International Journal of Applied Pharmaceutics

ISSN- 0975-7058 Vol 12, Special Issue 3, 2020

Full Proceeding Paper

POSTOPERATIVE ANALGESIA IN KIDNEY TRANSPLANT LAPAROTOMY: QUADRATUS LUMBORUM BLOCK AS AN ALTERNATIVE

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Received: 14 Oct 2019, Revised and Accepted: 09 Feb 2020

ABSTRACT

Objective: Effective postoperative pain management promotes better recovery. Continuous epidural (CE) is the standard postoperative analgesia for kidney transplantation; however, patients still report pain and unfavorable side effects. This present study compares the effectiveness of quadratus lumborum block (QLB) versus CE for managing pain and reducing morphine requirements following kidney transplantation.

Methods: This randomized-controlled study compared 37 kidney transplant patients: a QLB group (N=19) who received 20 ml 0.375% ropivacaine injection bilaterally and a CE group (N=18) who received 0.2% ropivacaine epidurally by infusion at 6 ml/h. Participants were assessed at 2, 6, 12, and 24h postoperatively for morphine requirements and with a visual analogue scale (VAS) for pain while resting and moving.

Results: The VAS scores when resting and moving were similar for both QLB and CE at all-time points (p>0.05 for both treatments). Postoperative morphine requirements also did not differ (p>0.05) between the two groups at any time point. Both groups had similar first-time morphine requirements (802.63 min for QLB vs 871.39 min for CE, p=0.814). Both groups achieved 100% blockade at the level of T10–L1 and had comparable Bromage and Ramsay scores.

Conclusion: QLB appears to be a viable alternative approach to CE for pain management after kidney transplantation.

Keywords: Continuous epidural, Kidney transplant, Postoperative analgesia, Quadratus lumborum

DOI: http://dx.doi.org/10.22159/ijap.2020.v12s3.39465

INTRODUCTION

Kidney transplantation remains the treatment of choice for patients with chronic kidney disease (CKD) due to the better quality of life provided when compared to other treatment modalities. Indonesia has conducted kidney transplantations since 1977, and a total of 270 patients underwent kidney transplantation between 2011 and 2015 [1, 2].

The kidney transplantation procedure is an open surgery between the ribs and pelvis that causes moderate to severe pain postoperative pain. Inadequate pain management can disturb the inflammatory mediator and immunity systems and eventually disrupt the postoperative recovery process. Opioids are widely used and provide adequate analgesia, but they have undesirable side effects of nausea, vomiting, pruritus and respiratory depression [3–6]; therefore, continuous epidural (CE) is the current standard of care for postoperative analgesia following kidney transplantation. However, CE also has side effects, such as paresthesia, hypotension, hematomas, impaired lower limb motor function, and prolonged urinary catheterization, which can delay recovery and thereby increase the risk of graft failure [5, 7, 8].

In 2007, Blanco injected the local anesthetic into the interfascial surface of anterolateral side quadratus lumborum muscle using ultrasound guidance as the lateral quadratus lumborum block (QLB) [9]. Unlike CE, QLB does not cause hypotension, has a minimal chance of motor block and supporting early mobilization. Some studies have shown good visceral analgesia because of the paravertebral space and the potential epidural space allow the spreading of local anesthetic. A QLB lasts up to 48h with ropivacaine (0.375%) as the local anesthetic [10–12]. Our study assessed the effectiveness of QLB as a potential alternative for managing pain intensity and reducing morphine requirements following kidney transplantation in comparison to CE. The primary outcome was a 24h visual analogue scale (VAS) while resting and moving; the secondary outcome was the 24h postoperative morphine requirement. The postoperative blockade heights, Bromage and Ramsay scores were recorded.

MATERIALS AND METHODS

This prospective randomized-controlled study was carried out at a university teaching hospital. After registration in ClinicalTrials. gov (NCT 03771339) and was approved by the ethical committee, we recruited 40 CKD patients scheduled for kidney transplant surgery who met the inclusion criteria of age 18 or older. All patients provided written consent. Exclusion criteria were patients with body mass index above 30 kg/m^2, contraindication to CE or QLB procedures, and a history of local anesthetic allergy. The study protocol, the QLB and CE procedure, VAS 0–100 mm for describing the degree of pain, and using the patient-controlled analgesia (PCA) morphine pump if their VAS score reached 40 and above were explained to each patient. The patients were randomized into the QLB group (intervention group) or the CE group (control group) using a computerized-randomization sequence (www.randomizer.org) by independent research assistants. The randomization allocation number of each subject was written on paper and put in a closed envelope, which was opened by the anesthetist appointed to perform epidural or QLB for this study. Primary investigators and statisticians were blinded to data collection throughout the study.

All patients underwent standard monitoring, such as electro-cardiograms, oxygen saturation, non-invasive, and invasive blood pressure. Patients in the CE group underwent epidural catheter placement under local analgesia before general anesthesia induction. An epidural catheter was inserted into intervertebral space between thoracic 11–12 at a depth of 4–6 cm within the epidural space using an 18G Tuohy needle (Perifix®, BBraun, Germany), and the placement was confirmed by vacuum catheter aspiration.

General anesthesia was performed using fentanyl (2 µg/kg), propofol (2 mg/kg), and atracurium (0.5 mg/kg) to facilitate the intubation. The volume control ventilation was set with a tidal volume of 8 ml/kg, PEEP of 5 cmH_2O, FiO_2 of 0.3–0.5, respiratory rate adjustment with $ETCO_2$ target of 35–45 mmHg. The anesthesia maintenance was performed using 2.5% sevoflurane with 1.0 L/min fresh gas flow, O_2 compressed air ratio of 40:60, atracurium 0.5

mg/kg/h, with the target of BIS at 40–60, sevoflurane inspired fraction of 0.8 and train of four (TOF) ratio ≤ 0.25. During surgery, the subjects received fentanyl (1 µg/kg) i. v. bolus if the systolic blood pressure (SBP) or heart rate increased >20% from the baseline value, and the overall administered fentanyl was documented.

After the surgery, the CE group was given an epidural regimen of ropivacaine (0.2%) and epinephrine (1:200,000) in a total volume of 3 ml as a test dose. Upon confirmation of a negative test dose, ropivacaine 0.2% was maintained at 6 ml/h. In the QLB group, the patients underwent ultrasonography-guided (C5-1E, DC-70, Mindray, Shenzhen China) bilateral injection of ropivacaine (0.375%) with a total volume of 20 ml on each side using a 21G 100-mm peripheral block needle (Stimuplex®, BBraun, Germany). The block was performed by anesthetist consultants using anterior QLB approach.

Neostigmine (0.04–0.07 µg/kg) was given to reverse the residual neuromuscular block, and the patient was extubated upon reaching a TOF of 0.9–1.0. The PCA morphine was administered i. v. through a programmed pump (Perfusor® Space PCA, BBraun, Germany) with 1 mg bolus, 10 min lock time, and maximum dosage of 6 mg/h without basal opioid infusion. Participants were re-educated regarding the PCA usage and VAS reporting and were assessed at 2, 6, 12, and 24h postoperatively for pain with the VAS while resting and moving and for their morphine requirements.

We hypothesized that achieving the difference of 50% in 24 h morphine consumption or 25 points of VAS difference between the two groups was clinically relevant for sample size determination of 18 subjects per group. We applied the Statistical Package for Social Sciences version 20.0 (IBM Corp., Armonk, New York) in analyzing the data. A two-sample t-test for normally distributed data and the Mann-Whitney test for data without a normal distribution were applied to analyze numerical variables differentiation. Categorical variables were assessed using the chi-square test. Numerical data with a normal distribution were shown as means (standard deviation), and data without a normal distribution were presented as medians (minimum-maximum), while categorical variables were presented as absolute counts (percentages). Differences were considered statistically significant if the *p*-value was less than 0.05.

RESULTS

This study enrolled 40 subjects between November 2018 and August 2019. The subjects were randomly assigned to the two groups and underwent their allocated intervention. Three subjects were excluded for failure to comply with the PCA utilization rules that had been explained. The remaining 37 subjects were analyzed (fig. 1). The QLB and CE groups showed similar demographic baseline and perioperative characteristics (table 1).

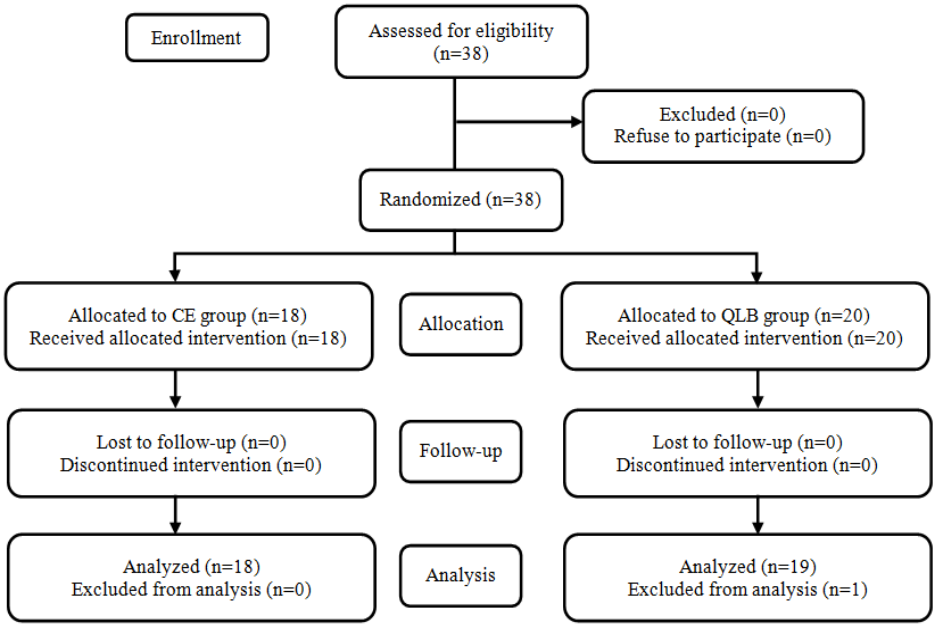

Fig. 1: CONSORT flow diagram

CE: continuous epidural; QLB: quadratus lumborum block.

Table 1: Baseline subject characteristics and intraoperative data

Characteristic	CE group (n=18)	QLB group (n=19)	*p*-value*
Male	14(77.8)	12(63.2)	0.540
Age (years)	42.00±11.282	43.47±11.27	0.694
Weight (kg)	65.42±9.43	67.88±13.09	0.515
Height (cm)	166.44±9.31	167.89±8.18	0.619
Body mass index (kg/m^2)	23.54±2.88	23.84±2.75	0.749
Duration of surgery (h)	5.20±1.21	5.21±0.648	0.987
Duration of anesthesia (h)	6.70±1.12	6.61±0.63	0.762
Intraoperative fentanyl (mcg)	279.17±73.39	248.68±103.57	0.024

Categorical data are presented as n (%), numerical data are presented as mean±standard deviation, *two-sample t-test, $p<0.05$ considered significant, CE: continuous epidural; QLB: quadratus lumborum block

Pain scores at rest and during movement during 24h after anesthesia recovery did not differ significantly between the QLB and groups. The lowest pain scores in both groups at rest and in the movement were immediately after surgery and after 12h of anesthesia recovery (table 2).

Table 2: VAS comparisons between groups

	CE group (n=18)	QLB group (n=19)	*p*-value
VAS at rest during post-anesthesia recovery (mm)			
immediate	0 (0–20)	0 (0–45)	0.228*
2h	10 (0–33)	15 (0–70)	0.108*
6h	10 (0–20)	10 (0–30)	0.224*
12h	10 (0–20)	10 (0–30)	0.056*
24h	10 (0–20)	10 (0–35)	0.179*
VAS while moving during post-anesthesia recovery (mm)			
immediate	10 (0–40)	10 (0–45)	0.813*
2h	30 (0–50)	30 (10–85)	0.865*
6h	27.5 (0–50)	25 (10–50)	0.947†
12h	20 (0–50)	30 (10–50)	0.063†
24h	20 (10–80)	20 (0–50)	0.408*

Numerical data presented as median (minimum-maximum), *Mann-Whitney test, $p<0.05$ considered significant, †two-sample t-test, $p<0.05$ considered significant, CE: continuous epidural; QLB: quadratus lumborum block

Table 3 shows comparable cumulative morphine requirements for both groups at each time point of measurements. The time to first morphine initiation using PCA did not differ significantly between the QLB and CE (802.63 vs 871.39 min, p=0.814). Overall, 8 subjects in the QLB group and 7 subjects in the epidural group did not need additional morphine during the 24h after anesthesia recovery.

Table 3: PCA (morphine) requirements

	CE group (n=18)	QLB group (n=19)	*p*-value*
PCA Morphine Requirements (mg)			
2h	2 (0–2)	2 (0–2)	0.380
6h	2 (0–2)	2 (0–2)	0.425
12h	2 (0–2)	2 (0–3)	0.664
24h	0 (0–5)	0 (0–4)	0.854
Total cumulative morphine	1 (0–12)	2 (0–9)	0.789
First postoperative morphine required (min)			
First PCA attempt	920 (30–1440)	420 (60–1440)	0.814

Numerical data presented as median (minimum-maximum)., *Mann-Whitney test, $p<0.05$ considered significant, CE: continuous epidural; QLB: quadratus lumborum block; PCA: patient-controlled analgesia

The Bromage score (table 4) showed no motor block between groups, except for one subject in the epidural group who reported paresthesia and a partial motor block, which resolved without any intervention within a 12h observation period. All subjects were cooperative, oriented and tranquil at all assessed time points according to the Ramsay sedation scale (table 5).

Table 4: Bromage score comparison between groups

Bromage score	1		2		*p*-Value*
	CE	QLB	CE	QLB	
at RR	18(100)	19(100)	0(0)	0(0)	1.000
2h	17(94.4)	25(100)	1(5.6)	0(0)	0.775
6h	17(94.4)	25(100)	1(5.6)	0(0)	0.775
12h	18(100)	19(100)	0(0)	0(0)	1.000
24h	18(100)	19(100)	0(0)	0(0)	1.000

Data presented in n (%). CE: continuous epidural; QLB: quadratus lumborum block; RR: recovery room; 1: nil block; 2: partial block, *Mann-Whitney test, $p<0.05$ is significant.

Table 5: Ramsay score comparison between groups

Ramsay score	2		*p*-Value*
	CE	QLB	
at RR	18(100)	19(100)	1.000
2h	18(100)	19(100)	1.000
6h	18(100)	19(100)	1.000
12h	18(100)	19(100)	1.000
24h	18(100)	19(100)	1.000

Data presented in n (%). CE: continuous epidural; QLB: quadratus lumborum block; RR: recovery room; 2: cooperative, *Mann-Whitney test, $p<0.05$ is significant.

Fig. 2 shows the variable degree of sensory block spread in both groups. The majority of the patients in the QLB group had a loss of cold and pinprick sensations from T10 to L1, compared with the majority of patients in the CE group, who had a loss of cold and pinprick sensations

from T9 to L1. None of the patients in the QLB group showed sensory blockade at T7 or L2 levels. Complications such as local anesthetic systemic toxicity, hematoma, local infection, and blocked or dislodged epidural catheters were not found during study observation.

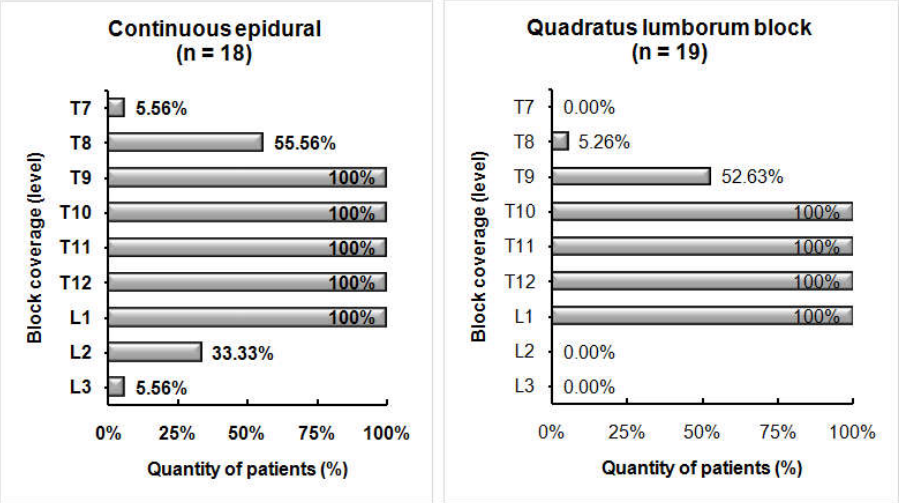

Fig. 2: Postoperative sensory block coverage comparison

The maximum and minimum dosages of vasoactive drugs (norepinephrine and dobutamine) were recorded for 24h postoperatively (table 6). We found 2 subjects in the QLB group and 3 subjects in the CE group did not require vasoactive drugs postoperatively. The norepinephrine and dobutamine dosages between the two groups were not statistically significantly different. The total urine production for the first 24h was 7,590±518 ml in the QLB group and 8,399±1,608 ml in the CE group (p=0.679), with the urine output of 4.76±0.39 ml/kg/h in the QLB group and 5.47±1.07 ml/kg/h in the CE group (p=0.581).

Table 6: Vasoactive drugs requirements

	CE group (n=18)	QLB group (n=19)	*p*-value*
Norepinephrine (µg/kg/min)			
Minimum	0.003 (0–0.10)	0 (0–0.20)	0.816
Maximum	0.050 (0–0.5)	0.09 (0–0.35)	0.135
Dobutamine (µg/kg/min)			
Minimum	0 (0–1)	0 (0–2)	0.054
Maximum	0 (0–3)	0.5 (0–5)	0.077

Numerical data presented as median (minimum-maximum)., *Mann-Whitney test, $p<0.05$ considered significant, CE: continuous epidural; QLB: quadratus lumborum block

DISCUSSION

Continuous epidural analgesia is effective for managing postoperative pain associated with abdominal surgery; however, the hypotension side effects could place kidney transplant patients at risk of graft failure. Regional blocks, such as QLB, have demonstrated good analgesia during various abdominal procedures and could be used in kidney transplant surgery as a way to avoid the unfavorable hypotension of CE.

No study has compared the analgesic effect of QLB directly with CE, except for a study by Rahendra *et al.* who investigated laparoscopic living donor nephrectomy and found no significant difference in pain intensity between QLB and CE, in agreement with the present study [13]. The similar pain intensity between the groups in this study may be related to a comparable spread of local anesthetic along the dermatomal or spinal nerve in both procedures. In CE, the local anesthetic acts directly on the nerve root, whereas the local anesthetic spreads transversally in QLB along the thoracolumbar fascial plane to block the nerve with similar dermatomal coverage [14].

Our study found dermatomal coverage of the QLB to extend from T8 to L1, which was lower than the QLB coverage from T7 to T12 reported by Murouichi and colleagues [15]. Kidney transplant laparotomy for recipients involves the abdominal area between the ribs and pelvis; therefore, the spread of local anesthetic covered the dermatome area of the incisions (T9–L1) and the analgesic effect was sufficient for surgical wound pain relief. Dam *et al.* demonstrated thoracic spread in cadaveric and magnetic resonance imaging studies in volunteers as a result of a more anterolateral penetration of the quadratus lumborum and anterior thoracolumbar fascia, which may be related to the cephalad distribution of local anesthetic. These findings support the fact that even though the QLB was performed at L4 level, the sensory blockade was found higher than L3 and L4 levels [16]. A higher block level does not contribute to a better analgesic effect. On the contrary, it could increase risk of hemodynamic instability due to a sympathetic block. The QLB can last for up to 24–48h due to shifting of the local anesthetic from intermuscular space to paravertebral space, which has plenty of adipose tissue. Low perfusion in the adipose tissue causes a low absorption of local anesthetic by the circulation, thereby extending the duration of analgesia [17]. This would also contribute to the low pain intensity observed in the present study.

The morphine requirements were also assessed at various postoperative times. The cumulative 24h morphine requirement and the first PCA morphine attempt showed no significant differences between the two groups. A high anxiety level is correlated with a higher pain score and a higher PCA drug demand. Anxiety about pain

could lead to an anticipatory attitude, so that the patient would tend to press the PCA even though they have not experienced any pain. Morphine usage from PCA is highly dependent on the patient's decision to press the PCA button; therefore, a good explanation and full patient understanding are critical for reducing unnecessary PCA usage for pain other than surgical pain [18].

In the present study, all patients were cooperative, oriented and tranquil. The Ramsay sedation scale assessment was conducted to evaluate the side effects of morphine usage. With a glomerular filtration rate of less than 50 ml/min/1.73m^2, a patient could build up morphine-6-glucuronidase and morphine-3-glucoronidase metabolites, that could lead to postoperative nausea vomiting, unexpected sedation effects, involuntary myoclonus, and respiratory depression [3, 19].

The vasoactive drug dosage seems to depend on the patient's preoperative blood pressure, as patients with preoperative SBP>140 mmHg had lower requirements for norepinephrine and dobutamine than patients with SBP<140 mmHg. The incidence of hypotension was about 4.6% in the QLB group, with local anesthetic spreading bilaterally to the paravertebral space. However, studies on this topic are still sparse [20, 21].

Epidural blocks using ropivacaine cause side effects correlated with dose and concentration. A study by Hong *et al.* showed that MAP and systemic vascular resistance (SVR) could decrease significantly in epidural with ropivacaine at doses of 0.75% but not at 0.375% and 0.2% [22, 23]. Hemodynamic changes during an epidural could occur due to a sympathetic block, which could cause dilatation of arteries and veins; a decrease in SVR; inotropic and chronotropic function disturbance; and changes in cardiac output. Generally, an epidural block in the lower thorax or lumbar area does cause significant hemodynamic changes [24]. In our present study, both groups showed an adequate perfusion pressure, as indicated by adequate urine production. A study by Schnuelle *et al.* set a five-year graft survival cutoff value of 81.8% in patients with urine production of 630 ml within the first 24h compared to 54.6% in patients with first 24h urine production<630 ml [25].

Our study had several limitations. We did not include a control group using PCA morphine i. v. alone or a perioperative multimodal analgesia regimen for assessing the pain intensity and the 24h morphine requirements after surgery without regional anesthesia to determine the true analgesic value of QLB and CE. A further limitation arose in blinding since the QLB was performed as the two-sided injections without the catheter, while CE was performed before general anesthesia induction and using an inserted catheter. However, these conditions were inevitable since these are the common approaches for using these blocks. The subjects were also patients with CKD who required renal replacement therapy; therefore, the risks and side effects of local anesthetic toxicity were a further concern that should be addressed in the future study to assess the safety profile of ropivacaine in CKD. Another limitation is that the block spread was assessed only one time at 1h after the surgery and was not re-assessed during the observation time; hence, this study did not evaluate block regression.

In conclusion, postoperative analgesia of the QLB did not significantly differ from CE. Therefore, the QLB has potential as an alternative pain management approach following kidney transplantation laparotomy. The QLB had a similar 24h cumulative morphine requirement, postoperative pain intensity and time to first additional analgesic requirement when compared with CE following kidney transplantation laparotomy. The block spread of both approaches covered the desired target area and reached a 100% block at the T10–L1 level.

CONCLUSION

Postoperative analgesia of QLB did not differ significantly compared to CE. The QLB has potential as alternative pain management following kidney transplantation laparotomy. The QLB had similar 24-hour cumulative morphine requirement, postoperative pain intensity, first additional analgesic required time in comparison with CE following kidney transplantation laparotomy. Postoperative block height covers the desired target area and reached 100% block at level T10–L1.

ACKNOWLEDGEMENT

This article was presented in the 4th International Conference and Exhibition on Indonesian Medical Education and Research Institute (ICE on IMERI 2019), Faculty of Medicine, Universitas Indonesia. We thank the 4th ICE on IMERI committee, who had supported the peer review and manuscript preparation before submitting to the journal.

FUNDING

Nil

AUTHORS CONTRIBUTIONS

All authors have contributed equally.

CONFLICT OF INTERESTS

All authors have none to declare.

REFERENCES

1. Mochtar CA, Alfarissi F, Soeroto AA, Hamid ARAH, Wahyudi I, Marbun MBH, *et al.* Milestones of kidney transplantation in Indonesia. Med J Indones 2017;26:229–36.
2. Kakaei F, Nikeghbalian S, Malekhosseini SA. Kidney transplantation techniques. In: Rath T. editor. Current issues and future direction in kidney transplantation. Rijeka, Croatia: InTech; 2013. p. 167–84.
3. Pham PC, Khaing K, Sievers TM, Pham PM, Miller JM, Pham SV, *et al.* 2017 update on pain management in patients with chronic kidney disease. Clin Kidney J 2017;10:688–97.
4. Abdelsalam KMA, Sultan SS. Effectiveness of ultrasound-guided transversus abdominis plane block for intraoperative and postoperative analgesia in kidney transplantation. Ain-Shams J Anaesthesiol 2015;8:140–3.
5. Srivastava D, Tiwari T, Sahu S, Chandra A, Dhiraaj S. Anaesthetic management of renal transplant surgery in patients of dilated cardiomyopathy with ejection fraction less than 40%. Anesthesiol Res Pract 2014:1–5. Doi:10.1155/2014/525969
6. Martinez BS, Gasanova I, Adesanya A. Anesthesia for kidney transplantation-a review. J Anesth Clin Res 2013;4:270.
7. Hirata ES, Baghin MF, Pereira RI, Alves Filho G, Udelsmann A. Influence of the anesthetic technique on the hemodynamic changes in renal transplantation. a retrospective study. Rev Braz Anesthesiol 2009;59:166–76.
8. Aulakh NK, Garg K, Bose A, Aulakh BS, Chahal HS, Aulakh GS. Influence of hemodynamics and intra-operative hydration on the biochemical outcome of renal transplant recipients. J Anaesthesiol Clin Pharmacol 2015;31:174–9.
9. 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. Reg Anesth Pain Med 2016;41:757–62.
10. Ueshima H, Otake H, Lin JA. Ultrasound-guided quadratus lumborum block: an updated review of anatomy and techniques. Biomed Res Int 2017:1–7. Doi:10.1155/2017/2752876.
11. 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. Anesth Analg 2018;126:559–65.
12. Mieszkowski MM, Mayzner Zawadzka E, Tuyakov B, Mieszkowska M, Żukowski M, Wasniewski T, *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. Ginekol Pol 2018;89:89–96.
13. Rahendra R, Pryambodho P, Aditianingsih D, Sukmono RB, Tantri A, Melati AC. Comparison of IL-6 and CRP concentration between quadratus lumborum and epidural blockade among living kidney donors: a randomized controlled trial. Anesthesiol Pain Med 2019;9:e91527.
14. Blanco R, Ansari T, Girgis E. Quadratus lumborum block for postoperative pain after caesarean section: a randomized controlled trial. Eur J Anaesthesiol 2015;32:812-8.
15. Murouchi T, Iwasaki S, Yamakage M. Quadratus lumborum block: analgesic effects and chronological ropivacaine concentrations after laparoscopic surgery. Reg Anesth Pain Med 2016;41:146–50.

16. Dam M, Moriggl B, Hansen CK, Hoermann R, Bendtsen TF, Børglum J. The pathway of injectate spread with the transmuscular quadratus lumborum block: a cadaver study. Anesth Anal 2017;125:303–12.
17. Yousef NK. Quadratus lumborum block versus transversus abdominis plane block in patients undergoing total abdominal hysterectomy: a randomized prospective controlled trial. Anesth Essays Res 2018;12:742–7.
18. Macintyre PE. Safety and efficacy of patient-controlled analgesia. Br J Anaesth 2001;87:36–46.
19. Aubrun F, Mazoit JX, Riou B. Postoperative intravenous morphine titration. Br J Anaesth 2012;108:193–201.
20. Elsharkawy H, El-Boghdadly K, Barrington M. Quadratus lumborum block: anatomical concepts, mechanisms, and techniques. Anesthesiology 2019;130:322–35.
21. Karmakar MK. Thoracic paravertebral block. Anesthesiology 2001;95:771–80.
22. Kuthiala G, Chaudhary G. Ropivacaine: a review of its pharmacology and clinical use. Indian J Anaesth 2011;55:104–10.
23. Hong JM, Lee HJ, Oh YJ, Cho AR, Kim HJ, Lee DW, *et al.* Observations on significant hemodynamic changes caused by a high concentration of epidurally administered ropivacaine: correlation and prediction study of stroke volume variation and central venous pressure in thoracic epidural anesthesia. BMC Anesthesiol 2017;17:153.
24. Brull R, MacFarlane A, Chan V. Spinal, epidural, and caudal anesthesia. In: Miller R, Eriksson L, Fleisher L, Wiener Kronish J, Cohen N, Young W. editors. Miller's anesthesia. 8th ed. Philadelphia: Elsevier-Saunders 2015. p. 1684–720.
25. Schnuelle P, Gottmann U, Köppel H, Brinkkoetter PT, Krzossok S, Weiss J, *et al.* Comparison of early renal function parameters for the prediction of 5 y graft survival after kidney transplantation. Nephrol Dial Transplant 2007;22:235–45.