

Ultrasound-guided TAP Block versus Port-site Infiltration for Postoperative Analgesia after Laparoscopic Donor Nephrectomy: A Double-blinded Randomised-controlled Study

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ABSTRACT

Introduction: Laparoscopic donor nephrectomy is a minimally invasive procedure, with postoperative pain being a major concern, increasing opioid use. The use of opioids is limited due to their adverse effects, and Non-Steroidal Anti-inflammatory Drugs (NSAIDs) are avoided due to their nephrotoxic effects.

Aim: To compare the pain control efficacy and opioid-reducing effect of Transversus Abdominis Plane (TAP) block using 0.5% Ropivacaine and port site local infiltration of 0.5% Ropivacaine in patients undergoing laparoscopic donor nephrectomy

Materials and Methods: This randomised double-blinded controlled study was conducted among 72 patients who underwent laparoscopic nephrectomy in Department of Anaesthesiology at Kovai Medical Centre and Hospital (KMCH), Tamil Nadu, India, from January 2023 to January 2024. Patients were randomised equally into two groups, 36 each. Group 1 was given port site local infiltration of 0.5% Ropivacaine, and Group 2 received 0.5% Ropivacaine via TAP block. The dose of Ropivacaine varied according to the weight of the patients. All the patients were evaluated a day before surgery, preoperatively. Postoperative pain scores, haemodynamic parameters, and

rescue analgesic requirement were assessed. Mean Visual Analogue Scale (VAS) score was compared between the two groups using the Mann-Whitney U test, and the Rescue analgesic requirement was assessed using the Chi-square test. A p-value <0.05 was considered statistically significant.

Results: Among the 72 patients who underwent laparoscopic nephrectomy, more than half of the patients were aged 21-50 years with the majority being Females in both groups. The mean postoperative VAS score at extubation was significantly lower in Group 2 than in Group 1 (1.5 ± 0.7 vs. 2.1 ± 0.7 ; $p=0.001$). At one hour post-extubation, the mean VAS score was significantly lower in Group 2 than in Group 1 (1.4 ± 1.4 vs. 2.3 ± 1.4 ; $p=0.006$). Furthermore, total rescue opioid administration was significantly lower in the TAP block group 14 (38.9%) compared to the port-site group 26 (72.2%), which was significant with a p-value of 0.03.

Conclusion: The ultrasound-guided TAP block provides early postoperative analgesia and achieves a highly significant reduction in systemic opioid consumption compared to port-site infiltration. These findings indicate that the TAP block serves as a highly effective, safe regional alternative.

Keywords: Kidney transplantation, Opioid, Pain management, Regional anaesthesia, Transversus abdominis plane

INTRODUCTION

Chronic Kidney Disease (CKD) is a major public health concern, affecting nearly 16.38% of Indians aged 15 years and older [1]. Renal transplantation is the gold standard treatment for ESRD, providing both long-term survival and improved quality of life [2]. However, due to the limited availability of deceased donor organs, living donor kidney transplantation has become increasingly common, with approximately 39% of donor nephrectomy surgeries being done worldwide each year [3].

Laparoscopic donor nephrectomy has replaced open donor nephrectomy due to advances in surgical technologies, which now accounts for nearly 70% of all donor nephrectomies [4]. Nephrectomies done through Laparoscopic techniques have several advantages over open type, like low blood loss, reduced surgical site infection, minimal invasion, reduced length of hospital stay, and postoperative morbidity [5]. Despite these advantages, it has complications like Deep Vein Thrombosis (DVT) and other pulmonary complications, which can contribute to increased mortality [6].

Postoperative pain remains a significant concern even with minimally invasive techniques like laparoscopic nephrectomy. Most of the patients undergoing laparoscopic donor nephrectomy report pain within the first 24 hours, and nearly half of them experience

trocar-site pain within 48 hours [7]. Although early postoperative pain is common, the persistence of pain beyond 3-4 days is often visceral in nature and is often associated with extensive peritoneal manipulation during surgery [8].

Effective management of postoperative pain is a key element of postoperative surgical care [9] as inadequate management of postoperative pain may lead to various other problems like delay in recovery, difficulty in mobilisation, increased need for rescue analgesics and opioids, which leads to an increase in hospital stay [10]. Postoperative pain can be managed using a variety of methods, including local anaesthetics and parenteral opioids. However, NSAIDs are often avoided because of their potential to cause nephrotoxic effects [11]. Opioids are among the most commonly used analgesics for managing postoperative pain and provide effective pain relief. However, despite their efficacy, their use is often limited by adverse effects such as nausea, vomiting, pruritus, and respiratory depression [9,10].

Therefore, techniques that minimise opioid consumption, such as local anaesthetic infiltration, epidural analgesia, peripheral nerve blocks, and intravenous analgesics, may provide improved postoperative pain control with fewer side effects [11]. Regional nerve blocks have increasingly emerged as a preferred alternative to

central neuraxial blocks owing to their ability to provide site-specific analgesia, maintain haemodynamic stability, and facilitate earlier postoperative recovery and discharge [12].

The TAP block is an ultrasound-guided regional anaesthetic procedure that provides analgesia to the anterior abdominal wall by delivering local anaesthetic between the transversus abdominis and internal oblique muscle layers, thereby blocking the Thoracolumbar nerves (T6-L1) [13]. By blocking somatic nerve transmission, the TAP block offers prolonged postoperative analgesia, with reduced need for opioids and their associated side-effects, and thereby enhances patient satisfaction [14]. The commonly used local anaesthetic for TAP block is 0.5% ropivacaine, which provides an intermediate to long-lasting analgesic effect. Its lower cardiotoxicity and motor-sparing properties make it particularly suitable for postoperative pain management, where pain relief is needed without compromising motor function [15]. Furthermore, the ultrasound guidance improves the accuracy of the block, allows for reduced doses of local anaesthetic, and minimises the risk of vascular puncture.

In contrast, local anaesthetic infiltration at the port site involves direct administration of anaesthetic into the skin, muscle, and subcutaneous tissue at the surgical site, providing localised analgesia. While this technique is simpler, does not require specialised skills, and is feasible in low-resource settings, it is associated with limited diffusion of the anaesthetic and provides shorter-duration pain relief compared with the TAP block [16]. The choice between these two techniques depends on the patient's condition, institutional protocols, and the availability of trained personnel.

The analgesic effect of the TAP block may be due to the visceral pain relief and the spread of local anaesthetic within the fascial plane. However, the reliability of this analgesic effect may be compromised by factors such as fibrosis and anatomical variation [17]. Although numerous studies have evaluated TAP blocks and port-site local infiltration in various laparoscopic procedures [18-20], direct comparisons of these techniques in laparoscopic donor nephrectomy remain limited.

Therefore, the present study aimed to assess the efficacy of ultrasound-guided TAP block versus port-site local infiltration using 0.5% Ropivacaine in reducing postoperative pain and rescue analgesic requirements among patients undergoing laparoscopic donor nephrectomy. The primary objective of the study was to assess the pain control efficacy of the TAP block vs port-site local infiltration, and the secondary objective was to determine the efficacy of TAP block and port-site local infiltration in reducing opioid consumption.

MATERIALS AND METHODS

A double-blinded randomised controlled trial was conducted in Department of Anaesthesiology at Kovai Medical Centre and Hospital (KMCH), a tertiary care, Tamil Nadu, South India among patients undergoing nephrectomy surgery between January 2023 and January 2024.

The study was approved by the Institutional Ethics Committee (Approval Number: EC/AP/1055/05/2023). Written informed consent was obtained from the participants after explaining the study procedure.

Sample size calculation: The sample size was calculated based on the findings reported by Agrawal S et al., [9]. The mean±Standard Deviation (SD) VAS score at 12 hours for the TAP block and local infiltration with 20 mL of 0.25 % ropivacaine was 3.64 (1.10) and 4.32 (0.94), respectively, yielding a mean difference of 0.68. Using these effect estimates, with a significance level of 5% and power of 80%, the required sample size was calculated to be 36 participants per group based on the standard formula:

$$n = \{2sd^2(z_{\alpha} + z_{1-\beta})\} / d^2$$

$$n = 2 * (1.023)^2 * (1.96 + 0.84)^2 / (0.68)^2$$

$$n = 2 * 1.0465 * 7.84 / 0.4624$$

$$n = 16.41 / 0.4624$$

$$n = 35.49$$

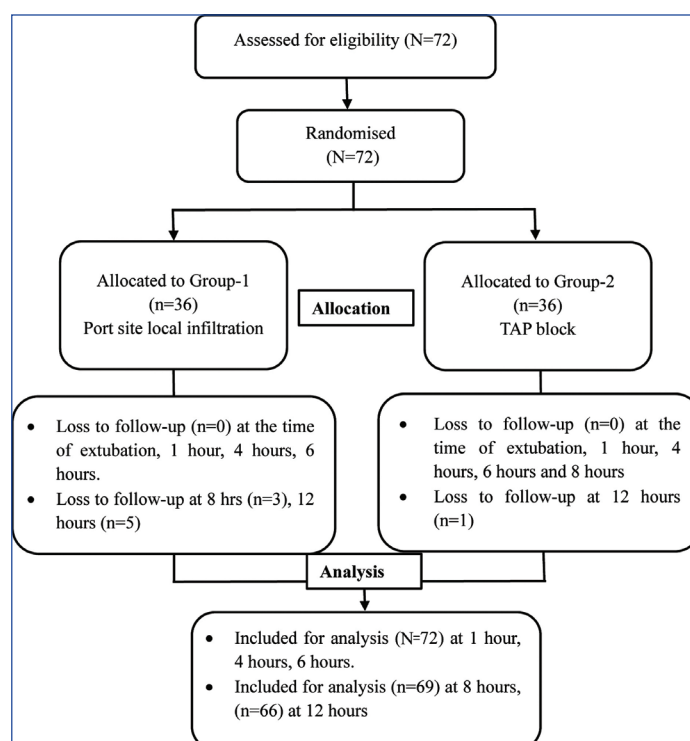
$$n = 36$$

Inclusion and Exclusion criteria: Patients aged 18-65 years, with an American Society of Anaesthesiologists (ASA) grade of I or II, undergoing laparoscopic donor nephrectomy, were recruited through consecutive sampling. Patients with a Body Mass Index (BMI) greater than 30 or a history of multiple previous abdominal surgeries were excluded.

Study Procedure

Following recruitment, all patients underwent preoperative evaluation a day before surgery, which included a detailed clinical history, physical examination, and routine investigations such as haemoglobin, blood urea, serum creatinine, and Electrocardiography (ECG). The ASA classification was also assigned to each patient.

The study participants were randomly allocated to one of the two interventional groups (Group 1 and Group 2) using a computer-generated random number [Table/Fig-1].



[Table/Fig-1]: Consolidated Standards of Reporting Trials (CONSORT) flowchart.

Randomisation sequences were generated by an independent statistician, and the assignment to interventions was executed using sealed, opaque envelopes to reduce selection bias and allocation bias. Group 1 received 0.5% Ropivacaine through port site local infiltration postoperatively, and Group 2 received 0.5% Ropivacaine through TAP block postoperatively [20]. Participants were unaware of their group assignment, and all procedures were performed by an independent anaesthesiologist who was not part of the study. Patients in both groups underwent laparoscopic nephrectomy under general anaesthesia. Patients were intubated with an endotracheal tube following the i.v. administration of fentanyl 2 µg/kg, propofol 2 mg/kg and atracurium 0.5 mg/kg. Induction was maintained using isoflurane with a 50% oxygen-air mixture. Analgesics such as paracetamol 1g and morphine 0.1 mg/kg were given intraoperatively to maintain stable haemodynamics.

Intervention was given to both groups postoperatively. For the TAP block, patients were placed in a supine position, the lower abdominal wall was disinfected with chlorhexidine and alcohol and a 22-gauge Quincke spinal needle was inserted in-plane from the anteromedial

approach under ultrasound guidance using a linear high-frequency probe (10-15 MHz). A total of 20-30 mL of 0.5% ropivacaine was administered on each side.

Following the administration of an analgesic, patients were extubated with neostigmine and glycopyrrolate and shifted to the postoperative clinic. In the recovery unit, for every patient, intravenous fluid maintenance was managed using Ringer's Lactate (RL) solution, at the rate of 2 mL/kg/hour, intravenous paracetamol 1g for pain management and intravenous ondansetron 4 mg was administered as part of the standard recovery care. The vitals such as SpO₂, Heart Rate (HR), and Blood Pressure (BP) were continuously monitored. Pain was assessed at 1, 4, 8, and 12 hours postoperatively using the VAS and the requirement of rescue analgesics was also recorded.

Primary outcome measures: The primary outcome was postoperative pain intensity, evaluated by VAS at the exact time of extubation, and subsequently at one hour, four hours, six hours, eight hours, and 12 hours postsurgery.

Secondary outcome measures: Secondary outcomes were rescue opioid consumption at the postoperative and variations in baseline haemodynamic metrics {Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Heart Rate (HR)}.

STATISTICAL ANALYSIS

Data were collected and entered into Microsoft Excel and analysed using Statistical Package of Social Science (SPSS) version 27.0. Categorical variables were presented as frequencies and percentages, while continuous variables were summarised as mean±Standard Deviation (SD). The Mann-Whitney U test was performed to compare the means between the two groups. A Chi-square test was performed to find the difference in opioid usage in both groups.

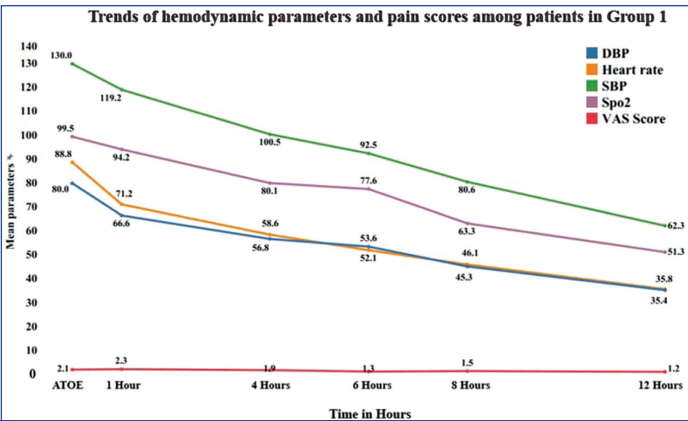
RESULTS

A total of 72 patients were enrolled and randomised equally into Group 1 (local infiltration) and Group 2 (TAP block) (n=36 each). Participants aged 21-50 years constituted the majority in both groups (Group 1: 19 (52.8%); Group 2: 23 (63.9%). Females predominated in both groups (Group 1: 23 (63.9%); Group 2: 20 (55.6%)) [Table/Fig-2].

	Group 1 (local infiltration) n=36	Group 2 (TAP block) n=36
Characteristics	n (%)	n (%)
Age (in years)		
21-50	19 (52.8)	23 (63.9)
>50	17 (47.2)	13 (36.1)
Gender		
Male	13 (36.1)	16 (44.4)
Female	23 (63.9)	20 (55.6)
Body Mass Index (BMI)*		
Normal	24 (66.7)	19 (52.8)
Overweight	12 (33.3)	17 (47.2)
ASA		
1 st grade	26 (72.2)	20 (55.6)
2 nd grade	10 (27.8)	16 (44.4)

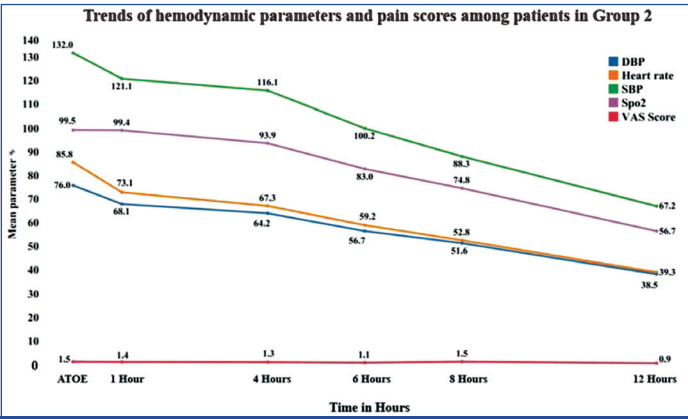
[Table/Fig-2]: Characteristics of the patients undergoing laparoscopic nephrectomy, (N=72).
*BMI based on Asian classification

Among the 36 patients in Group 1, haemodynamic parameters, including HR, SBP and DBP and SpO₂, showed a progressive decline from the time of extubation to 12 hours postoperatively. The pain assessed using the VAS score showed minimal variation at all the time points [Table/Fig-3].



[Table/Fig-3]: Line graph showing the temporal changes of haemodynamic parameters and pain score among the patients who undergone laparoscopic nephrectomy in group 1 (n=36).

Among the 36 patients in Group 2, haemodynamic parameters, such as HR, SBP and DBP and SpO₂, showed a progressive decline from the time of extubation to 12 hours postoperatively. The pain was assessed using the VAS score and showed minimal variation at all the time points [Table/Fig-4].



[Table/Fig-4]: Line graph showing the temporal changes of haemodynamic parameters and pain score among the patients who underwent laparoscopic nephrectomy in group 2 (n=36).

There were no statistically significant differences in HR, SpO₂, SBP or DBP at any postoperative time point between two groups.

Pain was assessed for all the patients using the VAS at various time points. The mean VAS score was compared between both groups. The difference in mean VAS scores was observed between both the groups at the time of extubation and at one hour after extubation with a mean difference of 0.6±0.2-0.9 and 0.9±0.2-1.5, respectively, which was statistically significant (p-value <0.05) [Table/Fig-5].

	Group 1 (Local infiltration)	Group 2 (TAP Block)	Mean difference (95% CI)	p-value
Time	Mean±SD	Mean±SD		
At the time of extubation	2.1±0.7	1.5±0.7	0.6 (0.2-0.9)	0.001
One hour	2.3±1.4	1.4±1.4	0.9 (0.2-1.5)	0.006
Four hours	1.9±2.1	1.3±1.2	0.6 ((-0.2)-1.4)	0.159
Six hours	1.3±1.6	1.1±1.1	0.2 ((-0.4)-0.8)	0.566
Eight hours	1.5±2.0	1.5±1.6	-	0.692
Twelve hours	1.2±1.8	0.9±1.1	0.3 ((-0.4)-1.0)	0.880

[Table/Fig-5]: Comparison of mean VAS scores between two groups undergoing laparoscopic nephrectomy, at various postoperative time points (N=72).
*Mann-Whitney U test

The opioid usage was assessed in both groups, and the difference in usage was compared. The difference in opioid usage was statistically significant across the groups, with a p-value of 0.03 [Table/Fig-6].

Groups	Opioid usage		p-values
	Given	Not given	
Group 1 (Local infiltration)	26 (72.2%)	10 (27.8%)	0.03
Group 2 (TAP block)	14 (38.9%)	22 (61.1%)	

[Table/Fig-6]: Difference in opioid usage among two groups undergoing laparoscopic nephrectomy surgery. (N=72).
Values presented as n (%)

DISCUSSION

The present study compared the efficacy of 0.5% Ropivacaine infused by ultrasound-guided TAP block against port site local infiltration in prolonging postoperative analgesia in patients undergoing laparoscopic donor nephrectomy at study Institute in South India. Patients receiving TAP block experienced lower postoperative pain scores during the early postoperative period and required significantly less opioid analgesia, indicating better pain control and enhanced recovery.

In the present study, the temporal changes of the haemodynamic parameters in both the groups showed a progressive decline from time of extubation to 12 hours after extubation, which underscores postoperative haemodynamic stabilisation. No statistically significant differences were observed between the two groups at any of the measured time points, indicating that both analgesic techniques provided comparable cardiovascular stability during the postoperative period. To the present knowledge, the direct comparison with previous studies in living donor nephrectomy is limited because no published study has specifically evaluated haemodynamic parameters between TAP block and local wound infiltration.

The present study demonstrated significantly lower VAS scores at extubation and one hour after extubation in patients who received a TAP block compared with those who underwent local wound infiltration. This observation aligns with the findings of Park JM et al., who reported improved postoperative pain control and enhanced recovery outcomes following TAP block administration in patients undergoing laparoscopic nephrectomy [21]. Similarly, Loganathan S et al., reported that ultrasound-guided Erector Spinae Plane Block (ESPB) provided better postoperative pain control than wound infiltration in patients undergoing laparoscopic nephrectomy [11]. These findings highlight the analgesic effect of the TAP block in the immediate postoperative period, when pain intensity is highest. In contrast, the study conducted by Agrawal S et al., reported that the VAS scores were similar in both groups during the initial postoperative period, but they were relatively lower in the TAP block group after six hours of surgery [9]. Similarly, Güner Can M et al., reported that the TAP block given with bupivacaine showed that the VAS score was lower compared to the Placebo group, but not at all the time points [22].

This finding underscores the early (immediate/first-hour) efficacy of TAP block in pain management, which might be due to the wider spread of local anaesthetic within the fascial plane and the blockade of thoracolumbar nerves. Although the VAS scores differed between the two groups, the difference was not statistically significant except at the time of extubation and one hour after extubation. However, patients in the TAP block group (Group 2) consistently reported lower pain scores throughout the postoperative period. Similar findings were reported by Araújo AM et al., who evaluated postoperative pain and recovery following TAP block and Trocar Site Infiltration (TSI) [19]. Their study demonstrated lower mean VAS scores in the TAP block group compared with the TSI group, but the difference was not statistically significant. This lack of statistical significance might be due to the relatively small sample size

In present study, opioid requirement was significantly lower in the TAP block group; this reduction in opioid consumption is clinically important in donor nephrectomy patients, as it reduces the opioid-related adverse effects and enhances the postoperative recovery.

This finding is consistent with the study conducted by Loganathan S et al., which reported that the 24-hour morphine consumption was significantly higher in the wound infiltration group compared to the ultrasound-guided ESPB group [11]. Similarly, Güner Can M et al., also reported that patients receiving a TAP block require less morphine [22].

This highlights the opioid-consumption reducing effect of the TAP block.

Limitation(s)

The present study has some limitations. Pain was assessed subjectively, which might have led to variation and introduced measurement bias. The psychological factors, like preoperative stress, fear, and anxiety that influence the pain perception were not studied. Variation in surgery duration and techniques may also influence postoperative pain, leading to bias.

CONCLUSION(S)

Ultrasound-guided TAP block showed improved postoperative analgesia following laparoscopic donor nephrectomy compared to port-site infiltration with lower early postoperative pain scores. Additionally, the TAP block also reduces opioid consumption by providing effective anterior abdominal wall coverage. Thereby, minimising narcotic exposure successfully limits opioid-related side effects and optimises the recovery pathway. Future studies could consider psychological factors, such as anxiety or fear, as well as visceral pain assessment to better understand their influence on pain perception and to establish a more comprehensive evaluation of the analgesic efficacy of the TAP block.

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