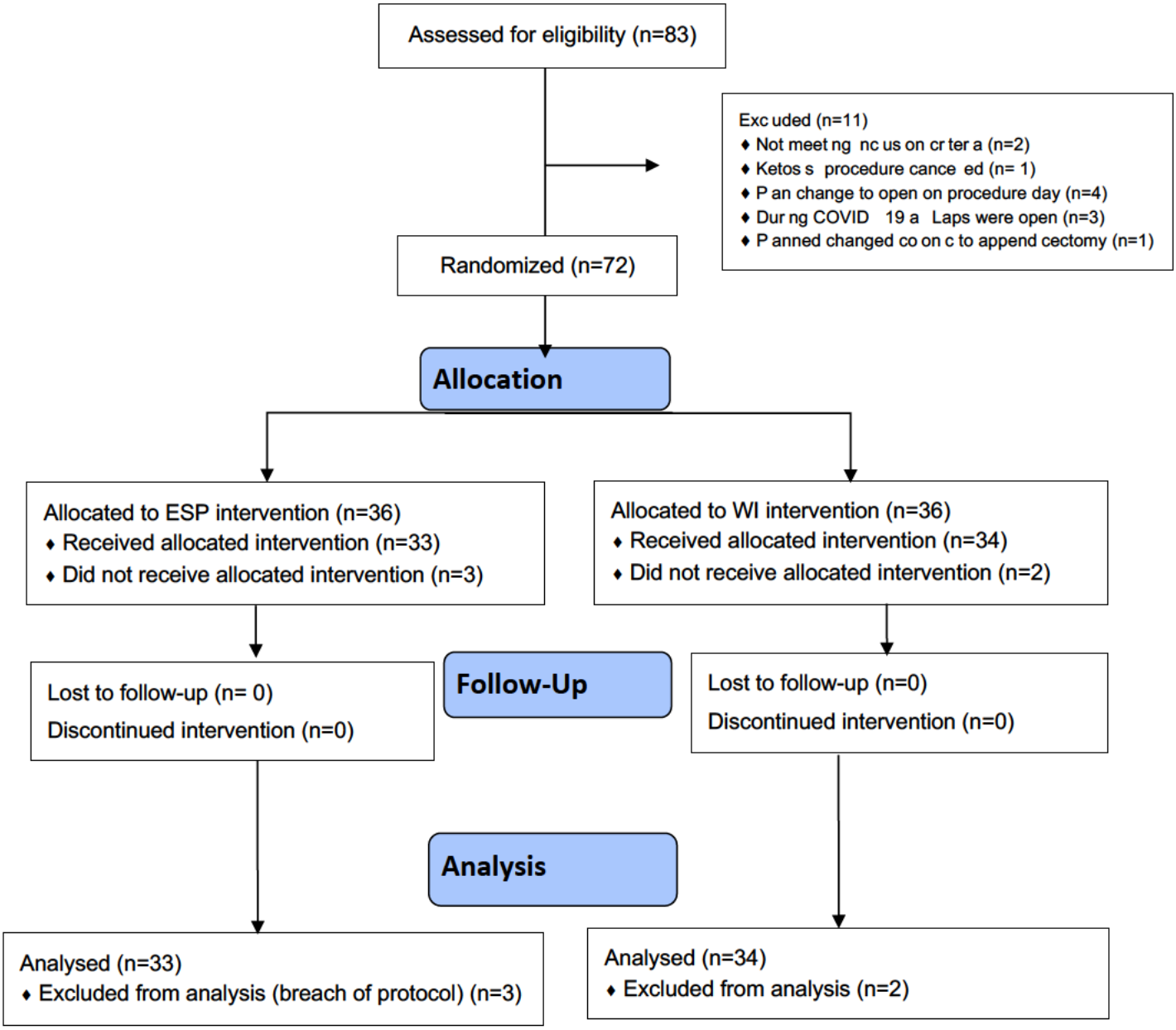
*The comparison is ESPB vs WI. ESPB denotes Erector Spinae Plane block; WI denotes wound infiltration; PACU: post anaesthetic care unit; CI: confidence interval. ** Total fentanyl used is the amount used during PACU and day one.

Table 3 Complications.

	ESP **N=33**	**WI** **N=34**	**Fisher's Exact Test p-value**
Ileus	3 (33%)	6 (67%)	0.48
Aspiration Pneumonia	1 (50%)	1 (50%)	1.00
Hypotension	1 (100%)	0 (0%)	0.49
Atelectasis	1 (50%)	1 (50%)	1.00

Data presented as n (%). ESP denotes Erector Spinae Plane; WI denotes wound infiltration.

Figure 1 CONSORT Flow Diagram



Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery - an observational study.

Summary

The erector spinae plane block (ESPB) is a novel technique involving injection of local anaesthetic (LA) below the erector spinae muscle in the para spinal region. The plasma concentrations of LA after this procedure have not been reported previously. The aim of this study was to assess the plasma concentrations of ropivacaine injected after ESPB and compare this with the blood concentration achieved with a similar volume of LA administered by wound infiltration (WI) for laparoscopic colorectal surgery.

Statement of Authorship

Title of paper	Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery- an observational study.
Publication status	published
Publication details	Kadam VR, Ludbrook GL, Hewett P, Westley I. Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery - An observational study. Indian J Anaesth. 2022;66(3):231-232.

Statement of Authorship

Title of Paper	Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery- an observational study.
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Kadam VR, Ludbrook GL, Hewett P, Westley I. Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery - An observational study. Indian J Anaesth. 2022;66(3):231-232.

Principal Author

Name of Principal Author (Candidate)	Vasanth Rao Kadam		
Contribution to the Paper	Designing, conceptualisation, recruitment, performance of the block, collection of samples, co-ordinating and writing manuscript. Also corresponding author.		
Overall percentage (%)	90		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	29.9.22

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	G.L. Ludbrook

Contribution to the Paper	Designing, editing, and drafting the manuscript		
Signature		Date	05 OCT 2022
Name of Co-Author	P. Hewett		
Contribution to the Paper	Designing, manuscript		
Signature		Date	12/10/22.
Name of Co-Author	I. Westley		
Contribution to the Paper	Blood Sample work, statistical analysis, editing and drafting the manuscript		
Signature		Date	18/10/2022

Background

Currently there are no trials on plasma ropivacaine levels estimation in erector spinae block. There is limited data on the local anaesthetic pharmacokinetics in this regional nerve block. Our aim was to estimate total ropivacaine levels in the initial 20 patients of this larger randomised trial in the immediate postoperative period. The pharmacokinetic profile will may establish its safety of the current local anaesthetics used in the fascial nerve blocks.

Abstract: Plasma concentrations of ropivacaine in adults in Erector spinae plane block (ESPB) is not reported. We report our study results on plasma total ropivacaine levels on a 20-patient cohort. The aim was to define the pharmacokinetic profile of ropivacaine following singe shot ESPB and wound infiltration (WI) groups after laparoscopic colonic surgery. A dose up to 3 mg/kg (200mg) diluted to 0.5%, up to 20 mL per side, was administered bilaterally. Similar dose was administered in the WI group. Arterial blood samples were collected 5min prior and, 10, 60, and 180 min following ropivacaine injection and observed for any adverse side effects. After elimination of error only 17 patients were included for analyses. The mean+/SD total ropivacaine dose/kg administered in the ESPB and WI groups were 2.43±0.22mg/kg and 2.67±0.25mg/kg respectively. In the ESPB group the total ropivacaine levels ranged from 0.05 to 2.22 μg/ml. The highest mean (SD) total concentration in the ESP group was observed at 10 minutes, it was 1.37 +/- 0.72 μg/ml. The highest individual peak concentration observed within the ESPB cohort was 2.22 μg/ml. In the WI group, the total ropivacaine levels ranged from 0.05 to 2.33 μg/ml. The highest mean (SD) total concentration in the WI group was observed at 60 minutes, it was 0.88 (0.42). Neither ESPB nor WI exhibited any symptoms of toxicity.

Published letter:

The erector spinae plane block (ESPB) is a new peripheral regional block that has been used for a wide variety of clinical settings [1-3]. The pharmacokinetics of ropivacaine have been well described following wound infiltration but there is paucity of data on plasma concentrations following EPSB [4,5]. Hence, we conducted a study to measure the plasma levels of ropivacaine in patients receiving EPSB and wound infiltration. The study patients were part of a bigger trial assessing the analgesic effect of ESPB vs wound infiltration (WI) in

laparoscopic colorectal surgery. After Human Ethics and Research Committee (HREC/18/CALHN/456) approval, the study was registered with the Clinical Trials Registry. The aim was to assess the safety of single shot ESPB and WI by estimating the total ropivacaine levels. Patients aged between 18-85 years, of American Society of Anesthesiologists physical status I-III, undergoing elective laparoscopic colonic surgery were included. Patients with sensitivity or allergy to local anaesthetics were excluded.

Twenty adult patients were randomised through computer generated sequence to receive standard general anaesthesia followed by bilateral ultrasound-guided ESPB or WI for postoperative analgesia prior to extubation. In ESPB group, a high-frequency linear probe of 6- to 15-MHz (Sonosite X-Porte, SonoSite Inc. Bothell, WA, USA), was used to visualise the erector spinae (ES) muscles, slightly cephalad to the T8 transverse process. A 22-gauge Stimuplex ®(B-Braun Medical, Bethlehem, PA, USA) nerve block needle was inserted deep to the ES muscle beneath the fascia in a cephalad to caudal direction. Drug dissemination was confirmed by visualizing lifting of the ES muscle in real time. Ropivacaine (AstraZeneca Pty Ltd, Sydney, NSW, Australia) diluted to 0.5%, up to 3 mg/kg (not to exceed 200 mg) was administered bilaterally, up to 20 mL per side. In the WI group, the surgeons injected a similar dose in the laparoscopic port-sites and into the minimally invasive wound. Arterial blood samples were collected 5min prior and, 10, 60, and 180 min following ropivacaine injection. Patients were observed for signs and symptoms of local anaesthetic systemic toxicity (LAST) for the next 24 hours. After calibration, total ropivacaine levels were assayed using high performance liquid chromatography-tandem mass spectrometry.

The demographic profile was similar in both the groups. The overall mean [+/- standard deviation (SD)] ropivacaine doses administered in the ESPB and WI groups were 198+/-3.7and 192mg+/-7.3 respectively. In the ESPB group the highest mean (+/- SD) and highest individual peak concentrations were 1.65 +/- 0.37 µg/ml and 2.22 µg/ml respectively. In the WI group, the highest mean (SD) and the highest individual peak concentration were 0.91 and 2.33 µg/ml respectively. The peak levels were reached earlier in the ESPB (10min) group than in the WI group (60min), probably reflecting a faster vascular absorption near the posterior muscle. The mean (SD) with 95%Confidence Intervals at 10 mins in ESPB and 60 min in WI were 1.65 +/- 0.37 µg/ml [1.28-2.02] and 0.91 +/- 0.36 µg/ml [0.55-1.2] respectively [Figure 1]. In the Griffiths et al. [6] study, the total venous plasma

concentrations of ropivacaine following transverse abdominis plane block exceeded the widely quoted toxic threshold of 2.2 µg/ ml (4.3µg/ ml of arterial equivalent) in 12 out of 30patients [6]. Levels in the current study did not exceed the toxic threshold. In another study, the highest arterial total ropivacaine levels observed after thoracic paravertebral with 2mg/kg ropivacaine was 2.47 µg/ml at 7.5 min. [7]. The highest concentrations following paravertebral block were achieved at a time frame similar to our ESPB group. However, our levels were very low (2.47 vs 1.65 µg/ml). As the ropivacaine levels following ESPB is yet to be established, our data may provide some information to guide future trials. The limitations of the study were small sample size, a ceiling dose of ropivacaine (200 mg) and the unavailability of free fraction levels.

To conclude, mean total ropivacaine levels following a single injection of EPSB or WI are well below toxic thresholds, if the total dose is limited to less than 3mg/kg, and are unlikely to cause any adverse effects.

Acknowledgements: The authors acknowledge A/prof Roelof M.A.W. van Wijk, A/prof Venkatesan Thiruvenkatarajan and Prof Sanjib Adhikary for their help in reviewing and editing of the article.

References

1. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block a novel analgesic technique in thoracic neuropathic pain. *Regional Anesthesia Pain Medicine* 2016; **41:** 621-7.

2. Hassan ME, Alfattah Wadod MA. Serratus anterior plane block and erector spinae plane block in postoperative analgesia in thoracotomy: A randomised controlled study. *Indian Journal of Anaesthesia* 2022; **66:** 119-25.

3. Ramachandran S, Ramaraj K, Velayudhan S, Shanmugam B, Kuppusamy S, Lazarus S. Comparison of erector spinae plane block and local anaesthetic infiltration of the incision site for postoperative analgesia in percutaneous nephrolithotomy - A randomised parallel-group study. *Indian Journal of Anaesthesia* 2021; **65:** 398-403.

4. Macaire P, Ho N, Nguyen V, et al. Bilateral ultrasound-guided thoracic erector spinae

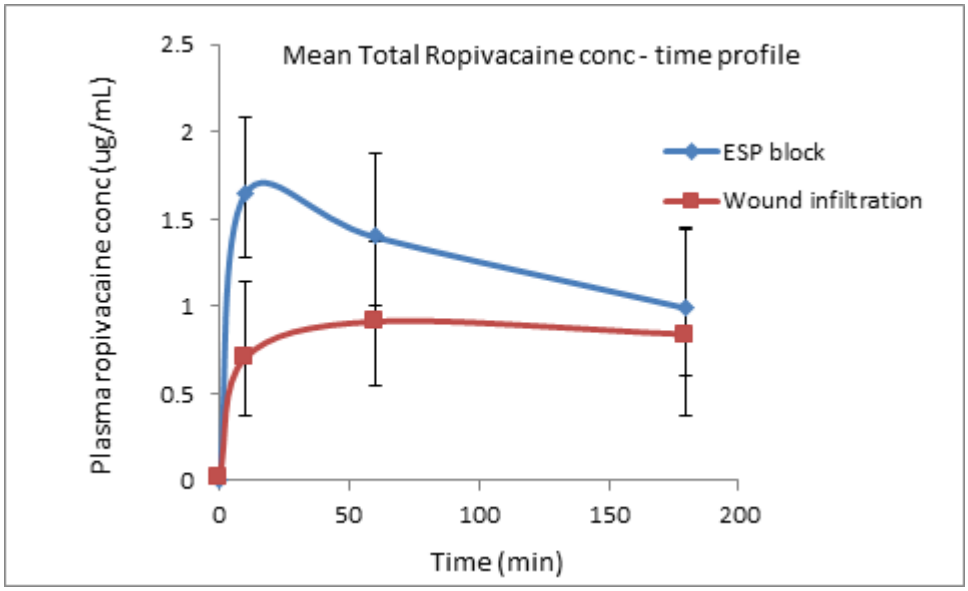
plane blocks using a programmed intermittent bolus improve opioid-sparing postoperative analgesia in pediatric patients after open cardiac surgery: a randomized, double-blind, placebo-controlled trial. *Regional Anesthesia Pain Medicine* 2020; **45:** 805-12.

5. Pettersson N, Emanuelsson BM, Reventlid H, Hahn RG. High-dose ropivacaine wound infiltration for pain relief after inguinal hernia repair: a clinical and pharmacokinetic evaluation. *Regional Anesthesia Pain Medicine* 1998; **23:** 189-96.

6. Griffiths JD, Le NV, Grant S, Bjorksten A, Hebbard P, Royse C. Symptomatic local anaesthetic toxicity and plasma ropivacaine concentrations after transversus abdominis plane block for Caesarean section. *British Journal of Anaesthesia* 2013; **110:** 996-1000.

7. Karmakar MK, Ho AMH, Law BK, Wong ASY, Shafer SL, Gin T. Arterial and venous pharmacokinetics of ropivacaine with and without epinephrine after thoracic paravertebral block. *Anesthesiology* 2005; **103:** 704-11.

Figure 1: Showing the mean total ropivacaine levels over the time course in Erector spinae plane block and wound infiltration groups. Blue diamond shape represents time points for ESPB = Erector spinae plane block and orange square for WI = wound infiltration group. Error bars (+/-) represent 95% confidence intervals.



Chapter 5- Conclusion and Future directions for perioperative pain for colonic surgery

Fascial plane blocks have been used for the last decade. Almost every year there is a new peripheral regional block added to the growing list of regional anaesthesia techniques such as transversus abdominis plane block, rectus sheath block, quadratus lumborum block, erector spinae plane block, pectoralis block, and serratus anterior blocks. The use of ultrasonography in clinical practice has facilitated the extensive application of transversus abdominis plane and rectus sheath blocks, as well as the more recent novel techniques of quadratus lumborum and erector spinae plane block [1].

Innovative analgesic techniques, and multimodal approaches are essential in addressing the challenges of post-operative pain in the recovery of our patients. Results of the randomised open label study comparing trans-muscular quadratus lumborum (TQL) group to preperitoneal catheter (PPC) group revealed comparable pain scores during cough and rescue opioid requirement. There was no difference between the groups in terms of pain on coughing over time and no interaction between therapy and time. The PPC technique was more cost-effective compared to TQL.

Similarly, a prospective, single centre, randomised, open label study compared erector spinae plane (ESP) block to wound infiltration (WI), revealing that both WI and ESPB techniques were comparable in terms of pain scores and rescue opioid requirement during the first 24 h post-operatively. There were no differences in complications observed between the two groups. The strengths of these regional blocks include adequate pain relief, minimised opioid use, and opioid related side effects, as well as reduced hospital length of stay. These analgesic techniques are also devoid of motor or sensory complications. There is occasional failure of obtaining an adequate regional block and analgesic inadequacy requiring systemic opioids. Both ultrasound-guided analgesic techniques require skills and expertise in ultrasound and needle technique. The mechanism of the TQL and ESP blocks are still not clear. There is more research required in this area and its application in colonic surgery.

A systemic review reported that TQL block reduces post-operative opioid consumption with minimal adverse effects. TQL block appears to be an applicable option for post-operative

analgesia after abdominal surgeries [1]. In other systemic reviews it has been shown to reduce opioid use post-operatively and enabled early mobilization compared with placebo [2]. More evidence is needed comparing TQL with other standard comparators.

Despite achieving expertise in regional analgesia there are many factors beyond analgesic methods to achieve optimal patient outcomes. Benefits of dynamic pain relief may only be realized if additional aspects of peri-operative care, such as the use of minimally invasive surgery, approaches to reduce stress responses, optimizing fluid therapy and enhancing post-operative nursing care with early mobilization, and oral feeding are utilized [3,4].

Many experts now consider the erector spinae plane block an alternative analgesic option to thoracic epidural analgesia and paravertebral blocks, especially where these techniques are contraindicated. This block has a good safety profile with very few reported complications [5].

Similarly, in some laparoscopic procedures ESP block invariably resulted in improved post-operative pain control and decreased breakthrough analgesic requirement [6]. We hypothesized that ultrasound guided ESP block for laparoscopic procedures was superior to wound infiltration in providing post-operative pain relief. However, we found no significant differences between the groups for rest or cough pain scores, or cumulative fentanyl use in PACU or on day one. This is contradictory to other published studies. So far, there are only limited systemic reviews or studies on ESP block in abdominal surgeries. The evidence of pain relief is supported in thoracic procedures but we may need to await more data in abdominal procedures. A systematic review in paediatrics reported low-quality evidence that erector spinae plane block exhibits superior analgesia compared to no block in children [7]. Due to the limited data, evidence regarding the comparison with other regional blocks remains unclear. Future large-sized and well-designed randomized controlled trials are needed [6].

Neuraxial block or peripheral nerve blocks may play a key role in the prevention of chronic post-operative pain in the peri-operative period by modulating pain signalling created by a surgical incision [8]. Historically, studies on any new regional anaesthetic block focussed on extent and duration of analgesia and opioid consumption. In the future regional block studies will not only need to measure pain relief for 24hours, but also other outcome measures such as functional recovery, patient reported assessments (physical, mental, social health), and outcomes over a longer time horizon than 24–48 hours [8]. Multimodal analgesia with

regional fascial blocks will also need to be assessed regarding possible prevention of chronic post-operative pain [9]. Though many studies were published on ESP block they show heterogeneity and lack in quality [10].

RCTs investigating on ESP block, lack reporting on meaningful patient-centred outcomes [11,12]. The recent systematic review and consensus statement from the Standardized Endpoints in Perioperative Medicine (StEP) initiative on patient comfort states that at least one of six standardized end points should be used in trials assessing “patient comfort” such as regional anaesthesia studies [13]. Chin and Barrington, suggested patient centred outcomes in ESP block, but there is still no agreement on what outcomes should be evaluated [12]. This evaluation may apply to any other regional anaesthesia technique, hence more future clinical trials are required. With regards to opioid crisis, pain management is moving towards non-opioid options. A regional block application in post-surgery will significantly reduce opioid use. More clinical trials of these blocks are needed as analgesic role, which may enhance its benefits in anaesthesia and pain medicine.

References:

1. Korgvee A, Junttila E, Koskinen H, Huhtala H, Kalliomaki ML. Ultrasound-guided quadratus lumborum block for postoperative analgesia: A systematic review and meta-analysis. *European Journal of Anaesthesiology* 2021; **38:** 115-29.
2. Uppal V, Retter S, Kehoe E, McKeen DM. Quadratus lumborum block for postoperative analgesia: a systematic review and meta-analysis. *Canadian Journal of Anaesthesia* 2020; **67:** 1557-75.
3. Brown AK, Christo PJ, Wu CL. Strategies for postoperative pain management. *Best Practice Research Clinical Anaesthesiology* 2004; **18:** 703-17.
4. Joshi GP. Multimodal analgesia techniques and postoperative rehabilitation. *Anesthesiology Clinics of North America* 2005; **23:** 185-202.
5. Pourkashanian A, Narayanan M, Venkataraju A. The erector spinae plane block: a review of current evidence. *Update in Anaesthesia* 2020; **35:** 27-33.
6. Saadawi M, Layera S, Aliste J, Bravo D, Leurcharusmee P, Tran Q. Erector spinae plane block: A narrative review with systematic analysis of the evidence pertaining to clinical indications and alternative truncal blocks. *Journal of Clinical Anesthesia* 2021; **68:** 110063.

7. Luo R, Tong X, Yan W, Liu H, Yang L, Zuo Y. Effects of erector spinae plane block on postoperative pain in children undergoing surgery: A systematic review and meta-analysis of randomized controlled trials. *Paediatric Anesthesia* 2021; **31:** 1046-55.
8. Wu CL, Kirksey M, Liguori G. This is what innovation looks like. *Regional Anesthesia & Pain Medicine* 2021; **46:** 569-70.
9. Chen YK, Boden KA, Schreiber KL. The role of regional anaesthesia and multimodal analgesia in the prevention of chronic postoperative pain: a narrative review. *Anaesthesia* 2021; **76 Suppl 1:** 8-17.
10. Kendall MC, Alves L, Traill LL, De Oliveira GS. The effect of ultrasound-guided erector spinae plane block on postsurgical pain: a meta-analysis of randomized controlled trials. *BMC Anesthesiology* 2020; **20:** 99.
11. Chin KJ, McDonnell JG, Carvalho B, Sharkey A, Pawa A, Gadsden J. Essentials of our current understanding: abdominal wall blocks. *Regional Anesthesia & Pain Medicine* 2017; **42:** 133-83.
12. Grocott HP. Erector spinae plane block for postoperative analgesia: A magic bullet too good to be true, or is it just too soon to tell? *Anesthesia & Analgesia* 2020; **130:** e29.
13. Myles PS, Boney O, Botti M, et al. Systematic review and consensus definitions for the Standardised Endpoints in Perioperative Medicine (StEP) initiative: patient comfort. *British Journal of Anaesthesia* 2018; **120:** 705-11.

Appendices

Appendix A

Presentations at national and international meetings

The student presented studies at the national conferences run by Australian Society of Anaesthetists, ANZ College of Anaesthetists and Australian pain society. The research related to this doctoral programme was supported to present at the international conferences. The main one was ASRA (American Society of Regional Anaesthesia) and ESRA (European Society of Regional Anaesthesia).

Dr Vasanth Rao Kadam, Dr Ming Tong, Dr Lee Taylor. *Continuous Trans muscular Quadratus Lumborum Block catheter technique for post-operative pain relief in upper abdominal surgery- Case report*. E-poster moderated oral presentation at the Australian and New Zealand College of Anaesthetists and Faculty of Pain Medicine ASM 2016 held at the Aotea Centre, Auckland, New Zealand from April 30 – May 4.

Rao Kadam V. *Various approaches to Continuous trans muscular quadratus lumborum block catheter technique for post-operative pain relief in major abdominal surgery.* Presented as e-Poster at the 35th Annual ESRA congress 2016, 7-10 Sept Maastricht Netherlands.

Vasanth R. Kadam. *Ultrasound guided anterior quadratus lumborum block l2 level safe approach for post-operative analgesia for laparotomy- case report.* E-Poster presented at the 36th Annual ESRA Congress held in Lugano, Switzerland | September 13-16, 2017.

Vasanth Rao Kadam, John Currie. *Continuous Erector Spinae plane block for Video Assisted Thoracotomy in critically ill patient-case report*. E-poster and moderated oral presentation at the 16th Annual Pain Medicine Meeting, November 16-18, 2017, Lake Buena Vista, Florida.

Vasanth R. Kadam, Medhat Wahba. *Use of Erector Spinae Block in Open Abdominal Surgery and Cancer Pain. Case Reports.* Oral Presentation presented at the 2018 World Congress on Regional Anesthesia and Pain Medicine. April 19-21, 2018, New York, New York

Vasanth R. Kadam. *A randomised controlled trial examining the analgesic efficacy of the erector spinae plane block (ESPB) vs the wound infiltration technique in laparoscopic colonic surgery (preliminary report)* was accepted at "World Congress on Pain Research & Management" during March 26-27, 2020 at Barcelona, Spain (due to pandemic it was cancelled).

V. Rao Kadam, G. Ludbrook, R. M. van Wijk, P. Hewett, V. Thiruvenkatarajan, S. Edwards, P. Williams, S. Adhikary. *Comparison of Ultrasound guided Erector Spinae Plane block (ESPB) versus wound infiltration (WI) for postoperative analgesia in laparoscopic colonic surgery-Prospective randomized study.* Presented as poster at the 2022 Australian Pain Society 42nd Annual Scientific Meeting, held at the Hotel Grand Chancellor, Hobart, from the 10 - 13 April 2022.

Appendix B

Grants awarded during candidature

Rao Kadam V, Van Wijk RM, Moran JL, Thiruvenkatarajan V, Williams P.

ANZCA research committee awarded 2018 Novice investigator Grant to support project on Comparison of Trans-muscular Quadratus Lumborum (TQL) block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery-Prospective randomized study to a total amount of $15,618 for two calendar years.

Appendix C

Other Achievements during the candidature

After presentation of the QL Block papers, Completed part 2 exam of the European society of Regional Anaesthesia and Acute Pain Management (EDRA) in 2017 at Lugano Switzerland. Successfully achieved this Diploma, which encouraged me to continue my regional analgesia research work.

Appendix D

Protocol of Trans-muscular Quadratus Lumborum (TQL) block catheter technique with surgical pre-peritoneal catheter study.

PROTOCOL

Government of South Australia
Central Northern Adelaide Health Service

The Queen Elizabeth Hospital
28 Woodville Road,
Woodville South, SA 5011
ABN 21 464 837 284
www.cnaha.sa.gov.au
Department of Anaesthesia

Ph 08 8222 6640

(Protocol version 2, dated 18.08.16)

Principal Investigator: Dr Vasanth Rao Kadam

Study Title: Comparison of ultrasound guided Trans-muscular Quadratus Lumborum (TQL) block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery- Prospective randomized study

A. SPECIFIC AIMS

The primary aim of the study is to compare the pain intensity and analgesia between surgically inserted pre-peritoneal catheter and TQL catheter infusion techniques in abdominal surgery. Secondary aim is to assess the quality of pain relief (satisfaction score) discharge time and cost analysis of the two methods.

B. BACKGROUND AND SIGNIFICANCE

In recent years Transversus abdominis plane block catheter placed under either ultrasound or under direct surgical vision has gained popularity as a means to provide postoperative analgesia after abdominal surgery (1, 2). TAP block success is based on the level of incision, subcostal TAP (for supra-umbilical incision) and posterior TAP (for infra-umbilical) blocks have been shown to be effective in reducing pain scores and opioid usage (1). Recently, there has been interest in a newer technique called quadratus lumborum block or Trans- muscular Quadratus Lumborum (TQL) block. It has been shown to be beneficial in covering multiple dermatomal segments with any type of incision. (3-8). Surgical infiltration and surgically placed technique of pre-peritoneal catheter (PPC) can also provide similar benefits or could be superior to TAP block (9, 10). A randomised trial on PPC has shown to be effective analgesia and accelerates recovery after colorectal surgery (11). The Surgical team at our institution have already been using this modality as a way of providing postoperative analgesia. The

investigator has gained some experience in TQL block based on our earlier work at our institution (ref). Our aim is to compare existing technique of pre-peritoneal catheter to the newer TQL block. There are no studies comparing these two methods.

C. PRELIMINARY STUDIES

1. Kadam VR. Ultrasound-guided quadratus lumborum block as a postoperative analgesic technique for laparotomy. J Anaesthesiol Clin Pharmacol 2013; 29:550-2
2. Rao Kadam. Quadratus lumborum (QL) block catheter infusion as a postoperative analgesic technique for abdominal surgery. Letter to the Editor J Anaesthesiol Clin Pharmacol 2015 Vol 31; 130-31

Posters presented describing the technique of QL block:

1.Rao Kadam V.Ultrasound-guided quadratus lumborum block as a postoperative analgesic technique for laparotomy. Poster presented at the ASM Melbourne May 2013.

2. Rao V Kadam.Quadratus lumborum (QL) block catheter infusion as a postoperative analgesic technique for abdominal surgery. E-Poster presenteed at the ASM conference Singapore 2014.

3. Rao Kadam V, Lee Taylor, Tong Ming. Continuous transmuscular quadratus lumborum block catheter technique for post-operative pain relief in upper abdominal surgery - Case report' presented as e-poster at the Australian and New Zealand College of Anaesthetists and Faculty of Pain Medicine ASM 2016 held at the Aotea Centre, Auckland, New Zealand from April 30 – May 4

D. PATIENTS, TECHNIQUES AND METHODS

All patients complying with the inclusion and exclusion criteria, planned to undergo elective open abdominal surgery will be given an opportunity to participate in this study. The participants may follow the standard discharge pathway. The study is designed to recruit 80 patients: 40 in each arm of the study. Patients will be provided with oral and written information (see patient information and consent).

Sample size: Appropriate data from other comparable trials were not available during the design phase of the trial so a study power estimate was based on single study that performed single shot TQL block for the lower abdominal surgery (8). In that study based on reduced opioid consumption, 25 patients were required in each group; probability (power) was set at 0.8 and type I error associated with this test for null hypothesis was 0.01. However, to prevent type two error we have decided to increase the total number of patients to 80.

Randomization: is through random group allocations generated by a computer programme done by simple randomisation table created by computer software (computerised sequence generation). This allocation will be concealed by a sealed opaque envelope. The proceduralist couldn't be blinded; however, the patients would be blinded to group allocation.

Inclusion Criteria:

- Elective open abdominal surgery (e.g. hemicolectomy, Hartman's procedure, ultra- low resection)
- Between 18 and 85 years of age
- ASA 1-3
- Adequate English language and communication

Exclusion criteria:

- Emergency surgery
- Allergy to local anaesthetic
- Pregnancy
- On regular opioid medication prior to surgery (<30mg/day or equivalent), chronic pain
- Mental handicap or psychiatric condition precluding adequate communication

During the surgical procedure patients will have standard monitoring with standardized general anaesthetic technique comprising propofol, rocuronium, O2, air and sevoflurane titrated to BIS of 50 ± 10. For intraoperative analgesia Fentanyl will be used which is standard practice in this institute.

Patients randomized to the pre-peritoneal catheter group will receive infiltration with 0.375% ropivacaine, which will be performed by the surgical faculty. All layers of the surgical incision will be infiltrated with a 22-gauge, 40-mm needle in a controlled and systematic manner under direct visualization in a fanlike fashion on each side of the incision. Ropivacaine 30 mL (225 mg) will be diluted with 30 mL of normal saline to total volume of 60 mL, of which 20 mL is infiltrated in the preperitoneal plane, 20 mL in the subfascial plane, and 20 mL into the subcutaneous plane. Thereafter, the surgeon places the catheter in the pre-peritoneal region. This is to facilitate for the continuous infusion of 0.2% ropivacaine in the recovery room and ward till 48 hours.

In TQL group, at the end of the surgery, in a lateral position the QI muscle will be visualised with a curved transducer. Under aseptic precautions, an 18-gauge Touhy's needle will be used

to reach the QL muscle at the posterior aspect. This is confirmed by injecting saline followed by the bolus dose of 20 ml of 0.375% Ropivacaine, this is followed by catheter insertion. The same technique will be repeated on the other side. Finally, each group of participant will have one catheter on each side of the abdomen and each one of them is connected to the continuous infusion device. A continuous infusion of 0.2% Ropivacaine at 5 ml/h will be delivered by infusion device called 'On Q pain relief system' pain buster pump in both groups for 48 hrs (Kimberly Clark CA USA). Once the patient is stable in recovery then further care is done in surgical ward. The dermatomal segments of TQL block will be assessed by the recovery staff after one hour in PACU and pain service team in the post-operative period. If the block is inadequate another bolus dose may be considered.

Primary end points:

1. In PACU pain assessment a Numerical Rating Scores for Pain (NRS-P; 0-10) at rest and on coughing will be recorded.
2. Rescue analgesia used will be recorded. Also, in PACU, nausea and vomiting and PACU ready to discharge time will be noted.

Acute Pain Service (APS) personnel will independently assess postoperative pain scores and analgesia used in recovery and on day one and two. During this daily morning post-surgery visit they assess pain scores and follow up if any side effects related to fentanyl, local anaesthetics and follow up on the catheter care.

Secondary end points:

Procedure related technical issues, duration of introduction of catheter insertions, complications like block failures or motor weakness will be noted. A 4 point 'Likert'-scale will be used on day 2 and during a follow-up telephone call at one month to assess patient satisfaction with the analgesic technique used and any adverse events experienced. The first flatus or bowel opening times and discharge times will also be tracked from surgeon's progress note from electronic data. Personnel and material costs will be analysed and a cost-benefit analysis. The information related to this is obtained from pharmacy and business manager.

Patients in both groups would receive Paracetamol 1-gram QID (orally or IV) and a Fentanyl PCA device (bolus 20 to 40 mcg; lockout time 5 min; no back-ground infusion) as part of a multimodal analgesic approach.

All results will be recorded on a data collection sheet in a prospective fashion and subsequently entered in a protected database.

The data will be analysed using the following methods: differences between the continuous variables by the "t"-test; categorical variables by Fisher's exact test. The pain scores between groups will be analysed by rank non-parametric methods (Man Whitney U test).

F. REFERENCES

1. Petersen PL,Mathiesen O, TorupH, Dahl JB. The transversus abdominis plane block: a valuable option for postoperative analgesia? A topical review. Acta Anaesthesiol Scand 2010; 54: 529–35.

2. Bharti N, Kumar P, Bala I, Gupta V. The efficacy of a novel approach to transversus abdominis plane block for postoperative analgesia after colorectal surgery. Anesth Analg 2011 Jun; 112(6):1504-8

3.Børglum J et al. March 2013 http://www.bjaoxfordjournals.org (accessed 29/1/2016).

4. Shaaban M et al. Bilateral Continuous Quadratus Lumborum Block for Acute Postoperative Abdominal Pain as a Rescue After Opioid-Induced Respiratory Depression A&A Case Reports. 2015; 5:107–11

5.Dalim K. Baidya, Souvik Maitra, Mahesh K. Arora Anil Agarwal. Quadratus lumborum block: an effective method of perioperative analgesia in children undergoing pyeloplasty. J of clin anaesth. 2015:27: (8):694–696.

6. Murouchi T., Iwasaki S., Yamakage M. Quadratus lumborum block: Analgesic effects and chronological ropivacaine concentrations after laparoscopic surgery Regional Anesthesia and Pain Medicine. 2016; 41: 146-150.

7. Rao Kadam. Quadratus lumborum (QL) block catheter infusion as a postoperative analgesic technique for abdominal surgery. Letter to the Editor J Anaesthesiol Clin Pharmacol 2015 Vol 31; 130-31

8. Blanco R, Ansari T and Girgis E. Quadratus lumborum block for postoperative pain after caesarean section- A randomised controlled trial. Eur J Anaesthesiol 2015; 32:812–818

9.Irina Gasanova et al. Transversus Abdominis Plane Block Versus Surgical Site Infiltration for Pain Management After Open Total Abdominal Hysterectomy Anesth Analg 2015;121:1383–8)

10. Krishnan S, Morris RG, Hewett PJ, Field J, Karatassas A, Tou S, Westley IS, Wicks FA, Tonkin JA. A randomized double-blind clinical trial of a continuous 96-hour levobupivacaine infiltration after open or laparoscopic colorectal surgery for postoperative pain management--including clinically important changes in protein binding. Ther Drug Monit. 2014 Apr;36(2):202-10

11. Beaussier M., El'Ayoubi H., Schiffer E., Rollin M., Parc Y., Mazoit J.-X., Azizi L., Gervaz P., Rohr S., Biermann C., Lienhart A., Elediam J. Continuous preperitoneal infusion of ropivacaine provides effective analgesia and accelerates recovery after colorectal surgery: A randomized, double-blind, placebo-controlled study. J. Anesthesiology. 2007;107 (3): 461-468.

G. INVESTIGATORS

Dr Vasanth Rao Kadam
Supervisors:
Professor Guy Ludbrook
A/prof Roelof van Wijk
Prof Peter Hewett

Co-investigators:
John L. Moran, Venkatesan Thiruvenkatarajan, Patricia Williams

This project is under consideration for Master's degree at The University of Adelaide.

H. APPENDICES

1. Patient information and consent
See copy

2. NRS-P and Patient Satisfaction Likert-scale
Numerical (11 point) Rating Scale for Pain: Number between 0 and 10; with 0 representing 'no pain' and 10 representing 'worst pain'.

Likert scale for satisfaction with pain relief methods: 4 point rating used: 1. completely relieved; 2. relieved; 3. somewhat relieved; and 4. not relieved

3. Questions at 30 day follow up:
1. Thanks for participating in the study; how was your experience of pain relief methods after the surgery?
2. How well do you think we managed your pain on the scale of 4?
    1 completely relieved; 2. relieved; 3. somewhat relieved; and 4. not relieved.
3. post-surgery did you experience any numbness in the mouth or in the leg or any other adverse effects?

11. Beaussier M., El'Ayoubi H., Schiffer E., Rollin M., Parc Y., Mazoit J.-X., Azizi L., Gervaz P., Rohr S., Biermann C., Lienhart A., Elediam J. Continuous preperitoneal infusion of ropivacaine provides effective analgesia and accelerates recovery after colorectal surgery: A randomized, double-blind, placebo-controlled study. J. Anesthesiology. 2007;107 (3): 461-468.

G. INVESTIGATORS

Dr Vasanth Rao Kadam
Supervisors:
Professor Guy Ludbrook
A/prof Roelof van Wijk
Prof Peter Hewett

Co-investigators:
John L. Moran, Venkatesan Thiruvenkatarajan, Patricia Williams

This project is under consideration for Master's degree at The University of Adelaide.

H. APPENDICES

1. Patient information and consent
See copy

2. NRS-P and Patient Satisfaction Likert-scale
Numerical (11 point) Rating Scale for Pain: Number between 0 and 10; with 0 representing 'no pain' and 10 representing 'worst pain'.

Likert scale for satisfaction with pain relief methods: 4 point rating used: 1. completely relieved; 2. relieved; 3. somewhat relieved; and 4. not relieved

3. Questions at 30 day follow up:
1. Thanks for participating in the study; how was your experience of pain relief methods after the surgery?
2. How well do you think we managed your pain on the scale of 4?
    1 completely relieved; 2. relieved; 3. somewhat relieved; and 4. not relieved.
3. post-surgery did you experience any numbness in the mouth or in the leg or any other adverse effects?
4. Do you have any other comments to make?

Appendix E

Protocol of Erector Spinae Plane (ESP) block versus wound infiltration (WI) study

PROTOCOL

Central Adelaide
Local Health Network

Critical Care Services
The Queen Elizabeth Hospital
Department of Anaesthesia

28 Woodville Road
Woodville South SA 5011
Tel 08 8222 6640
Fax 08 8222 7065

Health.QEHAnaestheticServices@sa.gov.au
www.sahealth.sa.gov.au

ABN: 96 269 526 412

Study Title: Comparison of Ultrasound guided Erector Spinae Plane (ESP) block versus wound infiltration (WI) for postoperative analgesia and estimation of blood levels of ropivacaine in laparoscopic colonic surgery- Prospective randomized study

Short title: ESP block vs WI technique for postoperative analgesia in colonic surgery

Principal Investigator:

Dr Vasanth Rao Kadam, MBBS MD, DNB, FANZCA, EDRA

Role: Ethics approval work, participant recruitment, obtaining consent, data/sample collection, performing the regional blocks, sample collection and coordinating the team at the two centres.

Co-investigators:

Prof Guy Ludbrook, MBBS FANZCA PhD GAICD

Designing the study, coordinating the research activity at the Royal Adelaide Hospital and support the researchers and supervise them.

A/Prof R van Wijk, MD PhD FANZCA FFPMANZCA AFRACMA AFACHSM

Designing the study and support the researchers and supervise them.

Prof Peter Hewett. MBBS, FRACS.

Designing the study and support the researchers and supervise them.

Dr Gilberto Arenas MBBS, TEA, FANZCA

Performing the regional blocks, participant recruitment, obtaining consent, data/sample collection

Dr Ian Westley PhD

Coordinating the collection of blood samples and analysis in the lab for ropivacaine levels.

Dr Venkatesan Thiruvenkatarajan. MBBS MD, DNB, FANZCA

Designing the study, participant recruitment, obtaining consent and data/sample collection

Dr Stuart Howell. For statistical analysis

Table of Contents

A. INTRODUCTION AND BACKGROUND

Erector Spinae Plane (ESP) block was first described by Forero, in 2016. This has gained popularity in the last 3 years as one of the options for postoperative pain relief after abdominal surgery (1). Initially, the block was performed for thoracic and breast surgery and now its use has been reported for abdominal surgery. The technique involves injecting local anaesthetic (LA) into the myofascial plane beneath the fascia covering the Erector Spinae muscle under ultra sound guidance. This approach is gaining popularity as it is simple to visualise, the para spinal muscles at the mid thoracic or even lower levels about 3 cm lateral to the midline. A single bolus injection has proven to be beneficial as a part of multimodal analgesia in surgeries involving thorax and abdomen (1,2,3,4,5). Levobupivacaine, ropivacaine (ROP), and bupivacaine have been used in these case studies at

various concentrations and volumes. Information on the pharmacokinetic investigations of the LA drugs injected in ESP block is limited.

The purpose of this study is to assess the safety and efficacy of this newer regional analgesic technique for the postoperative analgesia in major laparoscopic abdominal surgeries.

Anticipated start and finish dates: July 15 2018 –Dec 15 2019

B. SPECIFIC AIMS

Aim: The primary aim of this study is to study the efficiency of the ESP block with a single bolus dose of ropivacaine (ROP) in laparoscopic surgery in comparison with wound infiltration technique. The secondary aim is to assess safety of local anaesthetic (LA) injected after erector spinae block by estimating the blood levels. Efficiency is assessed by comparing pain scores, analgesics use and other outcomes measures analysed are, discharge time and clinical determinants of adverse effects.

We hypothesize; that ultrasound-guided ESP block is superior to surgically guided wound infiltration in providing superior pain relief without major side effects.

C. PRELIMINARY STUDIES

First study on ESP block:

Forero M, et al The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41:621–627.

Our experience:

Posters and moderated presentation:

1.VASANTH RAO KADAM, John Currie. Continuous Erector Spinae plane block for Video Assisted Thoracotomy in critically ill patient-case report. E-poster and oral presentation at the 16th Annual Pain Medicine Meeting, November 16-18, 2017, Lake Buena Vista, Florida

2. Vasanth R. Kadam, Medhat Wahba. Use of Erector Spinae Block in Open Abdominal Surgery and Cancer Pain. Case Reports. Oral Presentation presented at the 2018 World Congress on Regional Anesthesia and Pain Medicine,April 19-21, 2018, New York, New York

Publications:

1.RaoKadam V, Thiruvenkatarajan V.ESP block: an evolving technique. Letter of response to: The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. Chin K, Adhikary S, Sarwani N, Forero M. Aneasthesia. 72(4):452-60, 2017.

2.Vasanth Rao Kadam, John Currie. Continuous Erector Spinae plane block for Video Assisted Thoracotomy. Anaesth Int Care 2018;46(2):243-44.

Case study: We have performed a bilateral ESP block with a continuous catheter infusion technique for abdominal surgery at T7 level, and a unilateral ESP block with a continuous catheter at the T6 level for video assisted thoracotomy. We administered 10ml of saline to open the tissue plane, followed by a LA bolus dose of 10ml of 0.75% ropivacaine for video assisted thoracotomy (VATS) procedure and achieved a sensory spread between T6 to L1. The patient had adequate analgesia with an uneventful post-operative recovery (2).

We also reported a case of successful ESP block using a continuous catheter technique for pain relief in a critically ill patient undergoing open cholecystectomy. This case report was presented at the World congress of Regional Anaesthesia in April 2018.

Case 2: 81 year old male was, admitted to the intensive care unit (ICU) with acute cholecystitis systemic sepsis. He required noradrenaline 13 mcg/min to maintain his BP. His medical co-morbidities were; hypertension, ischaemic heart disease, hypercholesterolemia Type 2 Diabetes mellitus, chronic obstructive airway disease, Parkinson's disease, acute renal failure. In view of the deranged coagulation (INR 1.9) and sepsis we were not keen on a paravertebral block but instead ESP was considered. Consent was obtained from the patient for ESP block for the post-operative pain relief. Surgery was uneventful. Due to poor exchange of gases and requirement of high inotropic support, he was considered for delayed extubation in the ICU. Post-surgery, in the right lateral position, an Erector Spinae plane block was performed under ultrasound guidance at the level of the T7 transverse process, 3 cm from the midline. An 18-gauge, Touhy needle was inserted in a caudad to-cephalad direction until the tip touched the transverse process and lay in the interfascial plane deep to the Erector Spinae muscle (fig1). After saline test dose a total of 10ml of 0.75% ropivacaine was injected followed by catheter insertion. In the ICU, an infusion of ropivacaine 0.2% 4-6ml/hr was administered for 5 days. After extubation in ICU he didn't require any opioids and was able to participate in deep breathing and coughing.

D. PATIENTS, TECHNIQUES AND METHODS

The study will be conducted at the CALHN sites comprising TQEH and RAH sites with patients who are scheduled for elective laparoscopic colonic surgery. Participants will be recruited by the treating clinician in the colorectal surgical outpatient clinic at the TQEH and RAH. Subsequently in preadmission clinic at the TQEH and RAH, the anaesthetist consent would be obtained by the anaesthetists. All patients complying with the inclusion criteria and planned to undergo elective surgery will be enrolled in this study. The anticipated study period will be from July 15th and December 15th 2019.

The first stage of the study is designed to recruit 10 patients in the active group (ESP) and 10 patients in the control group (WI) to estimate the ropivacaine levels. In the second stage 26 patients in each arm to receive the intervention without the estimation of serum ropivacaine levels. With 36 in each group in total there will be 72 patients. Patients will be provided with oral and written information (see patient information and consent form).

The inclusion criteria are: ASA 1-3 for laparoscopic colonic surgery under general anaesthesia between the age of 18-85 yrs and non-child bearing potential patients.

Exclusion criteria are inability to comprehend English, allergy to any drug used in the study, preoperative daily use of opioids equivalent to 10mg/day of morphine, or conversion to open surgery. Patients on more than 10 mg of morphine equivalent or any medication for chronic pain management will be excluded.

During the surgical procedure, patients will undergo a standardized general anaesthetic technique with standard monitoring. The radial artery will be accessed with a 22-gauge catheter as usual practice. Post procedure ESP block will be performed by an experienced anaesthetist and the wound infiltration performed by the surgical fellow/consultant. Arterial blood sample will be drawn at 0, 10, 60, and 180 mins after ropivacaine administration.

Technique of the block: An in plane approach in the lateral position will be attempted under the ultrasound guidance. Using a 6- to 15-MHz high-frequency linear probe, the 3 muscle layers of the posterior spine anatomy namely: trapezius, romboids and Erector spinae (ES) muscles will be visualized slightly cephalad to T8 transverse process. Needle position will be confirmed by saline test dose puncture and drug dissemination will be confirmed in real time under ultrasound guidance, and the needle tip will be placed under the ES muscle beneath the fascia in a cephalad to caudal direction. A recommended dose of 3mg/kg up to 200mg of ropivacaine (0.5%, 20 mL per side) will be administered bilaterally using a 22-gauge nerve block needle after confirmation of the most appropriate location with a test dose of saline. In the control group, the surgeons will inject LA up to 200mg of ropivacaine in the surgical ports and in to the minimally invasive wound. Blood samples will be collected at the same time for both groups. In the post anaesthetic care unit (PACU) and subsequently in the wards, patients will be questioned for signs and symptoms of ROP toxicity, such as: perioral numbness, tingling sensation, tinnitus, metallic taste, muscle twitching, and convulsions.

Serum ropivacaine assay technique:

All the samples collected will be sent to FMC SA pathology lab where they will be spun and the serum/plasma stored at -20C until assay. Samples will be assayed according to the method used in the previous study (6) using high performance liquid chromatography ultra violet (HPLC-UV)

detection. Samples will also be used to determine (AlphA-1-Acid Glycoprotein) AAG levels by ELISA assay. Samples will be discarded after the analysis.

Sensory block will be assessed after surgery using a cold test on either sides of the anterior abdomen between xiphi-sternum to pubic symphysis from dermatomes T6-L1.

All Patients will have a preoperative ECG. Post operatively, a repeat ECG will be done if there are any signs and symptoms of LA toxicity.

Patients will be administered with paracetamol 1 gram QID (orally or IV) and single dose of dexamethasone 8mg (intraop) as part of a multimodal analgesic approach. A Fentanyl PCA device (bolus 10 to 40 mcg based on the age; lockout time 5 min; no back-ground infusion) will be provided as rescue analgesia. The difference in PCA usage would be an indication of efficiency of the analgesic techniques examined.

The following endpoints will be registered:

- Numerical verbal rating Scores for Pain (NRS-P; 0-10) at rest and on coughing in PACU at 0 and I hour and in the postoperative ward at 24 hrs.
- Fentanyl use in PACU and postoperative ward on day 1 and any rescue medication used
- Procedure related: Technical issues, Potential side effects or complications in relation to the technique used.
- discharge time

All study parameters from EPAS or paper records will be recorded on a data collection sheet in a prospective fashion and subsequently entered in a protected database for analysis. The information is coded (re-identifiable) and stored for 15years accessible only to researchers.

Benefits/risks and ethical considerations: the potential direct benefits of the study are the participants achieving pain relief in both interventions. This may benefit the researchers in understanding more about the strategies of pain relief enhancing after surgery. Hospital and the community may benefit if the patients can be discharged early allowing cost savings. The risks are very rare (1:20,000) from LA injected close to the nerve or blood vessel resulting in LA toxicity. These risks are minimised by precise identification of the site of LA injection under ultrasound guidance. If

LA toxicity occurs, there are existing protocols in place in the hospital to manage. Dissemination of study findings shouldn't pose risk to the participants.

Randomisation is through random group allocations generated by a computer programme done by simple randomisation table created by computer software (computerised sequence generation). This allocation will be concealed by a sealed opaque envelope. The proceduralist couldn't be blinded; however, the patients would be blinded to group allocation. The person analysing the data also will be blinded.

Statistical tests: The data will be analysed using the following methods: differences between the continuous variables by the "t"-test; categorical variables by Fisher's exact test. The pain scores between groups will be analysed by rank non-parametric methods (Man Whitney U test).
Statistical analysis: Continuous measures will be presented as means with standard deviations and medians with interquartile range. Categorical measures will be presented as counts and percentages. Group comparisons on baseline characteristics will be assessed using Student's T-test or Pearson's Chisquare statistic as required. For outcome measures, changes over time will be assessed using linear mixed effects models with patient treated as a random factor. All tests will be two-tailed and assessed at the 5% alpha-level.

Sample size: The study is powered to detect effects at the 5% alpha level with 80% statistical power. Calculations are based on the primary outcome (pain scores) and it was determined that a clinically meaningful difference between groups would be 2.5 points. Assuming constant variance and a standard deviation of 3 points, a sample of 24 patients per group is required. The sample will be inflated to 36 patients per group to account for intra-patient correlations arising from repeated measures. Thus, a total of 72 patients are required

F. REFERENCES

1 Forero M, et al The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41:621–627.
2.Vasanth Rao Kadam, John Currie. Continuous Erector Spinae plane block for Video Assisted Thoracotomy. Anaesth Int Care 2018 (In press)

3. Restrepo-Garces CE1, Chin KJ, Suarez P, Diaz A. Bilateral Continuous Erector Spinae Plane Block Contributes to Effective Postoperative Analgesia After Major Open Abdominal Surgery: A Case Report. A A Case Rep. 2017 Jul 19.

4. K. J. Chin, S. Adhikary, N. Sarwani, and M. Forero, "The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair," Anaesthesia, vol. 72, no. 4, pp. 452–460, 2017.

5. Serkan Tulgar, Onur Selvi, and Mahmut Sertan Kapakli, "Erector Spinae Plane Block for Different Laparoscopic Abdominal Surgeries: Case Series," Case Reports in Anesthesiology, vol. 2018, Article ID 3947281, 3 pages, 2018.

6. Corso OH, Morris RG, Hewett PJ, et al. Safety of 96-hour incision-site continuous infusion of ropivacaine for post-operative analgesia following bowel-cancer resection. Therapeutic Drug Monitoring. 2007; 29:57-63.

G. INVESTIGATORS

Dr Vasanth Rao Kadam

Prof Guy Ludbrook,

A/Prof R van Wijk,

Prof P Hewett

Dr Gilberto Arenas

Dr Ian Westley

Dr Venkatesan Thiruvenkatarajan

Dr Stuart Howell

H. APPENDICES

1. Patient information and consent form

Appendix F

Protocol on Acute Kidney Injury in the colorectal division of surgery - Quality assurance audit

Central Adelaide
Local Health Network

Critical Care Services
The Queen Elizabeth Hospital
Department of Anaesthesia

28 Woodville Road
Woodville South SA 5011
Tel 08 8222 6640
Fax 08 8222 7065

Health.QEHAnaestheticServices@sa.gov.au
www.sahealth.sa.gov.au

ABN: 96 269 526 412

PROTOCOL

Incidence of Acute Kidney Injury during the perioperative period in the colorectal division of surgery

- Observation study (Quality assurance audit) (Protocol version 1, dated 22.07.18)

Principal Investigator: Dr Vasanth Rao Kadam

1. Title: Incidence of Acute Kidney Injury during the perioperative period in the colorectal division of surgery - Observation study (Quality assurance audit)

a. Short title

Audit of Acute Kidney Injury in the colorectal surgery

2. Investigators details:

Dr Vasanth Rao Kadam

MBBS, MD, FANZCA, EDRA, Vasanth.rao@sa.gov.au phone 82224680

The investigator is working as consultant in the department of anaesthesia at the TQEH, which is part of the CALHN site and his role in the study is to collect the data and analyses it this site only.

Co-author: Vincent Loo. 6th year Medical student and his role is to collect the data as part of research team.

3. Introduction

Acute kidney injury (AKI) is commonly occurred following cardiac surgery but it may also occur in other surgeries like colorectal surgeries [1]. This may have a detrimental impact on patient on cost, length of hospital stay and mortality. The risk factors for AKI after cardiac and colorectal may not be same. The aim of this study was therefore to evaluate the incidence, risk factors, and outcome of AKI in the first 7days after surgery in a cohort of patients undergoing major colorectal surgery.

4. Anticipated start dates July 31/07/2018-Anticipated End Date30/12/2018

5. Background

AKI definition evolved from acute renal failure to risk Injury failure loss of kidney function end-stage kidney disease(RIFLE) and acute Kidney Injury Network (AKIN) to kidney disease improving global outcomes (KDIGO (1-4), There have been several studies on the AKI during the hospital stay in major abdominal surgery (5-8). Also, it has been investigated for patient related risk factors as predictors and type of surgery. However, studies on AKI developed after colorectal surgery is limited (9, 10). The incidence is 4.8-11.8%. The objectives of this study is to investigate the incidence at this center and predictors of AKI in colorectal surgery by KDIGO criteria; and evaluate the impact of AKI on the 30 day mortality

Our aim was to obtain available biochemical and patient data on AKI via EPAS and ORMIS system at The Queen Elizabeth hospital for the year 2016 from June to June 2018.

6. Purpose

The aim of the study is to assess the kidney function parameters (creatinine, eGFR) from preoperative to postoperative period. This study also evaluates the incidence, risk factors, and outcome of AKI in the first 7days after surgery in a cohort of patients undergoing major colorectal surgery.

7. Study design

This is a retrospective single Centre study, which involves all open colorectal procedures performed at TQEH. The data will be collected from the EPAS and ORMIS system at The Queen Elizabeth hospital from June 2016 to June 2018.

Inclusion criteria: Those patients who had general anaesthesia with propofol , fentanyl and rocuronium with endotracheal intubation for colorectal surgery will be considered. Other inclusion criteria are

- Age 18 and above
- Elective/emergency procedures
- Major abdominal surgery
- General anaesthesia
- Laparoscopic or open procedures
- Fluids used

Exclusion criteria

- Non-availability of GFR or creatinine
- Chronic kidney disease or creatinine > 1.5
- Transplanted kidney
- Renal replacement therapy
- Multiple surgeries in the same admission

If an error is discovered during the review it will be notified to the Head of Department Anaesthesia in the normal fashion as we do for any incident management or safety learning system (SLS). In this process there will be action or recommendations from review.

Consent Waiver: Since this study I audit, there is no requirement of patient information sheet or consent process. When neither explicit consent nor an opt-out approach is appropriate, the requirement for consent may sometimes be justifiably waived. The consent for research conducted

retrospectively, research participants will characteristically not know that they, or perhaps their data, are involved in the research. There will be sufficient protection of their privacy and there is sufficient protection of the confidentiality of data. (NHMRC National Statement 2007; 2.3)

Will a databank be established-No

v. For all data and tissue/samples

Initially the information will be identifiable for validation of data. Subsequently the database will be deidentified. . Data will be noted in excel sheet and subsequently entered in a protected database in password protected computer at the department of anaesthesia. Only the principal researcher will have access is for the data.

d. Analysis

Sample size and power analysis is not possible at this stage. Multivariate logistic regression method may be used for analysis.

Data storage: The research data is locked in secure cabinet. Access to data is password protected. The results in the study database will not identify patient and as per the guidelines, this information will be kept for 15 years.

9. Publication

Results of the audit will be presented in the departmental meeting or if suitable may be published.

10. Ethical considerations

This study may benefit for improvement of our practice or for the future research.

b. Risks

No risks involved in this audit data to the patients or researchers or local community.

d. Responsibility for liability of injury (Not applicable)

e. Conflicts of interest: There are no conflicts of interest; it is purely for the research purpose.

References:

1.Sawhney S, Fraser SD. Epidemiology of AKI: utilizing large databases to determine the burden of AKI. Adv Chronic Kidney Dis.2017;24(4):194–204.

2.Bellomo R, Ronco C, Kellum JA, et al. Acute renal failure—defnition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. Crit Care. 2004;8:R204–12

3. Mehta RL, Kellum JA, Shah SV, et al. Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. Crit Care. 2007;11(2):R31.

4. Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Work Group. KDIGO clinical practice guideline for acute kidney injury. Kidney Int Suppl. 2012;2:S1–138.

5. Abelha FJ, Botelho M, Fernandes V, et al. Determinants of post-operative acute kidney injury. Crit Care. 2009;13:R79.

6. Kheterpal S, Tremper KK, Englesbe MJ, et al. Predictors of post-operative acute renal failure after noncardiac surgery in patients with previously normal renal function. Anesthesiology. 2007;107:892–902

7. Kheterpal S, Tremper KK, Heung M, et al. Development and validation of an acute kidney injury risk index for patients undergoing general surgery: results from a national data set. Anesthesiology 2009;110:505–15.

8. Cho A, Lee J, Kwon G, et al. Post-operative acute kidney injury in patients with renal cell carcinoma is a potent risk factor for new-onset chronic kidney disease after radical nephrectomy. Nephrol Dial Transplant. 2011;26(11):3496–501

9. M. W. Causey, J. A. Maykel, Q. Hatch, S. Miller, and S. R Steele, "Identifying risk factors for renal failure and myocardial infarction following colorectal surgery," Journal of Surgical Research, vol. 170, no. 1, pp. 32–37, 2011.

10. Masoomi H., Carmichael J.C., Dolich M., Mills S., Ketana N., Pigazzi A., Stamos M.J. Predictive factors of acute renal failure in colon and rectal surgery. Am Surg. 2012;78:1019–1023.

Appendix G - Published papers

Article

Anaesthesia and Intensive Care

Anaesthesia and Intensive Care
2019, Vol. 47(2) 141–145

DOI: 10.1177/0310057X1983993 1
journals.sagepub.com/home/aic
SAGE

Anatomical and ultrasound description of two transmuscular quadratus lumborum block approaches at L2 level and their application in abdominal surgery

Vasanth Rao Kadam[1,2], Roelof M Van Wijk[1], Guy L Ludbrook[1,2] and Venkatesan Thiruvenkatarajan[1]

Abstract

The transmuscular quadratus lumborum (TQL) block is one of the recently evolved myofascial blocks utilised in abdominal surgery. It involves injecting local anaesthetic into the fascial plane anterior to the thoracolumbar fascia. This block has previously been described with a transverse oblique paramedian approach at the L2 level in the sitting position. We describe a TQL block at the same level in the lateral position using a transverse posterolateral approach to provide analgesia for patients undergoing abdominal surgery. We elaborate on these two approaches of TQL block at the L2 level, in relation to the anatomy, sonoanatomy and technical aspects.

Keywords

Quadratus lumborum, transmuscular quadratus lumborum block, thoracolumbar fascia, ultrasound, postoperative analgesia

Introduction

The transmuscular quadratus lumborum (TQL) block is one of the recently evolved myofascial blocks utilised in abdominal surgery. It involves injecting local anaesthetic (LA) into the fascial plane anterior to the thoracolumbar fascia (TLF). Børglum et al. first described the ultrasound-guided TQL block at the level of the fourth lumbar vertebra (L4).[1] It is also termed the anterior quadratus lumborum block because it involves injecting the LA at the anterior aspect of the quadratus lumborum (QL) muscle blocking dermatomes from T6 to L1. In comparison, to achieve sensory block covering the entire abdominal wall, a four point transversus abdominis plane block would be necessary.[2] Bilateral TQL can provide similar analgesia. Due to the presence of surgical drains at the flank level and poor visualisation of anatomical structures at this position, Dam et al. later used the transverse oblique paramedian (TOP) approach at the L2 level in the sitting position.[3] After encountering side-effects such as leg paresis with Børglum et al.'s L4 approach, we attempted TQL block at a higher level (L2 transverse process) with patients in the lateral position, using a transverse posterolateral (TPL) approach, in abdominal surgery.[4–6] In this brief communication, we elaborate on these two approaches of TQL block at the L2 level, in terms of the anatomy, sonoanatomy and technical aspects.

Anatomy

Myofascial blocks around the QL plane are based on the anatomy of the TLF. It is a tubular connective tissue structure formed by the binding aponeuroses and fascia layers, which, by enveloping the back muscles, connects the anterolateral abdominal wall with the lumbar paravertebral region (Figure 1).[7] On its medial side, the TLF is attached to the thoracic

[1]Department of Anaesthesia, The Queen Elizabeth Hospital, Adelaide, Australia
[2]School of Medicine, The University of Adelaide, Adelaide, Australia

Corresponding author:
Vasanth Rao Kadam, Department of Anaesthesia, The Queen Elizabeth Hospital, The University of Adelaide, Adelaide, Australia.
Email: vasanth.rao@sa.gov.au

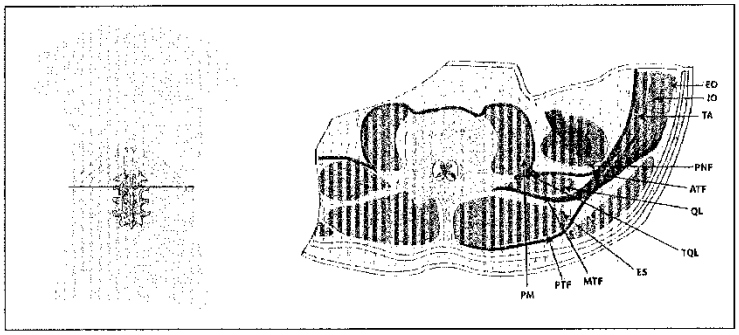


Figure 1. The anatomy of the thoracolumbar fascia at L2. EO: external oblique; IO: internal oblique; TA: transversus abdominis; PNF: perinephric fascia; ATF: anterior thoracolumbar fascia; QL: quadratus lumborum muscle; TQL: site of transmuscular quadratus lumborum block at L2; ES: erector spinae; MTF: middle thoracolumbar fascia; PTF: posterior thoracolumbar fascia; PM: psoas muscle.

and lumbar vertebrae, and continues cranially as the endothoracic fascia. The TLF divides into three layers (anterior, middle and posterior) around the muscles of the back. The posterior layer is posterior to the erector spinae muscles; the middle layer is sandwiched between the erector spinae and QL muscle (and is thus posterior to the QL); the anterior layer is anterior to the QL muscle. The anterior layer also blends medially with the fascia of psoas major and blends laterally with the transversalis fascia. Injection between the anterior layer and QL can spread cranially under the lateral arcuate ligament to the endothoracic fascia and reach the lower thoracic paravertebral space posterior to the endothoracic fascia.[8]

Technical description

TPL TQL approach

This approach can be performed pre-, intra- and post-operatively. We focus on block performance at the end of the surgical procedure before extubating the patient with the therapeutic aim of enhancing postoperative analgesia.[5] It can be done unilaterally or bilaterally depending on the type of the incision. It is performed in the lateral decubitus position with the block side upwards. On the lower side a wedge is placed between the rib cage and the iliac crest to make the QL muscle prominent. To improve visualisation, anaesthetic assistants would need to retract the rib cage and the iliac crest to increase the gap. A curved low frequency probe 2–5 MHz is placed transversely between the iliac crest and the costal margin in the posterior axillary line. The structures visualised are the abdominal muscles, psoas muscle, peritoneum, kidney and QL muscle (Figure 2). After identifying the QL an 18 gauge Tuohy needle (with the tip pointing upwards) is introduced in plane and medial to the transducer probe and advanced posterior to anterior through QL muscle. Hydrodissection is carried out while the needle is above the L2 transverse process till it passes through the QL muscle. This will help to identify the muscle plane and reach the anterior TLF. The kidney is very close to the QL muscle, which is separated from it by perinephric adipose tissue and the posterior layer of renal fascia. The LA is injected in the myofascial plane between the QL muscle and the anterior TLF, close to the psoas muscle, where a tactile feel of layer penetration may also be appreciated. The hydrodissection with the Tuohy needle may avoid entry into the peritoneal cavity or perinephric area. After a test dose of saline 5 mL, 0.5% ropivacaine 20 mL is given in 5 mL aliquots after aspiration. This is followed by the catheter insertion.

In our view, the risk of puncture of intra-abdominal structures such as the kidney can be minimized by careful tactile feel of fascia, visualisation of the needle tip, the use of a blunt Tuohy needle and hydrodissection. We believe the risk is likely to be reduced by taking these measures.

Personal observations.

- Performing TQL block at a higher level (L2) will minimize the chance of lower lumbar nerve root blockade (femoral nerve). These roots are likely to get blocked if the injection point is close to the psoas muscle at L4 level, which is in close proximity to where the nerve roots join to form the femoral nerve.
- Hydrodissection above the L2 transverse process to the anterior TLF can avoid entry into the peritoneal cavity or perinephric area, thus preventing damage to the vital structures in the vicinity.

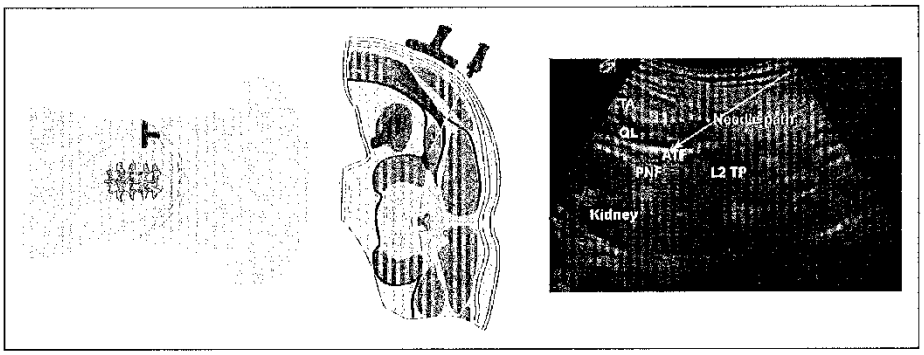


Figure 2. TPL (transverse posterolateral) TQL L2 approach showing transverse probe placement, in plane needle placement and ultrasound image. TA: transversus abdominis; QL: quadratus lumborum muscle; ATF: anterior thoracolumbar fascia; PNF: perinephric fascia; L2 TP: transverse process of L2; TQL: transmuscular quadratus lumborum.

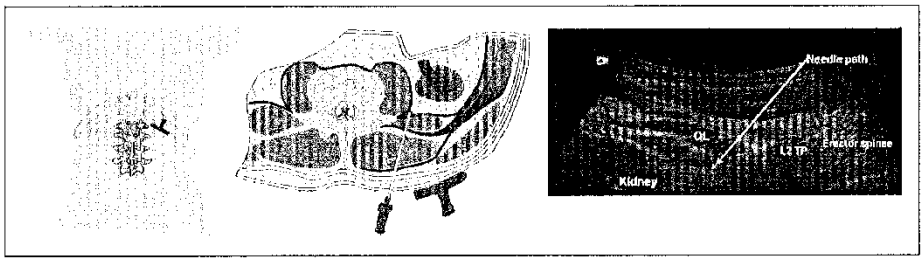


Figure 3. TOP (transverse oblique paramedian) TQL L2 approach showing transverse oblique probe placement, in-plane needle placement and ultrasound image. TQL: transmuscular quadratus lumborum; QL: quadratus lumborum; L2 TP: transverse process of L2.

- Use of a blunt Tuohy needle and the tactile feel of fascial click may be a safer technique than the use of a sharp needle.

TOP TQL approach

This is a TOP approach of the TQL block, with the patient in a sitting position. The original sources used the hypoechoic shadow of the transverse processes as the primary proxy endpoint marker for injection.[3] The cephalad border of the iliac crest and the spinous processes of the lumbar vertebral column are palpated and marked on the skin. A curvilinear transducer 2–5 MHz is placed with a transverse oblique and paramedian orientation approximately 3 cm lateral to the L2 spinous process (Figure 3). The transducer is first shifted cephalad or caudad to identify the L2 transverse process and the adjoining QL muscle. The needle is then inserted in plane from the medial end of the transducer and advanced in plane laterally to enter the interfascial plane between the QL and psoas major muscles and LA is injected.

Discussion

This short communication describes two recently developed variations of the TQL approach at the L2 level, with illustrated anatomy and related probe and needle positions to assist in understanding the sonoanatomy and performance of these blocks in abdominal surgery.

A comparison between the TPL and TOP approaches is given in Table 1. It should be noted that the endpoints in both approaches are similar; i.e. the myofascial plane between the QL muscle and the anterior TLF, close to the psoas muscle. Dam et al., using the TOP approach in a cadaver model, reported medial spread of dye limited to the lateral part of the psoas fascia and cranial spread into the thoracic

Table 1. Comparison of transverse posterolateral and transverse oblique paramedian approaches to transmuscular quadratus lumborum blockade.

	TPL TQL block	TOP TQL Block
Cadaveric study	No	Yes
Position of patient	Lateral	Sitting
Transducer placement	Transverse in posterior axillary line and above L2 transverse process	Transverse, oblique, paramedian orientation approximately 3 cm lateral to the L2 spine
Clinical indications	Abdominal surgery only	
Reported studies	Case report and case series	No studies
Dermatomes covered	T6–L1	Used in nephrolithotomy, levels not reported
Area of abdominal wall covered	Epigastrium to pubic area	Not reported
Visceral and vascular injury likely	Potential for kidney, lumbar artery injury	Similar injury potential
Ease of technique	Moderate complexity block; positioning assistance required	Moderate complexity block
Coagulation precautions	As a deep retroperitoneal block consider same precautions as central neuraxial block	Similar precautions
Limitations with flank surgical drains	Except in renal surgical dressing	Except in renal surgical dressing

TPL, transverse posterolateral; TQL, transmuscular quadratus lumborum; TOP, transverse oblique paramedian.

paravertebral space[8]. It was noted in this cadaver study that injectate administered at the myofascial QL plane at L2 level could reach lower thoracic up to the T10 thoracic paravertebral space and T9–12 ventral rami. There was no spread of injectate into the psoas major muscle or the lumbar plexus, and a consistent spread of injectate into the thoracic paravertebral space and the thoracic sympathetic trunk was noted. This could possibly reduce both somatic and visceral pain although, as yet, data are limited in this regard.

This, and the favourable results reported in recent limited case series in major abdominal surgery, demonstrating cranial spread, without the occurrence of lumbar root blockade,[4 6,9] make this approach appropriate in intra- and retroperitoneal abdominal surgery, either as a single-sided (e.g. nephrectomy) or double-sided (e.g. bowel surgery) block.

The needle skin entry points differ between a more posteromedial (TOP) and posterolateral (TPL) approach. Also, the patient position differs with Dam et al. advocating a sitting position and we suggest a lateral position with a wedge under the patient to enable better access.

Both, in their early publications, suggest administering the block postoperatively. However, from a pain management point of view, having a regional anaesthetic block in situ during surgery will be more advantageous. Other advantages include being able to use the block in patients who are unable to sit up, such as whilst anaesthetised or immediately postoperatively in the post-anaesthesia care unit or intensive care unit. From a patient comfort and safety perspective, inserting the catheter(s) prior to surgery would be preferable to doing so either with the patient sitting up in the post-anaesthesia care unit or moving the patient to one lateral position, and subsequently to the other, while still anaesthetised.

Unfortunately, no major clinical studies have been reported on this approach. In a case series of TPL for abdominal surgeries, a dermatomal spread as high as T6 was achieved.[6] It is unclear to what extent this technique covers intra-abdominal visceral pain. A randomized trial is underway in our institution exploring its use during open major abdominal surgery. Till now, there has been only a single case series comparing the needle position at the anterior aspect of the QL muscle, between the L2 and L4 level approach[6]. Anecdotally we have not observed lower limb weakness, but this was not formally studied. LA spread to the lumbar plexus is a possibility. We found no other adverse events at the L2 level. However, data is limited on the differences between these approaches[6]. Further studies should investigate the role of TQL in open upper gastrointestinal and colorectal surgeries using TQL at L2 level (higher) and for pelvic surgery at lower (L3–L4) level.

In conclusion, based on anatomical considerations and the limited clinical data available, both ultrasound-guided TQL approaches (TPL and TOP) at L2 level have theoretical advantages. However, these would need to be confirmed in prospective studies.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Børglum J, Moriggl B, Lönnqvist PA, et al. Ultrasound-guided transmuscular quadratus lumborum blockade. *Br J Anaesth* 2013; 111.
2. Børglum J, Maschmann C, Belhage B, et al. Ultrasound-guided bilateral dual transversus abdominis plane block: a new four-point approach. *Acta Anaesthesiol Scand* 2011; 55: 658–663.
3. Dam M, Hansen CK, Børglum J, et al. A transverse oblique approach to the transmuscular quadratus lumborum block. *Anaesthesia* 2016; 71: 603–604.
4. Rao Kadam V. Ultrasound guided continuous transmuscular quadratus lumborum block and transient femoral nerve palsy. *Anaesthesia* 2017; 72. Available at: http://www.respond2articles.com/ANA/forums/2363/ShowThread.aspx#2363 (accessed 3 May 2019)
5. Rao Kadam V, Ludbrook G, Hewett P, et al. Ultrasound guided anterior quadratus lumborum block L2 level safe approach for post-operative analgesia for laparotomy-case report. *Reg Anesth Pain Med* 2017; 42: e182.
6. Rao Kadam V and Howell S. Ultrasound-guided continuous transmuscular quadratus lumborum block–L4 or L2 level catheter insertion for analgesia in open abdominal surgery: case series. *Indian J Anaesth* 2018; 62: 555–557.
7. Willard FH, Vleeming A, Schuenke MD, et al. The thoracolumbar fascia: anatomy, function and clinical considerations. *J Anat* 2012; 221: 507–536.
8. 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: 303–312.
9. Rao Kadam V. Ultrasound guided transmuscular quadratus lumborum block, mid-level safe approach for postoperative analgesia for laparotomy. Letter of response to: A cadaver study comparing spread of dye and nerve involvement after three different quadratus lumborum blocks. *Br J Anaesth* 2017.

Brief Communication

Ultrasound-guided continuous transmuscular quadratus lumborum block- L4 or L2 level catheter insertion for analgesia in open abdominal surgery: Case series

INTRODUCTION

Quadratus lumborum block (QLB) is a technique for postoperative analgesia after abdominal surgeries. Nomenclature on types of QLB keeps changing.[1] An ultrasound-guided transmuscular quadratus lumborum (TQL) block, which involves passage of the needle through the QL muscle and injection of the local anaesthetic (LA) into the anterior aspect of the fascial interspace between the QL and psoas muscle is also called the QLB3.[2] There have been case reports on the use QLB block in abdominal surgery as an analgesic technique in paediatric and adult patients.[3-5] There is a general paucity of literature on continuous use of TQL block in adults for major abdominal surgery.[6,7] We have previously reported TQL block performed at L4 resulting in transient paraesthesia of the leg in one case.[6] In view of this issue, we performed the same block at L2 level without adverse effect. So far, no studies examined the analgesic effect of TQL catheters placed at different levels utilizing the anterior approach for major abdominal surgery. The aim of this study was to evaluate the efficacy of these blocks at two levels in open midline incision surgery.

METHODS

Ten consecutive patients (7 males, 3 females) undergoing elective open abdominal surgery with any midline incision were recruited in 2016 at The Queen Elizabeth Hospital. Patients unable to provide consent and allergic to fentanyl, ropivacaine, and oral opioids were excluded. Human Research Ethics Committee approval was obtained. All patients received general anaesthesia with endotracheal intubation and were administered intermittent doses of Fentanyl for analgesia. The patients were placed in a lateral position following the surgical procedure and prior to extubation to insert the QLB catheters under ultrasound guidance using a 2–5-MHz frequency curved probe (SonoSite X-Porte, SonositeInc, Bothell, Washington, USA). A lower approach (L4) was used in five patients where the probe was placed transversely in the posterior axillary line and moved towards L4 transverse process (iliac crest level). In the remaining five patients the probe was placed close to the transverse process at the L2 level. After identifying the QL muscle above the transverse process, an 18-gauge Touhy's needle was introduced at the respective transverse process, in a posterior to anterior direction, in plane through the QL muscle by saline hydro-dissection to reach the anterior thoracolumbar fascia [Figures 1 and 2]. A bolus of 20 ml of ropivacaine 0.5% was administered followed by bilateral catheter insertion directing cephalad to the depth of 3–4 cm to infuse ropivacaine 0.2% at 5–8 ml/h each side for 48 h. Patients were also administered multimodal analgesia with 1 g Paracetamol every 6 h, Dexamethasone 8 mg, and Fentanyl PCA. Parameters measured by acute pain service were dermatomal levels, pain scores on cough, and total analgesic consumption in the 48 h after surgery. Pain score ranged from 0 (no pain) to 10 (worst possible pain).

RESULTS

Table 1 provides details of patient characteristics and the nerve block. Mean pain score during recovery was slightly higher among patients who had the block at L2 when compared to those at L4 (L2 v L4: 4.20 v 1.20). However, group differences were negligible at both time points (24 h: L2 v L4: 5.4 v 5.0) (48 h: L2 v L4: 5.6 v 5.6).

Mean fentanyl consumption over the 48 h was 1024 and 1277 mcg for block performed at L2 and L4, respectively. Femoral nerve palsy and hypotension occurred when blocks were performed at L4; however, there were no adverse events at L2. There were no complications relating to catheter, infections, or systemic side effects to ropivacaine during the study period.

DISCUSSION

Continuous TQL block in abdominal open surgery reduced pain scores; the lower-level (L4) approach resulted in adverse effects such as hypotension and nerve palsy. This nerve palsy is possibly from the LA tracking to the lower lumbar roots and its proximity to the lumbar plexus in psoas muscle. Unanticipated femoral nerve

palsy was also reported after transversalis fascia block and QLB.[8,9] Unexplained hypotension following this block has also been reported.[10] We chose Borglum's QLB3, reporting anaesthesia from T7 to L1 based on traces of contrast in the thoracic paravertebral space.[11] There are no such studies performed at L2 level.

Ueshima reported that a single shot technique was effective for almost 24 h with dermatomes level up to T7.[12] We achieved dermatomal level up to T8, but there is a need for a technique that achieves cephalad block with catheters providing prolonged analgesia. However, because T6 is ideal for an incision close to xiphoid, there may be room for improvement on cephalad spread in terms of bolus dosing and infusions.

TQL catheters have the advantage of analgesic benefit for both upper and lower abdominal surgery. The lower iliac crest level at L4 and higher near L1 spine, near the 12th rib have been established as approaches to TQL block.[2,13] At the L2 level we would qualify for the in between (mid-level) TQL block. At this stage we are unsure whether high,[13] mid or low level[2] TQL technique is optimal; however, this series suggests that L2 Rao's technique has an advantage with no adverse effects. Larger studies and randomized control trials are warranted to establish the efficacy and safety of these techniques. This study is limited by the small case series.

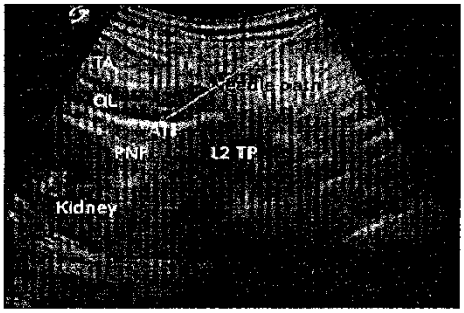


Figure 1: The sonoanatomy of TQL block at L2. TA = Transversus abdominis, QL = Quadratus lumborum muscle, ATF = Anterior thoracolumbar fascia, PNF = Perinephric fascia, TP = Transverse process

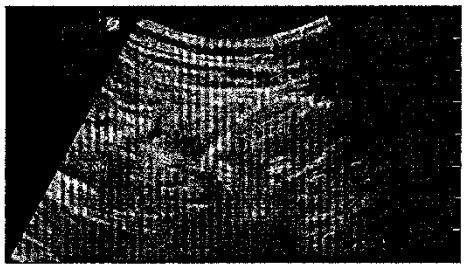


Figure 2: The ultrasound guided TQL with LA injected at L2 level. QL = Quadratus lumborum muscle, ATF = Anterior thoracolumbar fascia, TP= Transverse process

	Age (yrs)	Sex	ASA*	TQL† block level	Dermatomal level	Pain scores PACU‡	Analgesia in PACU	Pain scores Day 1	Pain scores Day 2	Total Fentanyl Used in 48 h (µg)	Type of surgeries
1	69	Male	2	L4	T8-L1	0	0	5	4	310	Subtotal Gastrectomy
2	77	Female	3	L4	T6-L1	1	160	5	5	1800	Reversal of hartmans
3	63	Female	3	L4	T8-L1	5	80	2	4	2300	Extended hemi colectomy
4	42	Female	3	L4	T8-L1	0	0	7	6	900	Extended hemi colectomy
5	68	Male	2	L4	T8-L1	1	60	5	8	1075	Right hemicolectomy
6	60	Male	2	L2	T8-L1	0	0	5	5	500	Anterior resection
7	62	Male	2	L2	T8-L1	7	100	5	5	170	Reversal of ilestomy
8	50	Male	2	L2	T8-10	6	100	6	8	800	Left hemicolectomy
9	62	Male	3	L2	T8-10	0	0	6	7	3000	Laparotomy bowel resection
10	65	Male	3	L2	T8-L1	2	80	5	3	650	Low anterior resection

*ASA=American society of anaesthesiologist, †TQL=Trans-muscular Quadratus lumborum ‡PACU=Post anaesthesia care unit, mcg=microgram

CONCLUSION

A TQL catheter placed either at L4 and L2 levels reduced postoperative pain scores and analgesic use after major abdominal surgeries. Absence of neurological adverse events in the L2 group may suggest its possible safety.

Acknowledgement

We thank Dr Venkatesan Thiruvenkatarajan for his editing and Karen Taylor and P Williams for spell check.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Vasanth Rao Kadam, S Howell

Acute Care Medicine, The University of Adelaide, The Queen Elizabeth Hospital, Adelaide, Australia

Address for correspondence:
Dr. Vasanth Rao Kadam,
Department of Anaesthesia, Senior Clinical lecturer,
Acute Care Medicine, The University of Adelaide,
Adelaide, Australia.
E-mail: vasanth.rao@sa.gov.au

REFERENCES

1. El Boghdadly K EH. Short A, Chin KJ. Quadratus lumborum block nomenclature and anatomical considerations. Reg Anesth Pain Med 2016;41:548-9.
2. Borglum J MB, Jensen K, Lonnqvist PA, ChristonsenAF, Sauter A, *et al*. Ultrasound-guided transmuscular quadratus lumborum blockade. Br J Anaesth 2013.
3. Baidya DK,Maitra S,Arora MK,Agarwal A.Quadratuslumborum block: An effective method of perioperative analgesia in children undergoing pyeloplasty. J Clin Anaesth 2015;27:694-6.
4. Chakraborty A, Goswami J, Patro V. Ultrasound-guided continuous quadratus lumborum block for postoperative analgesia in a pediatric patient. A A Case Rep 2015;4:34-6.
5. Shaaban M,Esa WA,Maheshwari K,Elsharkawy H,Soliman LM. Bilateral Continuous Quadratus Lumborum Block for Acute Postoperative Abdominal Pain as a Rescue After Opioid-Induced Respiratory Depression. A A Case Rep 2015;5:107-11.
6. Kadam VR, Taylor L, Tong M. Continuous Transmuscular Quadratus Lumborum Block Catheter Technique for Post-Operative Pain Relief in Upper Abdominal Surgery-Case Report. J Anesth Pain Med 2016;1:1-2.
7. Warusawitharana C, Basar SHMA, Jackson BL, Niraj G. Ultrasound guided continuous transmuscular quadratus lumborum analgesia for open renal surgery: A case series. J Clin Anesth 2017;42:100-1.
8. Lee S, Goetz T, Gharapetian A. Unanticipated motor weakness with ultrasound-guided transversalis fascia plane block. A A Case Rep 2015;5:124-5.
9. Wikner M. Unexpected motor weakness following quadratus lumborum block for gynaecological laparoscopy. Anaesthesia 2017;72:230-2.
10. SáM,Cardoso JM,Reis H,Esteves M,Sampaio J,Gouveia I,*et al*. Quadratus lumborum block: Are we aware of its side effects? A report of 2 cases. Rev Bras Anestesiol 2017;23:S0034-7094.
11. Carney J, Finnerty O, Rauf J, Bergin D, Laffey JG, Mc Donnell JG. Studies on the spread of local anaesthetic solution in transversus abdominis plane blocks. Anaesth Intensive Care 2011;66:1023-30.
12. Ueshima H, Yoshiyama S, Otake H. The ultrasound-guided continuous transmuscular quadratus lumborum block is an effective analgesia for total hip arthroplasty. J Clin Anesth 2016;35:235-7.
13. Elsharkawy H. Quadratus lumborum block with paramedian sagittal oblique (subcostal) approach. Anaesthesia 2016;71:241-2.

Access this article online

Quick response code

Website: www.ijaweb.org

DOI: 10.4103/ija.IJA_242_18

How to cite this article: Kadam VR, Howell S. Ultrasound-guided continuous transmuscular quadratus lumborum block- L4 or L2 level catheter insertion for analgesia in open abdominal surgery: Case series. Indian J Anaesth 2018;62:555-7.

Original Article

Comparison of ultrasound-guided transmuscular quadratus lumborum block catheter technique with surgical pre-peritoneal catheter for postoperative analgesia in abdominal surgery: a randomised controlled trial

V. Rao Kadam,[1] **G. Ludbrook,**[2] **R. M. van Wijk,**[1] **P. J. Hewett,**[3] **J. L. Moran,**[4] **V. Thiruvenkatarajan**[5] and **P. J. Williams**[6]

1 Associate Professor, 2 Professor, 6 Affiliate Lecturer, Acute Care Medicine, 3 Professor, Department of Surgery, 4 Associate Professor, Discipline of Acute Care Medicine, 5 Senior Clinical Lecturer, University of Adelaide, SA, Australia

Summary

Following abdominal surgery, the provision of postoperative analgesia with local anaesthetic infusion through both transmuscular quadratus lumborum block and pre-peritoneal catheter have been described. This study compared these two methods of postoperative analgesia following laparotomy. Eighty-two patients 18–85 years of age scheduled to undergo elective surgery were randomly allocated to receive either transmuscular quadratus lumborum block or pre-peritoneal catheter block. In the transmuscular quadratus lumborum group, an 18-gauge Tuohy needle was passed through the quadratus lumborum muscle under ultrasound guidance to reach its anterior aspect. A 20-ml bolus of ropivacaine 0.375% was administered and catheters placed bilaterally. In the pre-peritoneal catheter group, 20 ml of ropivacaine 0.375% was infiltrated at each of three subcutaneous sub-fascial levels, and pre-peritoneal plane catheters were placed bilaterally. Both groups received an infusion of ropivacaine 0.2% at 5 $ml.h^{-1}$, continued up to 48 h along with a multimodal analgesic regime that included regular paracetamol and patient-controlled analgesia with fentanyl. The primary end-point was postoperative pain score on coughing, assessed using a numerical rating score (0–10). Secondary outcomes were pain score at rest, fentanyl usage until 48 h post-operation, satisfaction scores and costs. There was no treatment difference between the two groups for pain score on coughing ($p = 0.24$). In the transmuscular quadratus lumborum group, there was a reduction in numerical rating score at rest ($p = 0.036$) and satisfaction scores on days 1 and 30 ($p = 0.004$, $p = 0.006$, respectively), but fentanyl usage was similar. In the transmuscular quadratus lumborum group, the highest and lowest blocks observed in the recovery area were T4 and L1, respectively. The transmuscular quadratus lumborum technique cost 574.64 Australian dollars more per patient than the pre-peritoneal catheter technique.

Correspondence to: V. Rao Kadam
Email: vasanth.rao@sa.gov.au
Accepted: 6 July 2019
Keywords: costs; local anaesthetic; postoperative pain; quadratus lumborum; ultrasound

Introduction

Myofascial blocks (ultrasound-guided as well as under direct vision) such as the transversus abdominis plane (TAP) block have been advocated for postoperative analgesia for over a decade [1, 2]. Although TAP blocks have been shown to provide somatic analgesia and reduced opioid consumption, two TAP blocks are required to achieve analgesia for longer abdominal incisions [3]. A surgical infiltration technique has been reported to provide superior pain relief at rest and on coughing, with reduced opioid consumption compared with a TAP block [4].

Pre-peritoneal catheter (PPC) analgesia has been demonstrated to be effective in reducing opioid consumption and reducing pain scores at rest and when coughing compared with saline; the same variables were non-inferior to epidural analgesia after colorectal surgery [5–9]. The mechanism of action is presumably blockade of nociceptive afferents of the peritoneum [5]. The ease of the PPC technique and the reduced complexity involved in managing the catheters postoperatively has proved to be very attractive, and many surgical protocols have now promoted this technique as standard practice [5].

Transmuscular quadratus lumborum (TQL) block is a recently described myofascial plane technique where local anaesthetic is deposited adjacent to the quadratus lumborum muscle, aiming to anaesthetise the thoracolumbar nerves by distribution of the local anaesthetic to the paravertebral space [10]. It has been shown to provide visceral analgesia in abdominal surgery with any type of incision, blocking higher dermatomal levels T7-L1 [10]. There are both paediatric and adult case reports of single and continuous TQL blocks for postoperative analgesia [11–14].

To date, there have been no studies examining the continuous TQL technique for postoperative analgesia after major open abdominal surgery in adults. This study aimed to investigate whether continuous TQL had an analgesic advantage over continuous PPC. We hypothesised that ultrasound-guided TQL block provides superior analgesia, reflected by improved numerical rating scores (NRS) for pain on movement and reduced opioid requirement, compared with surgically-guided continuous pre-peritoneal block. The primary outcome was postoperative dynamic pain scores assessed by verbal NRS (0–10) on coughing. Secondary outcomes were: pain at rest; opioid usage; procedure-related technical issues in relation to anatomy; time taken for catheter insertion; incidence of motor weakness; and overall patient satisfaction.

Methods

Human Research Ethics Committee approval was obtained. This was a single-centre trial conducted at The Queen Elizabeth Hospital, with the main flow of patients recruited from the colorectal division of surgery between November 2016 and November 2018.

Patients undergoing elective abdominal surgery with a midline incision (above and below the umbilicus), 18–85 years of age, ASA physical status 1–3 who had adequate English language skills were included after obtaining informed consent. Patients were identified in the pre-admission clinic by the anaesthetist. Exclusion criteria were: emergency surgery; allergy to local anaesthetic; pregnancy; chronic opioid medication of > 30 $mg.day^{-1}$ (morphine equivalent); or mental handicap or psychiatric condition that precluded adequate communication and consent.

Group allocation was by a simple randomisation table using a user-written Stata module 'ralloc' [15]. This allocation was concealed using a sealed opaque envelope. The proceduralist could not be blinded, but patients were initially blinded to group allocation; the patients would only become aware of their group allocation once they arrived on the ward post-procedure. On arrival in theatre the chief investigator handed the box of envelopes to the attending nurse or anaesthetic colleague to assign participants for intervention.

During the surgical procedure, patients had a standardised monitoring and general anaesthetic technique that comprised propofol, rocuronium, oxygen, air and sevoflurane. For intra-operative analgesia, fentanyl was administered via intermittent bolus.

Patients randomly allocated to the PPC group received infiltration with ropivacaine (Naropin, AstraZeneca Pty Ltd, Sydney, NSW, Australia), via a catheter that was inserted by the surgeon. All layers of the surgical incision were infiltrated with a 22-gauge, 40-mm needle under direct visualisation. Ropivacaine (3 $mg.kg^{-1}$, maximum 225 mg) was diluted with 40 ml of saline to a total volume of 60 ml, of which 20 ml was infiltrated in the pre-peritoneal plane (Fig. 1), 20 ml in the sub-fascial plane and 20 ml into the subcutaneous plane. Thereafter, the surgeon placed the catheter on the superior aspect of the incision in the pre-peritoneal region under direct vision. This was to facilitate the continuous infusion of ropivacaine 0.2% in the recovery room and ward until 48 h.

In the TQL group, the patient was placed in a lateral position at the end of the surgery. The chief investigator visualised the quadratus lumborum muscle under ultrasound guidance using a curved transducer probe

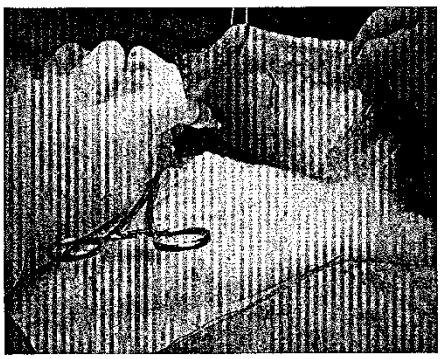


Figure 1 Showing the pre-peritoneal bolus infiltration under vision.

(Sonosite X-Porte, SonoSite Inc. Bothell, WA, USA). Under aseptic conditions, an 18-gauge Tuohy needle was inserted in plane, posterior to anterior, through the quadratus lumborum muscle to reach the anterior aspect and below the anterior thoracolumbar fascia near the perinephric fascia (Fig. 2). This was confirmed by injecting saline, followed by a bolus dose of 20 ml of ropivacaine 0.375%, and a catheter was placed in plane. The same technique was repeated on the other side.

The time taken from needle entry to catheter insertion was noted in both groups by either an anaesthetic colleague or a nursing staff member. Each group had one catheter on each side of the abdomen, and each was connected to an elastomeric infusion device ('On Q pain relief system' Kimberly Clark, CA, USA). A continuous infusion of ropivacaine 0.2% at 5 $ml.h^{-1}$ was delivered to both groups for 48 h. Once the patients were stable enough to leave the recovery area, they were discharged to the surgical ward. The dermatomal segments of the TQL block were assessed using ice by staff after 1 h in the recovery area, and the rest of the study duration did not involve dermatomal assessment. Patients in both groups received paracetamol 1 g four times per day (orally or IV) and fentanyl patient-controlled analgesia, bolus 20–40 μg, lockout time 5 min, no background infusion as part of a multi-modal analgesia approach.

Acute Pain Service (APS) personnel independently assessed postoperative pain scores and analgesia used in recovery on days 1 and 2. The APS team was not blinded, as it was not possible to perform catheter care without knowing group allocation. During the daily morning post-surgery visit, they assessed pain scores, followed up any side-effects related to fentanyl or local anaesthetics and cared for the catheters. All results were recorded prospectively on a purpose-built data collection sheet and subsequently entered into a protected database.

Postoperative pain was assessed using the NRS in recovery area (0 h and 1 h) and on the 1st and 2nd postoperative days. The primary outcome was dynamic pain score on coughing at the predetermined time-points.

Secondary end-points were rest pain scores, rescue analgesia fentanyl use, procedure-related technical issues and duration of catheter insertion. Complications such as motor weakness were also noted. A 4-point Likert scale was used to assess patient satisfaction of how well the pain was managed. The points used were: (1) completely relieved; (2) relieved; (3) somewhat relieved; and (4) not relieved. This

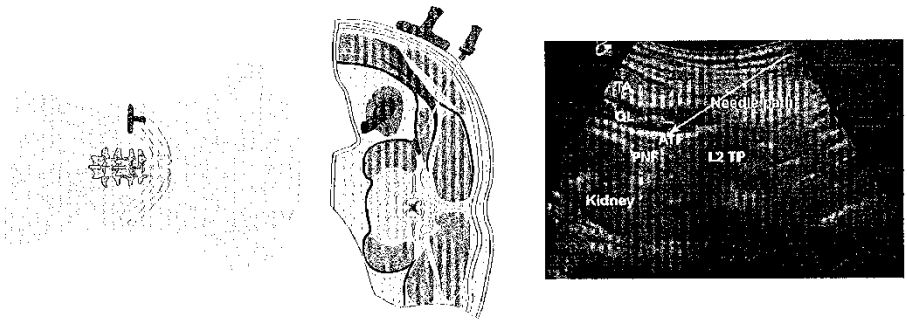


Figure 2 Showing the lateral position with illustrate anatomy and sono-anatomy with simulated needle path. TA, transversus abdominis; QL, quadratus lumborum muscle; ATF, anterior thoracolumbar fascia; PNF, perinephric fascia; L2 TP, 2nd lumbar transverse process.

was used on postoperative day 2 and during a follow-up telephone call at 1 month by a research assistant to assess patient satisfaction and adverse events. The first flatus or bowel opening times and hospital discharge times were also recorded from electronically recorded surgical progress notes. Personnel and material costs were analysed for cost-benefit analysis. Financial information was obtained from pharmacy and nurse/business managers.

Continuous data were analysed by the t-test (unequal variances) for normally distributed data (identified by moment analysis; skewness and kurtosis). Non-normally distributed data were analysed by the rank-sum test and categorical data by Fisher's exact test. As the pain scores were repeated over time, a linear mixed model analysis (patient as random intercept, patient-time as random slope, unstructured covariance) was undertaken to identify any treatment differences [16]. Model specification was assured by residual analysis. Model-based estimates and treatment contrasts were undertaken using the 'margins' procedure of Stata™ [17]. The statistical analysis was blinded to group allocation.

Based on our previous report [18], the peak cough pain score was mean (SD) 5.0 (3.0). As appropriate randomised clinical trials for the use of TQL block with infiltration have not been published, an approximate scenario was established for patient number. The total patient number (at

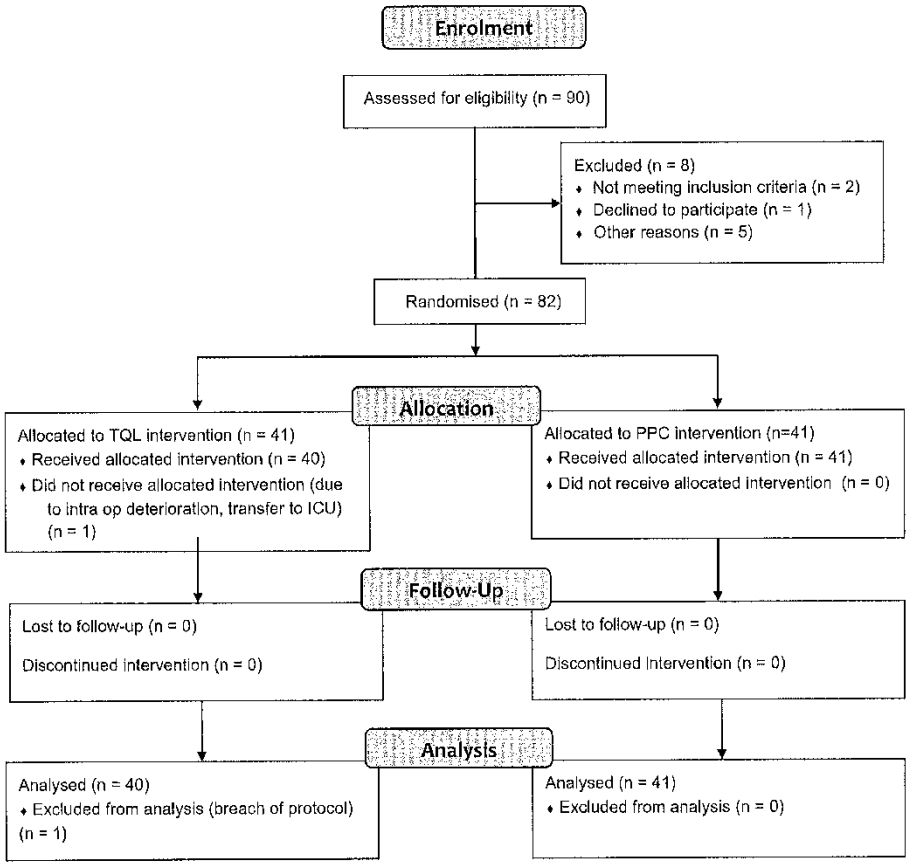


Figure 3 CONSORT flow diagram. TQL, transmuscular quadratus lumborum; PPC, pre-peritoneal catheter.

80% power) for a 2-point (40%) mean decrease in pain score was 72. On this basis, it was proposed to randomly allocate 82 patients to the two treatment arms allowing for dropout.

Results

Only one patient had a breach of protocol (did not receive TQL block), and none were lost to follow-up (Fig. 3). Both groups were comparable with respect to pre-operative status. Baseline characteristics and operative parameters are shown in Table 1. Pain scores, fentanyl usage and Likert satisfaction scores by group are shown in Table 2.

There was no difference between the groups in terms of pain on coughing over time ($p = 0.242$) and no interaction between therapy and time was noted ($p = 0.32$). The TQL group had less pain at rest over time ($p = 0.036$, two periods in recovery area and at two time-points in the ward) compared with the PPC group. Satisfaction scores were lower in the TQL group than the PPC group on days 2 and 30, $p = 0.006$ and 0.004, respectively. The cost analysis showed a difference of 574.64 Australian dollars in favour of the PPC technique, the main differences being the additional material required for TQL as well as the extra theatre utilisation time. No block-related complications (such as vascular/visceral puncture or local anaesthetic toxicity) were recorded. Catheter leaks were found in two patients in each group, and two patchy blocks (no uniform dermatomes distribution) were reported. Hypotension was comparable between the groups (Table 3). It was mild, necessitating only fluid therapy without intensive care unit admission. In the TQL group, the highest and lowest block observed in the recovery area was T4 and L1, respectively. In 20 patients there was clear dermatomal spread; in the other patients it was not well defined. Ketamine was used for additional pain relief in two patients, one from each group.

Table 1 Baseline characteristics and details by technique. Values are mean (SD), number (proportion) or median (IQR [range]).

	PPC n = 41	TQL n = 40	p value
Age; years	66.4 (14.1)	64.2 (15.0)	
Sex			
Female	21 (51%)	21 (53%)	
Male	20 (49%)	19 (48%)	
ASA physical status	3.0 (2.0–3.0 [2.0–4.0])	3.0 (2.0–3.0 [1.0–3.0])	
Operation			
Upper GI surgery	3 (7%)	1 (3%)	
Colorectal surgery	33 (80%)	35 (88%)	
Laparotomy	5 (12%)	4 (10%)	
Incision length; cm	21.0 (5.4)	22.6 (5.9)	0.20
Surgical duration; mins	170.0 (135.0–210.0 [90.0–310.0])	173.0 (140.0–262.5 [80.0–450.0])	0.42
Anaesthetic duration; mins	205.0 (153.0–240.0 [105.0–345.0])	207.5 (180.0–302.5 [110.0–510.0])	0.12
Catheter insertion; mins	10.0 (7.0–11.0 [4.0–19.0])	9.0 (7.0–11.5 [5.0–20.0])	0.77
Insertion difficulties			0.051
No	31 (76%)	22 (55%)	
Yes	10 (24%)	18 (45%)	
Recovery area time; mins	75.0 (63.0–105.0 [45.0–240.0])	90.0 (57.5–120.0 [1.0–170.0])	0.80
Postoperative ileus			0.21
No	29 (71%)	33 (83%)	
Yes	12 (29%)	7 (18%)	
Postoperative hypotension			0.62
No	39 (95%)	37 (93%)	
Yes	2 (5%)	3 (8%)	
Flatus time; h	72.0 (48.0–96.0 [24.0–144.0])	72.0 (48.0–74.0 [6.0–168.0])	0.94
Bowel motion time; h	88.0 (62.0–144.0 [1.0–240.0])	75.0 (72.0–126.0 [11.0–240.0])	0.95
Hospital LOS; days	9.0 (7.0–13.0 [2.0–50.0])	8.0 (5.5–11.0 [3.0–38.0])	0.15

PPC, pre-peritoneal catheter; TQL, transmuscular quadratus lumborum; LOS, length of stay.

Table 2 Numerical rating scores for pain (at rest and cough), fentanyl use (μg) and Likert scores. Values are median (IQR [range]) or mean (SD).

	PPC n = 41	TQL n = 40	p value
Intra-operative fentanyl use	500.0 (375.0–600.0 [0.0–950.0])	600.0 (500.0–700.0 [250.0–1000.0])	0.027
Recovery area cough pain 0 h	4.0 (2.0–7.0 [0.0–10.0])	2.0 (0.0–7.0 [0.0–10.0])	
Recovery area rest pain 1 h	3.3 (2.1)	3.1 (2.4)	
Recovery area cough pain 1 h	4.5 (2.0)	4.4 (2.6)	
Recovery area cumulative fentanyl; μg	100.0 (0.0–120.0 [0.0–400.0])	35.0 (0.0–160.0 [0.0–900.0])	0.52
Ward rest pain day 1	2.0 (1.0–4.0 [0.0–7.0])	2.0 (0.0–4.5 [0.0–7.0])	
Ward cough pain day 1	6.0 (5.0–8.0 [1.0–10.0])	6.5 (5.0–8.0 [0.0–10.0])	
Cumulative fentanyl day 1; μg	887.6 (646.5)	901.1 (704.1)	0.93
Ward rest pain day 2	2.0 (1.0–4.0 [0.0–10.0])	2.0 (0.0–3.0 [0.0–7.0])	
Ward cough pain day 2	6.0 (4.0–8.0 [0.0–10.0])	5.5 (3.0–7.0 [0.0–10.0])	
Cumulative fentanyl day 2; μg	350.0 (190.0–900.0 [75.0–2240.0])	515.0 (160.0–1210.0 [0.0–4900.0])	0.73
Total fentanyl; μg	1195.0 (825.0–1840.0 [285.0–6240.0])	1372.5 (692.5–2580.0 [170.0–8880.0])	0.91
Likert score day 2	2.2 (0.5)	1.8 (0.6)	0.006
Likert score day 30	2.3 (0.8)	1.8 (0.7)	0.004

PPC, pre-peritoneal catheter; TQL, transmuscular quadratus lumborum.

Table 3 Complications.

	PPC n = 41	TQL n = 40
Ileus	12	7
Nausea	10	11
Failed block	0	1
Catheter leak	Left (1) right (1)	Left (2)
Hypotension	2	2
Weakness in right leg (temporary)	0	1
Aspiration pneumonia	2	1
Tachycardia	2	2

PPC, pre-peritoneal catheter; TQL, transmuscular quadratus lumborum.

Discussion

The TQL block provided a small but significant reduction in pain scores at rest, both in the recovery area and on postoperative days 1 and 2 on the ward, compared with the PPC group. Although pain scores on coughing may be a more important patient outcome than rest pain relief, these were similar in both groups.

One possible reason for better analgesia at rest in the immediate postoperative period with TQL block may be the quicker onset with bolus injection and intra-operative opioid effect. Although improvement in dynamic pain scores is vital for recovery of respiratory function, the small reduction in rest pain in the TQL group compared with the PPC group would also have offered a clinical benefit. Both somatic and visceral analgesia may be achieved by TQL and PPC, which may reflect the modest amount of rescue analgesia used. Sympathetic effects such as hypotension were mild, and the frequency of this outcome and ileus was similar between the groups. We did not observe a profound sympathetic effect, implying that the visceral component was probably spared. The moderate–high frequency of ileus (29% with PPC, 18% with TQL) is difficult to explain, as both groups were comparable with regard to rescue opioid used. It is likely, therefore, that local anaesthetic agents injected through a catheter into the pre-peritoneal space are able to act locally to block nociceptive afferents of the fascia of the abdominal muscles and the peritoneum. Both the fascia of the abdominal muscles and peritoneum are injured during laparotomy and contribute to postoperative pain and primary mechanical hyperalgesia [19, 20]. The mechanism of action for TQL is local anaesthetic spread to the paravertebral space. Even though a cadaveric study reported dye spread to the thoracic paravertebral space and sympathetic chain, we did not observe any profound clinical effects related to this effect, such as exaggerated hypotension [21]. However, the dermatomal cover observed from T4 to L1 in the immediate postoperative period may indicate the possibility of the local anaesthetic reaching the paravertebral space and blocking the dorsal and ventral rami. Only one patient had right leg weakness; this was temporary, and it was difficult to ascertain whether it was block-related or procedure-related due to prolonged positioning in lithotomy. Even though no demonstrable

dermatomal spread was evident in 50% of patients, they were comfortable, as evidenced by lower resting pain scores and opioid use.

Pre-peritoneal catheter was more cost-effective in relation to consumables and medical assistance requirements. It was also technically more simple and easier to perform without requirement for ultrasound. The time taken from needle to catheter insertion was similar in both groups. Previous PPC practice included pre-peritoneal bolus and wound infiltration; in the PPC group this was modified to use an additional precise local anaesthetic bolus into the sub-fascial layers, followed by continuous infusion. This minor change could be incorporated into our routine practice.

There were several limitations of our trial. It was conducted in a single centre, was single-blind and our costings and current practice of PPC catheter insertion may not be applicable in other settings. Our optimistic postulate of a 40% mean decrease in pain score may have resulted in a type-2 (false negative) error. Within the constraints of a postoperative analgesia study involving catheter intervention, attempts were made to reduce bias as much as possible. Allocation concealment was ensured by only assigning computer-generated group allocation after induction of the patient in the operating theatre. Given the different catheter positions between the groups, patient blinding existed only until arrival on the ward, as it was considered undesirable to place sham catheters. The proceduralist could obviously not be blinded. The acute pain team who assessed pain scores on the ward also could not be blinded, as it would not be possible to perform catheter assessment and care otherwise. Except for the two catheter techniques, postoperative care and analgesia were standardised between the groups to reduce performance bias. We also ensured that statistical analysis was blinded to group allocation. Although we could not disprove our null hypothesis, true to academic principles we still pursued publication of this paper and thus helped to reduce reporting bias.

In conclusion, this prospective, single-centre, randomised, open-label study revealed a slight analgesic benefit (at rest) in the TQL group in the immediate postoperative period compared with the PPC group. Both techniques were similar in terms of pain scores when coughing and rescue opioid requirement. No difference in complications was observed between the two techniques. In the TQL group, the highest and lowest block observed was T4 and L1, respectively (in the recovery area). Considering the invasiveness and expertise required for the TQL block, the PPC technique may be a cost-effective and viable alternative for postoperative pain management after abdominal surgery.

Acknowledgements

This study was partially funded by the Australian and New Zealand College of Anaesthetists Research Foundation (N18/002). Clinical trial registry: Australian and New Zealand Clinical Trial Registry (ANZCTR: 12616000915459. 09/08/2016). No competing interest declared.

References

1. Petersen PL, Mathiesen O, Torup H, Dahl JB. The transversus abdominis plane block: a valuable option for postoperative analgesia? A topical review. *Acta Anaesthesiologica Scandinavica* 2010; **54**: 529–35.
2. Brady RR, Ventham NT, Roberts DM, Graham C, Daniel T. Open transversus abdominis plane block and analgesic requirements in patients following right hemicolectomy. *Annals of the Royal College of Surgeons of England* 2012; **94**: 327–30.
3. Børglum J, Maschmann C, Belhage B, Jensen K. Ultrasound-guided bilateral dual transversus abdominis plane block: a new four-point approach. *Acta Anaesthesiologica Scandinavica* 2011; **55**: 658–63.
4. Gasanova I, Alexander J, Ogunnaike B, et al. Transversus abdominis plane block versus surgical site infiltration for pain management after open total abdominal hysterectomy. *Anesthesia and Analgesia* 2015; **121**: 1383–8.
5. Ozer A, Yilmazlar A, Ozturk E, Yilmazlar T. Preperitoneal catheter analgesia is an effective method for pain management after colorectal surgery: the results of 100 consecutive patients. *Local and Regional Anesthesia* 2014; **7**: 53–7.
6. Fustran N, Dalmau A, Ferreres E, et al. Postoperative analgesia with continuous wound infusion of local anaesthesia vs saline: a double-blind randomised, controlled trial in colorectal surgery. *Colorectal Disease* 2015; **17**: 342–50.
7. Bertoglio S, Fabiani F, Negri PD, et al. The postoperative analgesic efficacy of preperitoneal continuous wound infusion compared to epidural continuous infusion with local anesthetics after colorectal cancer surgery: a randomised controlled multicenter study. *Anesthesia and Analgesia* 2012; **115**: 1442–50.
8. Beaussier M, El'Ayoubi H, Schiffer E, et al. Continuous preperitoneal infusion of ropivacaine provides effective analgesia and accelerates recovery after colorectal surgery: a randomised, double-blind, placebo-controlled study. *Anesthesiology* 2007; **107**: 461–8.
9. Krishnan S, Morris RG, Hewett PJ, et al. A randomised double-blind clinical trial of a continuous 96-hour levobupivacaine infiltration after open or laparoscopic colorectal surgery for postoperative pain management–including clinically important changes in protein binding. *Therapeutic Drug Monitoring* 2014; **36**: 202–10.
10. Börglum J, Moriggl B, Lonnqvist PA, Christensen AF, Sauter A, Bendtsen AF. Ultrasound-guided transmuscular quadratus lumborum blockade. *British Journal of Anaesthesia* 2013; **111**. https://doi.org/10.1093/bja/el_9919
11. Baidya DK, Maitra S, Arora MK, Agarwal A. Quadratus lumborum block: an effective method of perioperative analgesia in children undergoing pyeloplasty. *Journal of Clinical Anesthesia* 2015; **27**: 694–6.
12. Warusawitharana C, Basar SHMA, Jackson BL, Niraj G. Ultrasound guided continuous transmuscular quadratus

lumborum analgesia for open renal surgery: a case series. *Journal of Clinical Anesthesia* 2017; **42**: 100–1.
13. Corso RM, Piraccini E, Sorbello M, Bellantonio D, Tedesco M. The ultrasound-guided transmuscular quadratus lumborum block for perioperative analgesia in open nephrectomy: a case report. *Minerva Anestesiologica* 2017; **83**: 1334–5.
14. Mænchen NHC, Dam M, Børglum J. Ultrasound-guided transmuscular quadratus lumborum (TQL) block for pain management after caesarean section. *International Journal of Anesthetics and Anesthesiology* 2016; **3**: 1–3.
15. Ryan P. Allocation of treatments in controlled trials using random permuted blocks. *Stata Technical Bulletin* 2000; **54**: 49–3.
16. Mallinckrod CH, Lane PW, Schnell D, Peng Y, Mancuso JP. Recommendations for the primary analysis of continuous endpoints in longitudinal clinical trials. *Therapeutic Innovation and Regulatory Science* 2008; **42**: 303–19.
17. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. *Stata Journal* 2012; **12**: 308–31.
18. Kadam VR, Moran J. Epidural infusions versus transversus abdominis plane (TAP) block infusions: retrospective study. *Journal of Anesthesia* 2011; **25**: 786–7.
19. Ventham NT, O'Neill S, Johns N, Brady RR, Fearon KC. Evaluation of novel local anesthetic wound infiltration techniques for postoperative pain following colorectal resection surgery: a mota-analysis. *Diseases of the Colon and Rectum* 2014; **57**: 237–50.
20. Zahn PK, Brennan TJ. Incision-induced changes in receptive field properties of rat dorsal horn neurons. *Anesthesiology* 1999; **91**: 772–85.
21. Dam M, Moriggl B, Hansen CK, Hoermann R, Bendtsen TF, Børglum J. The pathway of injectate spread with the transmuscular quadratus lumborumblock: a cadaver study. *Anesthesia and Analgesia* 2017; **125**: 303–12.

Clinical Communication

Incidence of acute kidney injury during the perioperative period in the colorectal division of surgery - Retrospective study

INTRODUCTION AND BACKGROUND

Acute kidney injury (AKI) commonly occurs following cardiac surgery but is also seen in colorectal surgeries.[1] This may have a detrimental impact on cost, duration of hospital stay and mortality. Kidney disease improving global outcomes (KDIGO) defines AKI by an absolute increase in creatinine, ≥0.3 mg/dL within 48 h or by a 50% increase in creatinine from a baseline within 7 days, or a urine volume <0.5 mL/kg/h minimum duration of 6 hours.[1]There have been several studies on AKI during the hospital stay in major abdominal surgery.[2-4] However, studies on AKI developed after colorectal surgery are limited.[5-7] The incidence is 4.8-11.8%.[6]

This study aims to assess the kidney function from preoperative to postoperative period. In addition, it also evaluates the incidence and risk factors of AKI in the first 7 days after surgery in a cohort of patients undergoing major colorectal surgery. Notable secondary outcomes include hypotension and reduced urinary output in the post-anaesthetic care unit (PACU), medical complications in hospital, in-hospital mortality and time until discharge.

METHODS

Ethics approval was obtained from Central Adelaide Local Health Network Human Research Ethics Committee (Ref no HREC/18/CALHN/510). This retrospective single centre study involved all open/laparoscopic colorectal procedures performed at The Queen Elizabeth Hospital from June 2016 to June 2018. The biochemical and patient data were collected from the hospital electronic system during this period.

The patients who were enrolled in this study were the patients who had general anaesthesia with propofol, fentanyl and rocuronium with endotracheal intubation. They were aged 18 years and above undergoing elective/emergency or laparoscopic/open procedures. Patients with no renal parameters, chronic kidney disease, transplanted kidney, renal replacement therapy, multiple surgeries in the same admission were excluded.

AKI was defined as having a post-op to pre-op creatinine ratio ≥1.5 or a glomerular filtration rate (GFR) ≤0.8 on either Day 1 or Day 7 postoperatively.

Medical complications were defined as cardiopulmonary compromise during hospital stay requiring intensive care unit (ICU) admission.

Statistical analysis plan

Sample size analysis was not performed at commencement of study.

A Table 1 was constructed with descriptive statistics as appropriate.

Univariate binary logistic regressions were performed for AKI at Day 1 or Day 7 vs various potential predictors. Those potential predictors with P value <0.2 were included in an initial multivariable model, and backwards elimination was performed until all P values were less than 0.05.

Patient characteristics	Frequency (%)
Age (yrs), mean (SD)	56.8 (19.7)
Female	395 (52.4)
Weight (Kgs), mean (SD)	78.2 (20.6)
Comorbidities	
Hypertension	251 (33.3)
Diabetes	117 (15.5)
IHD	55 (7.3)
Hypercholesterolemia	90 (11.9)
Hyperlipidaemia	31 (4.1)
COPD	41 (5.4)
GORD	137 (18.2)
Heart failure	9 (1.2)
ASA category	
1	140 (18.6)
2	303 (40.3)
3	261 (34.7)
4	46 (6.1)
5	2 (0.3)
Pre-existing kidney disease	123 (16.6)
Operation type	
Laparoscopy	410 (54.4)
Laparotomy	339 (45.0)
Lap to Laparotomy	5 (0.7)
Operation elective/emergency	
Elective	492 (65.3)
Emergency	262 (34.8)

Cross tabulations were then performed for AKI vs operation variables, with associated Fisher's exact tests or Chi square tests.

The statistical software used was SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Out of 779 patients 25 did not satisfy the inclusion criteria. Descriptive statistics of patient demographics and perioperative variables are demonstrated in Tables 1 and 2. The incidence of AKI in our retrospective study was 6.9%.

Table 1: Descriptive statistics of perioperative variables (N=754)

Clinical parameters	Frequency (%)
Preop creatinine, Median (IQR*)	75 (63, 90)
Postop D1 creatinine, Median (IQR)	70 (55, 88)
Postop D7 creatinine, Median (IQR)	68 (53, 87)
Preop GFR, Median (IQR)	88 (70, 90)
Postop D1 GFR, Median (IQR)	90 (70, 90)
Postop D7 GFR, Median (IQR)	90 (70, 90)
Acquired kidney injury	52 (6.9)
Intraoperative variables	
Intraoperative hypotension	331 (43.9)
Vasoactive drug use	438 (58.1)
Bloods used	41 (5.4)
Intraop urine output (ml), Median (IQR)	245 (140, 550)
Intraop urine output (ml), adequate	208 (81.3)
Intraop urine output (ml), low	48 (18.8)
Fluids used	
Colloid	3 (0.4)
Crystalloid	598 (79.7)
Crystalloid and colloid	148 (19.7)
None	1 (0.1)
Volume of fluid used (Litre)	
0	6 (0.8)
1	357 (47.4)
2	220 (29.2)
3	114 (15.1)
4	27 (3.6)
5	14 (1.9)
6	7 (0.9)
7	5 (0.7)
8	1 (0.1)
9	3 (0.4)
Volume of albumin used, Median (IQR)	1000 (500, 1000)
PACU hypotension	48 (6.4)
PACU decreased urine output	33 (4.4)
Duration of surgery in minutes, Median (IQR)	157 (97, 239)
Postoperative complications	253 (33.6)
Medical complications	269 (38.3)
In -hospital mortality	22 (2.9)
Discharge time in days, Median (IQR)	6 (2, 11)

*IQR=Interquartile range; PACU=Post anaesthesia care unit; GFR=glomerular filtration rate

Odds ratios (OR), 95% CI, comparison and *P* values are presented in Table 3. The final multivariable binary logistic regression model is presented in Table 4. There is a significant association between AKI at Day 1 or Day7 and ASA category, adjusting for PACU decreased urine output (*P* value <0.0001). For every one unit increase in ASA category, the odds of developing AKI are multiplied by 2.7 (OR = 2.7, 95% CI: 1.8, 4.0). If the patient has decreased urine output in PACU, their odds of developing AKI are 2.7 times that of patients with adequate urine output (OR = 2.7, 95% CI: 1.1, 6.5).

There is a significant association between AKI and diabetes (*P* = 0.0120). Similarly, this was also observed between AKI and hypertension (*P* = 0.0200).

Patients with diabetes and hypertension were almost twice more likely to develop an AKI as compared to non-diabetics and non-hypertensives with occurrence of AKI being (15% vs 7.4%) and (12.1% vs 6.6%), respectively.

The 30-day mortality rate in patients with associated AKI was 7.7% compared with 2.2% in patients with no AKI. The median discharge time was found to be 3 days longer in patients with AKI (Median Interquartile range (IQR)) = 10 (5, 19.5) for patients with AKI and 7 (4,12) for patients without AKI).

DISCUSSION

This retrospective study showed significant association between AKI at Day 1 or Day7 and PACU decreased urine output. AKI is associated with medical morbidity and mortality, prolonged hospital stay, and higher hospital costs.[6]

Hypertension was deemed a major risk factor evidential by the Kheterpal study.[3]Thirty-day mortality after colorectal cancer (CRC) surgery ranged from 6.7% to 42%.[3,6] In our database, the 30-day patient mortality was 7.7% with AKI vs with 2.2% with no AKI. There was no difference in incidence of AKI in patients with heart failure, ischemic heart disease, hypercholesterolemia, chronic pulmonary airway disease or reflux disorders.

The incidence of AKI in our study was 6.9% as compared with 11.9% reported by Causey *et al.*[5] Although there is difference in the rate of AKI in elective surgery (3.38%), emergency surgery (12.99%) was

Table 3: Univariate binary logistic regression results for AKI at 1 Day or 7 Days vs various predictors

Predictor	Comparison	Odds Ratio (95% CI)*	Comparison *P* value	Global *P*
Pre-existing kidney disease	Yes vs No	1.41 (0.72, 2.73)		0.3128
Sex	Males vs Females	1.02 (0.58, 1.81)		0.9381
Hypertension	Yes vs No	1.95 (1.10, 3.46)		0.0218
Diabetes	Yes vs No	2.21 (1.18, 4.15)		0.0138
IHD	Yes vs No	1.81 (0.77, 4.25)		0.1743
Hypercholesterolemia	Yes vs No	1.39 (0.65, 2.98)		0.3946
Hyperlipidaemia	Yes vs No	0.87 (0.20, 3.77)		0.8468
COPD	Yes vs No	2.48 (1.04, 5.95)		0.0410
GORD	Yes vs No	0.97 (0.47, 2.00)		0.9344
Heart failure	Yes vs No	5.48 (1.33, 22.59)		0.0186
Operation type	Laparotomy vs Laparoscopy	2.09 (1.12, 3.90)		0.0205
Elective emergency	Emergency vs Elective	1.20 (0.66, 2.21)		0.5482
Intraop urine output	Low vs Adequate	0.95 (0.31, 2.95)		0.9330
Intraop hypotension_	Yes vs No	1.48 (0.83, 2.62)		0.1814
Vasoactive drug use	Yes vs No	2.30 (1.13, 4.68)		0.0220
Fluids used	Colloid vs Crystalloid/Colloid	3.82 (0.33, 44.45)	0.2839	0.1243
	Colloid vs Crystalloid	6.20 (0.55, 70.15)	0.1407	
	Crystalloid/Colloid vs Crystalloid	1.62 (0.87, 3.01)	0.1254	
Bloods used	Yes vs. No	1.17 (0.40, 3.44)		0.7703
PACU hypotension	Yes vs. No	2.35 (1.03, 5.34)		0.0413
PACU decreased urine	Yes vs. No	3.93 (1.67, 9.27)		0.0017
Postoperative complications	Yes vs No	2.38 (1.33, 4.25)		0.0034
Medical complication	Yes vs No	2.56 (1.40, 4.68)		0.0023
In-hospital mortality	Yes vs No	7.41 (2.92, 18.84)		<.0001
Age		1.04 (1.02, 1.06)		0.0003
Weight		1.00 (0.98, 1.01)		0.8549
ASA category		2.84 (1.92, 4.22)		<.0001
Duration of surgery		1.00 (1.00, 1.00)		0.5871
Duration of anaesthesia		1.00 (1.00, 1.00)		0.5470
Volume fluid used		1.11 (0.91, 1.36)		0.2847
Intraop urine output		1.00 (1.00, 1.00)		0.6794
Volume albumin used_		1.00 (1.00, 1.00)		0.1111
Discharge time		1.04 (1.02, 1.07)		0.0015

*Modelling the probability that AKI = "Yes"

Table 4: Final multivariable binary logistic model of AKI at Day 1 or Day 7 vs significant predictors

Predictor	Comparison	Odds ratio (95% CI)	Global *P*
ASA category (continuous)		2.71 (1.82, 4.03)	<.0001
PACU decreased urine output	Yes vs. No	2.65 (1.08, 6.50)	0.0334

ASA=American Society of Anesthesiologists; PACU=Post anaesthesia Care Unit

associated with 3.8 times higher rate of AKI.[5] We did not find any difference in rates of AKI in elective vs emergency surgery.

Prolonged duration of surgery together with vasopressors use can potentially affect renal blood flow, however there was no increase in the AKI rates in longer surgeries or with the use of vasopressors in our study. Preoperative dehydration is associated with increased rates of postoperative AKI.[9]The preoperative use of concentrated glucose solutions in these patients has been reported to decrease postoperative complications in colorectal surgery.[9]Solanki *et al.* guidelines recommend the use of balanced salt solutions or albumin with the goal of adequate urine output for patients undergoing cytoreductive surgery.[10] Our study has not shown a difference in incidence of AKI based on the amount and type of fluids used; however, our study was retrospective with no strict protocol on liberal or restrictive use of fluids. Myles *et al.* reported that the restrictive fluids regimen was associated with a higher rate of AKI.[11]

The pathogenesis of postoperative AKI is complex and is affected by patient, anaesthetic and surgical factors. Patients with mechanical ventilation can constitute an additional mechanism for increased fluid loss. Surgery increases catabolic hormones and cytokines, leading to increased antidiuretic hormone secretion, which results in water retention, impairing fluid electrolyte homeostasis.[12] Patients on long-term ACE inhibitor

therapy are at a higher risk of developing post-operative renal dysfunction due to the loss of ability of the renin–angiotensin system to compensate for the decrease in renal perfusion.[12] Though renal blood flow may be decreased during pneumo-peritoneum, in our study there was no difference between laparoscopic and laparotomy incidence of AKI.

LIMITATIONS

Owing to this being a retrospective study, there are many confounding factors such as the lack of data on antibiotic usage, NSAIDs and contrast during inpatient stay. Future research on this topic should be encouraged to consolidate the data on AKI and to find ways to improve outcomes in this patient population.

CONCLUSION

Patients undergoing colorectal surgery are at significant risk of developing AKI in the immediate postoperative period. The presence of medical complications is associated with AKI, including in-hospital mortality. Hence, monitoring during the intraoperative and immediate postoperative period to detect early signs of renal insufficiency is recommended.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

Vasanth Rao Kadam, Vincent Loo[1], Suzanne Edwards[2], Peter Hewett[3]

Acute Care Medicine, The University of Adelaide, [1]School of Medicine, The University of Adelaide, [2]School of Public Health, The University of Adelaide, [3]Colorectal division The University of Adelaide, Adelaide, SA, Australia

Address for correspondence:
Dr. Vasanth Rao Kadam,
Department of Anaesthesia, TQEH, 28 Woodville Rd, Woodville, SA5011, Australia.
E-mail: vasanth.rao@sa.gov.au

Submitted: 20-Mar-2020
Revised: 02-Jun-2020
Accepted: 15-Aug-2020
Published: 01-Oct-2020

REFERENCES

1. Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Work Group. KDIGO clinical practice guideline for acute kidney injury. Kidney IntSuppl 2012;2:S1-138.
2. Abelha FJ, Botelho M, Fernandes V, Barros H. Determinants of post-operative acute kidney injury.Crit Care 2009;13:R79.
3. Kheterpal S, Tremper KK, Heung M, Rosenberg AL, Englesbe M, Shanks AM, *et al.* Development and validation of an acute kidney injury risk index for patients undergoing general surgery: Results from a national data set. Anesthesiology 2009;110:505-15.
4. Cho A, Lee J, Kwon G, Huh W, Lee HM, Kim YG, *et al.* Post-operative acute kidney injury in patients with renal cell carcinoma is a potent risk factor for new-onset chronic kidney disease after radical nephrectomy. Nephrol Dial Transplant 2011;26:3496-501.
5. Causey MW, Maykel JA, Hatch Q, Miller S, Steele SR. Identifying risk factors for renal failure and myocardial infarction following colorectal surgery. J Surg Res 2011;170:32-7.
6. Masoomi H, Carmichael JC, Dolich M, Mills S, Ketana N, Pigazzi A, *et al.* Predictive factors of acute renal failure in colon and rectal surgery. Am Surg 2012;78:1019-23.
7. Balakrishnan KP, Survesan S. Anaesthetic management and perioperative outcomes of cytoreductive surgery with hyperthermic intraperitoneal chemotherapy: A retrospective analysis. Indian J Anaesth 2018;62:188-96.
8. Morris EJ, Taylor EF, Thomas JD, Quirke P, Finan PJ, Coleman MP, *et al.* Thirty-day postoperative mortality after colorectal cancer surgery in England. Gut 2011;60:806-13.
9. Moghadamyeghaneh Z, Phelan MJ, Carmichael JC, Mills SD, Pigazzi A, Nguyen NT, *et al.* Preoperative dehydration increases risk of postoperative acute renal failure in colon and rectal surgery. J Gastrointest Surg 2014;18:2178-85.
10. Solanki SL, Mukherjee S, Agarwal V, Thota RS, Balakrishnan K, Shah SB, *et al.* Society of on coanaesthesia and perioperative care consensus guidelines for perioperative management of patients for cyto reductive surgery and hyperthermicintraperitoneal chemotherapy (CRS-HIPEC). Indian J Anaesth 2019;63:972-87.
11. Myles PS, Bellomo R, Corcoran T, Forbes A, Peyton P, Story D, *et al.* Restrictive versus liberal fluid therapy for major abdominal surgery. N Engl J Med 2018;378:2263-74.
12. Sear J. Kidney dysfunction in the postoperative period. Br J Anaesth 2005;95:20-32.

Access this article online

Quick response code

Website: www.ijaweb.org

DOI: 10.4103/ija.IJA_276_20

How to cite this article: Rao Kadam V, Loo V, Edwards S, Hewett P. Incidence of acute kidney injury during the perioperative period in the colorectal division of surgery - Retrospective study. Indian J Anaesth 2020;64:894-7.

Rao Kadam et al. BMC Anesthesiol (2021) 21:255
https://doi.org/10.1186/s12871-021-01474-8

BMC Anesthesiology

RESEARCH ARTICLE

A comparison of ultrasound guided bilateral single injection shot Erector Spinae Plane blocks versus wound infiltration for post-operative analgesia in laparoscopic assisted colonic surgery- a prospective randomised study

V. Rao Kadam[1,2*], G. Ludbrook[3], R. M. van Wijk[1,2], P. Hewett[4], V. Thiruvenkatarajan[1,2], S. Edwards[5], P. Williams[1] and S. Adhikary[6]

Abstract

Background: Both wound infiltration (WI) with local anaesthetic and Erector Spinae Plane block (ESPB) have been described for post-operative analgesia after abdominal surgery. This study compared the efficacy of WI versus ESPB for post-operative analgesia after laparoscopic assisted colonic surgery.

Methods: Seventy-two patients between 18 and 85 years of age undergoing elective surgery were randomised to receive either WI or ESPB. In the WI group a 40 ml bolus of 0.5% Ropivacaine, infiltrated at the ports and minimally invasive wound at subcutaneous and fascia layers. In the ESPB group at T8 level, under ultrasound guidance, a 22-gauge nerve block needle was passed through the Erector Spinae muscle to reach its fascia. A dose up to 40 ml of 0.5% Ropivacaine, divided into two equal volumes, was injected at each side. Both groups had a multimodal analgesic regime, including regular Paracetamol, dexamethasone and patient-controlled analgesia (PCA) with Fentanyl. The primary end point was a post-operative pain score utilising a verbal Numerical Rating Score (NRS, 0–10) on rest and coughing in the post anaesthetic care unit (PACU) and in the first 24 h. Secondary outcomes measured were: opioid usage, length of stay and any clinical adverse events.

Results: There was no significant treatment difference in PACU NRS at rest and coughing (*p*-values 0. 382 and 0.595respectively). Similarly, there were no significant differences in first 24 h NRS at rest and coughing (*p*-values 0.285 and 0.431 respectively). There was no significant difference in Fentanyl use in PACU or in the first 24 h (*p*- values 0.900 and 0.783 respectively). Neither was there a significant difference found in mean total Fentanyl use between ESPB and WI groups (*p*-value 0.787).

Conclusion: Our observations found both interventions had an overall similar efficacy.

Trial registration: The study was registered with the Australian New Zealand Clinical Trial Registry (ACTRN: 12619 000113156).

*Correspondence: Vasanth.rao@sa.gov.au
[2] Department of Anaesthesia, The Queen Elizabeth Hospital, 28 Woodville Road, Woodville South, SA 5011, Australia
Full list of author information is available at the end of the article

Keywords: Ultrasound, Erector Spinae Plane, Post-operative analgesia, Local anaesthetic

Background

The Erector Spinae Plane block (ESPB) was first described by Forero, in 2016 [1]. Initially, the block was performed for thoracic and breast surgery and its use has now been reported for abdominal surgery [2–4]. This block has gained popularity in the last 5 years, as one of the options for post-operative pain relief after abdominal surgery [2–4]. Both single bolus injection and catheter technique have proven to be beneficial as part of multimodal analgesia in surgeries involving the thorax and abdomen [5–8]. The technique involves injecting local anaesthetic (LA) into the myofascial plane beneath the fascia covering the Erector Spinae muscle using real time ultrasound guidance. This approach is gaining popularity mainly due to its simplicity in performance. It is relatively easy to visualise the para spinal muscles at the mid thoracic about 3 cm lateral to the midline. Clinical trials reported to be effective in use of ESPB in laparoscopic cholecystectomy [9–11] but not in laparoscopic colonic surgery.

The purpose of this study was to assess the efficacy of single injection ESPB performed for post-operative analgesia in laparoscopic assisted colonic surgery. Efficiency was assessed by comparing pain scores. We hypothesized that ultrasound guided ESPB is superior to wound infiltration performed at the end of surgery in providing pain relief without major side effects.

Methods

The study was conducted at The Queen Elizabeth Hospital (TQEH), part of Central Adelaide Local Health Network (CALHN) between January 2019 and September 2020. The study was registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12619000113156 date 24/01/2019). Institutional Human Ethics and Research Committee (HREC/18/CALHN/456) approval was obtained and all patients provided prior informed consent for their participation in the study.

The primary end point was post-operative pain score utilising a verbal Numerical Rating Score (NRS, 0–10) on rest and coughing in PACU and during the first 24 h (worst NRS on rest and coughing). Secondary outcomes measured were opioid usage until 24 h post-operatively, length of stay (days) and clinical determinants of adverse effects.

Patients with an American Society of Anesthesiologists Physical Status 1–3, greater than 18 years of age, and undergoing elective laparoscopic colonic surgery, were recruited for the study to receive either ESPB or WI at the end of surgery and before extubation. Patients were excluded if they had communication barriers, sensitivity or allergy to local anaesthetics, were pregnant, had a pre-operative daily use of opioids equivalent to 10 mg/day of morphine or above or if the procedure could not be performed laparoscopically. The study was designed with the groups randomised to the intervention allocation based on a computer-generated sequence.

All patients received a standardized general anaesthetic technique and monitoring. They were administered intermittent intravenous fentanyl as intra-operative opioid analgesia. At the end of procedure, before extubation, an ESPB was performed by an experienced anaesthetist or the WI was performed by the surgical fellow/consultant.

An in-plane approach in the lateral position was used under ultrasound guidance for the ESPB. T8 level was confirmed by counting the spinous process from T1 down to T8. Using a 6- to 15-MHz high-frequency linear probe (Sonosite X-Porte, SonoSite Inc, Bothell, WA, USA), the 2 muscle layers of the posterior spine anatomy, namely trapezius and erector spinae (ES) muscles, were visualized slightly cephalad to the T8 transverse process. The 22-gauge stimuplex (Pajunk, Geisingen, Germany) nerve block needle tip was placed deep to the ES muscle, beneath the fascia in a cephalad to caudal direction. Needle position was confirmed by a 3 ml normal saline test dose under ultrasound guidance to observe linear spread lifting the ES muscle. Ropivacaine (AstraZeneca Pty Ltd., Sydney, NSW, Australia) dissemination was confirmed lifting the ES muscle in real time under ultrasound guidance from start to completion of injection. A dose of 40 ml of 0.5% Ropivacaine (200 mg), divided into two equal volumes, was injected at each side. In the WI group 40 ml of 0.5% Ropivacaine was injected at the surgical ports and into the minimally invasive wound. In the PACU and subsequently in the wards for 24 h (time from PACU), patients were observed and questioned for signs and symptoms of local anaesthetic systemic toxicity (LAST), such as perioral numbness, tingling sensation, tinnitus, metallic taste, muscle twitching, and convulsions. Sensory block was assessed by recovery staff after surgery in PACU using a cold test on either side of the anterior abdomen between xiphi-sternum and pubic symphysis (dermatomes T6-L1).

All patients had a pre-operative ECG and a repeat ECG was to be performed if any signs and symptoms of LA toxicity were observed. Patients were administered Paracetamol 1 g QID (orally or IV) and received a single

dose of Dexamethasone 8 mg intra-operatively as part of a multimodal analgesic approach. A Fentanyl PCA device (bolus 10 to 40 mcg based on age; lockout time 5 min; no background infusion) was provided as rescue analgesia. The difference in PCA usage was used as an indication of efficacy of the analgesic techniques. The primary endpoints measured were NRS for Pain at rest and on coughing in PACU at 0 and I hour and in the post-operative ward at 24 h. Other end points were Fentanyl use in PACU and first 24 h, any rescue medication used, procedure related technical issues, potential side effects or complications in relation to the technique used and length of stay (days). Data was entered in excel by the research assistant at the trial centre, who has blinded the statistician for group allocation.

Statistical analysis

Continuous measures are presented as means with standard deviations and medians with interquartile ranges, based on the normality of their distribution. Categorical measures are presented as frequencies and percentages. Group comparisons on baseline characteristics were assessed using Student's T-test, a Wilcoxon Rank Sum test, Pearson's Chi-square statistic or Fisher's Exact Test as required, and linear mixed-effects models were used to compare pain and fentanyl use between ESP and WI groups, across time periods, adjusting for repeated measurements over time. Linear regressions were also used for two fentanyl outcomes. All tests are two-tailed and assessed at the 5% alpha-level. The statistical software used was SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

Sample size

As RCTs for the use of ESP blocks in laparoscopic colonic surgery have not been published, an approximate scenario was established to obtain the required patient numbers. Calculations were based on the primary outcome (pain scores) and it was determined that a clinically meaningful difference between groups would be 2.5 points on the NRS. Assuming constant variance and a standard deviation of 3 points, a sample of 24 patients per group was required. The sample was inflated to 36 patients per group to account for intra-patient correlations arising from repeated measures. Thus, a total of 72 patients were required.

Randomisation

The randomisation schedule was generated by the Clinical Trials Division of the Pharmacy Department at The Queen Elizabeth Hospital. To ensure equal distribution

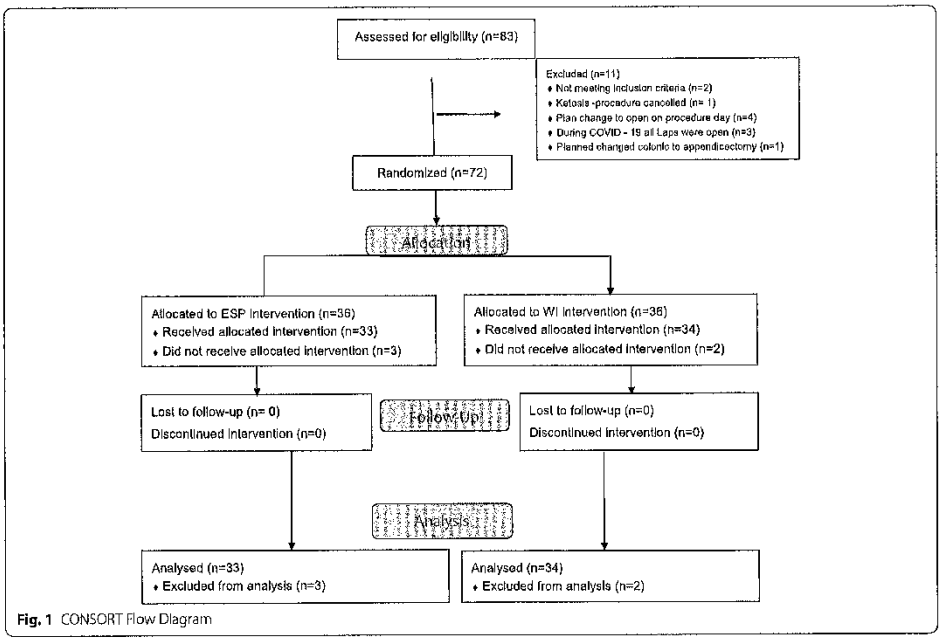


Fig. 1 CONSORT Flow Diagram

of the intervention arm, randomisation was done in specific blocks to pre-determined numbers known only to the clinical trials division. A simple randomisation table was created by computer software (computerised sequence generation). This allocation was concealed by a sealed opaque envelope. The proceduralist was unable to be blinded; however, the patients were blinded to group allocation. The person analysing the data was also blinded.

Results

Seventy-two patients were recruited. Five patients did not complete the study and 67 were included in the analysis. These five patients excluded from analysis had a breach of protocol and none were lost to follow up (see Consort flow diagram Fig. 1). Table 1 shows the patient demographics in each group. Wound infiltration time was significantly lower than ESPB ($p = < 0.01$), otherwise both the groups were comparable with respect to pre-operative status and operative specifications are shown in Table 1. No block related complications, such as vascular/visceral puncture or local anaesthetic toxicity were recorded. None of the patients had well defined dermatomal spread in the ESPB group in PACU. Only one patient had patchy spread. Table 2 shows the pain scores and fentanyl use with mean and standard deviation by technique and time period, mean differences, 95% confidence intervals (CI) and comparison and global *P* values. There were no significant differences between the groups on intra-operative fentanyl use or total fentanyl use. There were also no significant differences between the groups for rest or cough pain scores or cumulative fentanyl use in PACU or on day one (refer to Table 2). The mean differences between ESP and WI groups for rest and cough pain ranged from −0.6 to −0.3 were not significant. Table 3 shows the complications. There was no difference in the complication incidences between the groups. Technically, we did not have any failures but had slight difficulty in three obese participants in the ESPB group requiring 120 mm needles to reach the plane. None of the patients had any sign or symptoms of LAST in the 24- h study period. However, 3 patients developed tachycardia after 48 h which was related to low haemoglobin requiring transfusion and anastomotic leak requiring intervention. One patient developed bradycardia (50/min) in the ESP group at 24 h on the ward, but remained stable. The average theatre time for (LA loading and checking/positioning/setup ultrasound equipment) was 20 min for ESP group compared to 10 min in WI group.

Table 1 Patient demographics and details by technique

	ESPB group $N = 33$	WI group $N = 34$	*P*-value*
Age (years) mean (SD)	60.5 (17.8)	61.2 (13.3)	0.86
Gender			
Female	14 (52%)	13 (48%)	0.73
Male	19 (48%)	21 (52%)	
Weight (kg) mean (SD)	84.3 (14.6)	77.2 (17.5)	0.078
BMI (kg/ht.^2)	29.4 (5.4)	26.8 (5.7)	0.059
ASA status			
1	2 (50%)	2 (50%)	0.85
2	15 (54%)	13 (46%)	
3	16 (46%)	19 (54%)	
Operations			0.95
Hemicolectomy	14 (47%)	16 (53%)	0.70
Anterior resection	10 (50%)	10 (50%)	0.94
Hartmann's	2 (100%)	0 (0%)	0.15
Reversal of Hartmann's	1 (33%)	2 (67%)	0.57
Ultra low anterior resection	2 (50%)	2 (50%)	0.97
Ileocecal resection	1 (100%)	0 (0%)	0.31
Small bowel resection	0 (0%)	2 (100%)	0.16
Others	3 (60%)	2 (40%)	0.62
PACU time (mins) median (IQR)	60 (60, 105)	62 (45, 90)	0.61
Flatus time (mins) median (IQR)	48 (48, 72)	48 (48,72)	0.43
Bowel motion time (mins) median (IQR)	77 (72, 96)	72 (60, 120)	0.84
Hospital LOS (days) median (IQR)	5 (4, 7)	4 (4, 8)	0.92

Data are presented as mean (SD) or median (IQR) for continuous measures, and n (%) for categorical measures

ESPB denotes Erector Spinae Plane Block, *WI* denotes wound Infiltration, *PACU* Post anaesthetic care unit, *mins* Minutes, *LOS* Length of stay

*Independent t-test *P* value, Wilcoxon Rank Sum Test *P* value, Chi-Square *P* value or Fisher's Exact Test *P* value as appropriate

Discussion

The main outcome of the study was that we found no treatment- related differences in NRS pain scores at rest and coughing in PACU or day one between the groups. There was no statistically significant difference found in mean total fentanyl use between ESPB and WI groups. There were no differences in adverse events or length of stay between the groups. Though we hypothesised that ultrasound-guided ESP block is superior to wound infiltration in providing superior pain relief, this was not confirmed by our findings.

Technically, we did not have any failures but had slight difficulty in three obese participants in the ESPB group requiring 120 mm needles to reach the plane. Complications related to LAST were not observed. Only one patient in the ESPB group had bradycardia at 24 h on the ward, but remained haemodynamically stable with unremarkable ECG. Tulgar et al. found 3 mild cases of LAST in ESPB patients [12]. However, as stated, the patients in our study did not show any such symptoms. There were two patients in WI group who developed bradycardia, one in the PACU and the other outside the 24 h study period, both with unremarkable ECGs.

Table 2 Results for linear mixed-effects and linear models of pain variables versus interaction of technique and time period, adjusting for repeated measurements over time

Outcome	Interaction/ Predictor	Period - hours	ESPBN = 33 mean (SD)	WIN = 34 mean (SD)	Mean difference[a](95% CI)	Comparison P value	Interaction/ Global P value
Intraoperative fentanyl use	Technique		469.7 (198.4)	491.3 (265.4)	−21.6 (−136.2, 93.0)		0.708
Rest pain	Period*Technique	0	1.6 (2.5)	1.9 (3.1)	−0.3 (−1.5, 0.9)	0.606	0.892
		1	3.3 (2.2)	3.8 (2.4)	−0.5 (−1.7, 0.7)	0.382	
		24	2.4 (2.0)	3.0 (2.2)	−0.6 (−1.8, 0.5)	0.285	
Cough pain	Period*Technique	0	2.3 (3.3)	2.9 (3.5)	−0.6 (−2.0, 0.8)	0.375	0.953
		1	4.4 (2.4)	4.8 (2.8)	−0.4 (−1.7, 1.0)	0.595	
		24	5.3 (2.3)	5.9 (2.5)	−0.5 (−1.9, 0.8)	0.431	
Cumulative Fentanyl use	Period*Technique	1	117.6 (107.8)	104.1 (111.4)	13.5 (−200.0, 226.8)	0.900	0.911
		24	760.3 (682.1)	730.7 (527.3)	29.6 (−183.8, 242.9)	0.783	
Total fentanyl used[b]	Technique		877.9 (731.9)	834.9 (557.0)	43.0 (−273.7, 359.8)		0.787

ESPB denotes Erector Spinae Plane block, *WI* denotes wound infiltration, *PACU* Post anaesthetic care unit, *CI* Confidence Interval

[a] The comparison is ESPB vs WI

[b] Total fentanyl used is the amount used during PACU and day one

We performed ESPB at T8 level, however we did not observe any clinical effects on dermatome sensory distribution on the anterior aspect of the chest. We used 20 ml of 0.5% ropivacaine each side and it is possible that this may be an inadequate volume leading to poor sensory block. The optimal volume may range from 20 to 30 ml [13]. Tulgar et al. in their case series performed ESPB at T8 level for laparoscopic surgeries and reported its analgesic benefits but failed to report sensory block [8]. Similarly Chin et al. performed ESPB at T7 level in four patients undergoing laparoscopic ventral hernia repair and reported reduced pain scores in the first 24 h and oral morphine consumption [5]. They reported dermatome spread from T6 to T12 in one of their patients. In our study, though patients achieved analgesia, we did not observe any dermatomal sensory block. We are unable to explain this finding. Peng et al., described that the ESPB has characteristics of differential blockade [14]. Analgesia without motor block along discernible cutaneous sensory block has been described [14]. A review on dermatomal analysis of case reports revealed variable results of ESPB dermatomal spread [15]. Due to its unpredictable dermatomal spread more clinical trials are required to assess this. A recent narrative review reports that the mechanism of ESPB is from the direct effect of LA via physical spread and diffusion to ESP and adjacent tissue compartments [16, 17]. It also highlights the unpredictability and variability that result from myriad factors [16, 17].

Table 3 Complications

	ESPB N = 33	WI N = 34	Fisher's Exact Test p-value
Ileus	3 (33%)	6 (67%)	0.48
Aspiration Pneumonia	1 (50%)	1 (50%)	1.00
Hypotension	1 (100%)	0 (0%)	0.49
Atelectasis	1 (50%)	1 (50%)	1.00

Data are presented as n (%)

ESPB denotes Erector Spinae Plane block, *WI* denotes wound infiltration

This limited LA spread may be due to the mechanical barrier of the intertransverse ligament, intertransversalis muscle, and/or superior costotransverse ligaments in the thoracic paravertebral space [18]. Only intertransverse and superior costotransverse ligaments are found in the thoracic region posing a possible obstacle [19]. Some authors reported benefits of technical refinements of ESPB such as double injection technique, multiple level injections and injecting near the costotransverse ligament in breast procedures, to improve LA diffusion into the paravertebral space [20–22]. There are no published trials on these new approaches for performing ESPB in abdominal surgery. Future clinical trials on this should be considered. A metanalysis on ESP found reduction in postoperative opioid consumption compared to control [23]. However, this study had significant heterogeneity.

There were a few limitations of our trial: It was conducted in a single centre, was single blinded and practice of WI may not be applicable in other settings. As there were no RCTs, sample size calculation was not possible prior to commencement of this study. We were

optimistic in requiring a 2.5 points difference in pain scores between the groups. Nevertheless, given our findings, even using a minimally clinically important difference (MCID) of only 1 point as suggested by Myles et al. [24] may not have changed our overall outcomes. However, a substantially lower MCID would have made our study with current numbers underpowered. The volume we used (20 ml) may be low, higher volumes may produce more extensive physical spread.

In conclusion, this prospective, single-centre, randomised, open label study revealed that both WI and ESPB techniques were comparable in terms of pain scores and rescue opioid requirement during the first 24 h post-operatively. There were no differences in complications observed between the two techniques. As the ESPB appears to be more invasive, and requires expertise, local anaesthetic wound infiltration remains a more practical and relatively simple technique in laparoscopic colonic surgery.

Abbreviations
WI: Wound Infiltration; ESPB: Erector Spinae Plane Block; PACU: Post anaesthetic care unit; LA: Local anaesthetic; LAST: Local anaesthetic systemic toxicity; NRS: Numerical Rating Score; PCA: Patient controlled analgesia.

Acknowledgements
Not applicable.

Authors' contributions
VRK: Designing, ethics approval work, participant recruitment, obtaining consent, data collection, performing the regional blocks and coordinating the team. GL, RMvW, PH: Designing, supporting the researchers, drafting and editing the manuscript. SE: Statistical analysis drafting and editing the manuscript. VT: Designing the study, participant recruitment, drafting and editing. PW: Electronic data entry, blinding, drafting and editing. SA: Designing, supporting the researchers and drafting and editing the manuscript. The author(s) read and approved the final manuscript.

Funding
Not applicable.

Availability of data and materials
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Institutional Human Ethics and Research Committee (HREC/18/CALHN/456), Central Adelaide Local Health Network approval obtained. Informed consent for participation was obtained from all participants prior to participation in the study.
The research meets ethical and scientific requirements in accordance with the NHMRC and relevant legislative policy and requirements.

Consent for publication
Not applicable.

Competing interests
No Financial disclosures or conflicts of interest.

Author details
[1]Acute Care Medicine, The University of Adelaide, The Queen Elizabeth Hospital, Adelaide, SA, Australia. [2]Department of Anaesthesia, The Queen Elizabeth Hospital, 28 Woodville Road, Woodville South, SA 5011, Australia. [3]Acute Care Medicine, University of Adelaide, Royal Adelaide Hospital, Adelaide, SA, Australia. [4]Department of Surgery, University of Adelaide, The Queen Elizabeth Hospital, Adelaide, SA, Australia. [5]Adelaide Health Technology Assessment, School of Public Health, University of Adelaide, Adelaide, SA, Australia. [6]Department of Anesthesiology and Perioperative Medicine, Penn State Hershey Medical Center, Penn State College of Medicine, Hershey, PA, USA.

Received: 9 February 2021 Accepted: 21 September 2021
Published online: 26 October 2021

References
1. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41(5):621–7.
2. Hamed MA, Goda AS, Basiony MM, Fargaly OS, Abdelhady MA. Erector spinae plane block for postoperative analgesia in patients undergoing total abdominal hysterectomy: a randomized controlled study original study. J Pain Res. 2019;12:1393–8.
3. Hamed MA, Yassin HM, Botros JM, Abdelhady MA. Analgesic efficacy of erector spinae plane block compared with intrathecal morphine after elective cesarean section: a prospective randomized controlled study. J Pain Res. 2020;13:597–604.
4. Ibrahim M, Elnabtity AM. Analgesic efficacy of erector spinae plane block in percutaneous nephrolithotomy: a randomized controlled trial. Anaesthesist. 2019;68(11):755–61.
5. Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of preoperative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. Anaesthesia. 2017;72(4):452–60.
6. Rao Kadam V, Currie J. Ultrasound-guided continuous erector spinae plane block for postoperative analgesia in video-assisted thoracotomy. Anaesth Intensive Care. 2018;46(2):243–5.
7. Restrepo-Garces CE, Chin KJ, Suarez P, Diaz A. Bilateral continuous erector spinae plane block contributes to effective postoperative analgesia after major open abdominal surgery: a case report. A A Case Rep. 2017;9(11):319–21.
8. Tulgar S, Selvi O, Kapakli MS. Erector spinae plane block for different laparoscopic abdominal surgeries: case series. Case Rep Anesthesiol. 2018;2018:3947281.
9. Aksu C, Gurkan Y. Ultrasound-guided bilateral erector spinae plane block could provide effective postoperative analgesia in laparoscopic cholecystectomy in paediatric patients. Anaesth Crit Care Pain Med. 2019;38(1):87–8.
10. Altiparmak B, Korkmaz Toker M, Uysal AI, Kuscu Y, Gumus Demirbilek S. Ultrasound-guided erector spinae plane block versus oblique subcostal transversus abdominis plane block for postoperative analgesia of adult patients undergoing laparoscopic cholecystectomy: randomized, controlled trial. J Clin Anesth. 2019;57:31–6.
11. Tulgar S, Kapakli MS, Senturk O, Selvi O, Serifsoy TE, Ozer Z. Evaluation of ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: a prospective, randomized, controlled clinical trial. J Clin Anesth. 2018;49:101–6.
12. Tulgar S, Selvi O, Senturk O, Serifsoy TE, Thomas DT. Ultrasound-guided erector spinae plane block: indications, complications, and effects on acute and chronic pain based on a single-center experience. Cureus. 2019;11(1):e3815.
13. Chol YJ, Kwon HJ, Jehoon O, Cho TH, Won JY, Yang HM, et al. Influence of injectate volume on paravertebral spread in erector spinae plane block: an endoscopic and anatomical evaluation. PLoS One. 2019;14(10):e0224487.
14. Peng P, Finlayson R, Lee S, Bhatia A. Erector spinae plane block (ESP block). In: Ultrasound for Interventional pain management. Baltimore: Springer; 2020. p. 131–48.
15. Tulgar S, Ahiskalioglu A, De Cassai A, Gurkan Y. Efficacy of bilateral erector spinae plane block in the management of pain: current insights. J Pain Res. 2019;12:2597–613.
16. Chin KJ, El-Boghdadly K. Mechanisms of action of the erector spinae plane (ESP) block: a narrative review. Can J Anaesth. 2021;68(3):387–408.

17. Chin KJ, Lirk P, Hollmann MW, Schwarz SKW. Mechanisms of action of fascial plane blocks: a narrative review. Reg Anesth Pain Med. 2021;46(7):618–28.
18. Agur AM, Dalley AF. Grant's atlas of anatomy. Switzerland: Lippincott Williams & Wilkins; 2009.
19. Saadawi M, Layera S, Allste J, Bravo D, Leurcharusmee P, Tran Q. Erector spinae plane block: a narrative review with systematic analysis of the evidence pertaining to clinical indications and alternative truncal blocks. J Clin Anesth. 2020;68:110063.
20. Aksu C, Kus A, Yorukoglu HU, Tor Killc C, Gurkan Y. Analgesic effect of the bi-level injection erector spinae plane block after breast surgery: a randomized controlled trial. Agri Derg. 2019;31(3):132–7.
21. Cosarcan SK, Dogan AT, Ercelen O, Gurkan Y. Superior costotransverse ligament is the main actor in permeability between the layers? Target-specific modification of erector spinae plane block. Reg Anesth Pain Med. 2020;45(8):674–5.
22. Sahin A, Gültekin A, Yildirim I, Baran O, Arar C. Ultrasound guided erector Spinae Block with costotransverse ligament puncture is more effective than erector Spinae Block alone; eight cases for oncologic breast surgery; a brief technical report. Open J Anesthesiol. 2020;10(05):179–89.
23. Kendall MC, Alves L, Traill LL, et al. The effect of ultrasound-guided erector spinae block on postsurgical pain: a met-analysis of randomised controlled trials. BMC Anaesthesiol. 2020;20(1):99.
24. Myles PS, Myles DB, Galagher W, Boyd D, Chew C, MacDonald N, et al. Measuring acute postoperative pain using the visual analog scale: the minimal clinically important difference and patient acceptable symptom state. Br J Anaesth. 2017;118(3):424–9.

Publisher's Note

Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery - An observational study

Sir,

The erector spinae plane block (ESPB) is a new peripheral regional block that has been used for a wide variety of clinical settings.[1-3] The pharmacokinetics of ropivacaine have been well described following wound infiltration, but there is a paucity of data on plasma concentrations following ESPB.[4,5] Hence, we conducted a study to measure the plasma levels of ropivacaine in patients receiving ESPB and wound infiltration (WI). The study patients were part of a bigger trial assessing the analgesic effect of ESPB vs wound WI in laparoscopic colorectal surgery. After Human Ethics and Research Committee (HREC/18/CALHN/456) approval, the study was registered with the Clinical Trials Registry. The aim was to assess the safety of single-shot ESPB and WI by estimating the total ropivacaine levels. Patients aged between 18–85 years, of American Society of Anesthesiologists physical status I–III, undergoing elective laparoscopic colonic surgery were included. Patients with sensitivity or allergy to local anaesthetics were excluded.

Twenty adult patients were randomised through computer-generated sequence to receive standard general anaesthesia followed by bilateral ultrasound-guided ESPB or WI for postoperative analgesia before extubation. In the ESPB group, a high-frequency linear probe of 6- to 15-MHz (Sonosite X-Porte, SonoSite Inc. Bothell, WA, USA) was used to visualise the erector spinae (ES) muscles, slightly cephalad to the T8 transverse process. A 22-gauge Stimuplex ®(B-Braun Medical, Bethlehem, PA, USA) nerve block needle was inserted deep into the ES muscle beneath the fascia in a cephalad to caudal direction. Drug dissemination was confirmed by visualising the lifting of the ES muscle in real-time. Ropivacaine (AstraZeneca Pty Ltd, Sydney, NSW, Australia) diluted to 0.5%, up to 3 mg/kg (not to exceed 200 mg), was administered bilaterally up to 20 mL per side. In the WI group, the surgeons injected a similar dose in the laparoscopic port-sites and into the minimally invasive wound. Arterial blood samples were collected 5 min prior and 10, 60, and 180 min following ropivacaine injection. The patients were observed for signs and symptoms of local anaesthetic systemic toxicity (LAST) for the next 24 h. After calibration, total ropivacaine levels were assayed using high-performance liquid chromatography-tandem mass spectrometry.

The demographic profile was similar in both groups. The overall mean [+/- standard deviation (SD)] ropivacaine doses administered in the ESPB and WI groups were 198+/-3.7 and 192 mg+/-7.3, respectively. In the ESPB group, the highest mean (+/- SD) and highest individual peak concentrations were 1.65 +/- 0.37 μg/mL and 2.22 μg/mL, respectively. In the WI group, the highest mean (SD) and the highest individual peak concentration were 0.91 and 2.33 μg/mL, respectively. The peak levels were reached earlier in the ESPB (10 min) group than in the WI group (60 min), probably reflecting a faster vascular absorption near the posterior muscle. The mean (SD) with 95% confidence intervals at 10 mins in the ESPB and 60 min in the WI were 1.65 +/- 0.37 μg/mL [1.28–2.02] and 0.91 +/- 0.36 μg/mL [0.55–1.2], respectively [Figure 1]. In Griffith *et al.*'[6] study, the total venous plasma concentrations of ropivacaine following transversus abdominis plane block exceeded the widely quoted toxic threshold of 2.2 μg/mL (4.3 μg/mL of arterial equivalent) in 12 out of 30 patients. Levels in the current study did not exceed the toxic threshold. In another study, the highest arterial total ropivacaine level observed after thoracic paravertebral block with

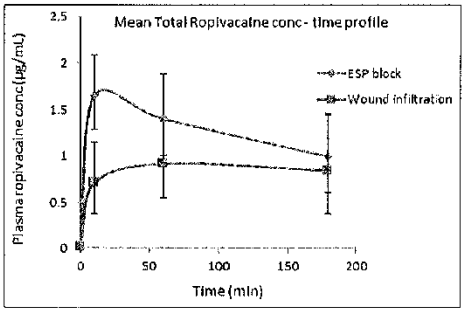


Figure 1: Showing the mean total ropivacaine levels over the time course in Erector spinae plane block and wound infiltration groups. Blue diamond shape represents time points for ESP = Erector spinae plane and orange square for WI = wound infiltration group. Error bars (+/-) represent 95% confidence intervals

2 mg/kg ropivacaine was 2.47 μg/mL at 7.5 min.[7] The highest concentrations following paravertebral block were achieved at a time frame similar to our ESPB group. However, our levels were very low (2.47 vs 1.65 μg/mL). As the ropivacaine levels following ESPB are yet to be established, our data may provide some information to guide future trials. The limitations of the study were small sample size, a ceiling dose of ropivacaine (200 mg) and the unavailability of free fraction levels.

To conclude, mean total ropivacaine levels following a single injection of EPSB or WI are well below toxic thresholds, if the total dose is limited to less than 3 mg/kg, and are unlikely to cause any adverse effects.

Acknowledgements
The authors acknowledge A/prof Roelof M.A.W. van Wijk, A/prof Venkatesan Thiruvenkatarajan and Prof Sanjib Adhikary for their help in reviewing and editing of the article.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

Vasanth Rao Kadam, Guy L. Ludbrook, Peter Hewett[1], Ian Westley[2]
Acute Care Medicine, The University of Adelaide, [1]Department of Surgery, The University of Adelaide, [2]Chemical Pathology, Flinders Medical Centre, South Australia, Australia

Address for correspondence:
Dr. Vasanth Rao Kadam,
TQEH (The University of Adelaide), 28 Woodville Road, Woodville, 5011, SA, Australia.
E-mail: vasanth.rao@.sa.gov.au

Submitted: 29-Oct-2021
Revised: 25-Feb-2022
Accepted: 01-Mar-2022
Published: 24-Mar-2022

REFERENCES

1. Forero MAS, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: A Novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med 2016;41:621-7.
2. Hassan ME, Wadod MA. Serratus anterior plane block and erector spinae plane block in postoperative analgesia in thoracotomy: A randomised controlled study. Indian J Anaesth 2022;66:119-25.
3. Ramachandran S, Ramaraj KP, Velayudhan S, Shanmugam B, Kuppusamy S, Lazarus SP. Comparison of erector spinae plane block and local anaesthetic infiltration at the incision site for postoperative analgesia in percutaneous nephrolithotomy – A randomised parallel-group study. Indian J Anaesth 2021;65:398-403.
4. Pettersson N, Emanuelsson BM, Reventlid H, Hanhn RG. High-dose ropivacaine wound infiltration for pain relief after inguinal hernia repair: a clinical and pharmacokinetic evaluation. Reg Anesth Pain Med 1999;23:189-96.
5. Macaire P, Ho N, Nguyen V, Phan Van H, Dinh Nguyen Thien K, Bringuier S, *et al*. Bilateral ultrasound-guided thoracic erector spinae plane blocks using a programmed intermittent bolus improve opioid-sparing postoperative analgesia in pediatric patients after open cardiac surgery: A randomized, double-blind, placebo-controlled trial. Reg Anesth Pain Med 2020;45:805-12.
6. Griffiths JD, Le NV, Grant S, Bjorksten A, Hebbard P, Royse C. Symptomatic local anaesthetic toxicity and plasma ropivacaine concentrations after transversus abdominis plane block for Caesarean section. Br J Anaesth 2013;110:996-1000.
7. Karmakar MK, Ho AM, Law BK, Wong AS, Shafer SL, Gin T. Arterial and venous pharmacokinetics of ropivacaine with and without epinephrine after thoracic paravertebral block. Anesthesiology 2005;103:704-11.

Access this article online
Quick response code
Website: www.ijaweb.org
DOI: 10.4103/ija.ija_956_21

How to cite this article: Kadam VR, Ludbrook GL, Hewett P, Westley I. Plasma ropivacaine levels after ultrasound-guided erector spinae plane block and wound infiltration in laparoscopic colonic surgery- An observational study. Indian J Anaesth 2022;66:231-2.