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Original Research Article

Ultrasound-guided subcostal transversus abdominis plane block versus erector spinae plane block for post-operative pain after percutaneous nephrolithotomy: A comparative observational study

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ABSTRACT

Background: In India, about 12% of the population has kidney stones, and out of these about 50% may end up with some kidney function loss or renal damage percutaneous nephrolithotomy (PCNL) is accepted as the procedure of choice for large or complex renal stones. Significant post-operative pain can occur after PCNL in first 24 hours due to distension in the renal capsule and pelvicalyceal system. The study aim was to compare the efficacy of ultrasonography guided subcostal transversus abdominis plane block with erector spinae plane block in PCNL.

Materials and Methods: This observational study included 67 consecutive cases (16-65 years, ASA grade I-II) divided into 2 groups. Group A (n=33) received subcostal transversus abdominis plane (SCTAP) block and Group B (n=34) received erector spinae plane block (ESPB). Post operative pain in terms of pain scores, opioid consumption, requirement of rescue analgesic in first 24 hours was noted. Quality of recovery and any adverse events were also noted.

Results: Post-operative opioid consumption was significantly less in ESPB group (34.41 ± 27.32 mcg), compared to SCTAP Group (270.91 ± 121.41 mcg). Group B patients had better post operative quality of recovery compared to Group A patients. VAS pain scores at almost all time-points were lower in the ESPB group.

Conclusion: ESPB provided effective postoperative analgesia and reduced fentanyl consumption postoperatively compared to SCTAP block.

1. Introduction

Renal stone is common worldwide, has a prevalence of more than 10% and a recurrence rate of nearly 50%. It affects people between age group 30 to 60 years, men slightly more than women.[1] PCNL is the gold standard treatment for large or complex renal stones.[2,3]

Despite being minimally invasive, PCNL is accompanied by severe postoperative pain due to renal capsule distension, dilatation of pelvicalyceal system and placement of nephrostomy tube.[4]

Currently many curative options have been used to control this pain.[5,6] Regional blocks given perioperatively is considered an essential component for multimodal analgesic regimes.[5]

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Hebbard et al. first described ultrasound-guided Sub costal TAP block. It is a variation of TAP block having a sensory block distribution between segments T6–T10 on the abdominal wall. Due to this extent of sensory block, it can be given in patients undergoing PCNL surgeries.[7,8]

In ESPB, the drug is injected into fascial plane between erector spinae muscles and transverse process of the vertebra ESPB blocks both dorsal and ventral branches of the thoracic as well as abdominal spinal nerves; providing both somatic & visceral analgesia.[9]

We hypothesized that ESPB or SCTAP block would provide effective pain relief and could be used as a component of multimodal opioid-sparing analgesia techniques. The primary outcome was to evaluate the fentanyl consumption in the first 24 hours and time of first post operative analgesic request. The secondary outcome were quality of recovery, opioid related side effects and block related complications

2. Materials and Methods

This observational study was conducted after approval from the university ethics committee (SRHU/HIMS/ETHICS/2021/98). We obtained written informed consent from all study participants. We enrolled patients of age 18-65 years and ASA grade I-II. The exclusion criteria being patient refusal, local anesthetics / opioids allergy, bleeding disorders, infection at local site, patient on anti-coagulants, psychiatric disorders, pregnancy, inability to give informed consent, and known abuse of alcohol and medications.

Sample size was calculated using the formula: -

$n_1 = \{(\sigma_1^2 + \sigma_2^2 / K) (Z_{1-\alpha/2} + Z_{1-\beta})^2\} / \Delta^2$

Where Δ = difference between the two means of fentanyl consumption in 24 hours[10]

σ_1 and σ_2 = variance in group 1 and 2

$Z_{1-\alpha/2}$ = standard variate at 95% confidence interval

$Z_{1-\beta}$ = power at 95%

$n_1 = 16 \sim 20$

Assuming 20% attrition rate;

A minimum of 25 cases is required in each group. To prevent sample size reduction owing to dropouts during the research, we enrolled a total of 70 patients. (Diagram 1)

All selected patients underwent routine pre-anesthetic checkup. Patients were kept fasting as per standard fasting guidelines and premedicated with tablet ranitidine 150 mg and tablet alprazolam 0.25 mg the night before and 2 hours prior to surgery. All study participants received general anesthesia as per the institution protocol. Injection paracetamol 1 gm was given intraoperatively ten minutes before completion of surgery. Ultrasound guided unilateral SCTAP block or ESP block was performed after the completion of surgery by a trained anaesthesiologist.

SCTAP block was performed in supine position with a linear high-frequency (6–13 MHz) ultrasound transducer (FUJIFILM Sonosite, Inc., Bothell, Washington, USA). Ultrasound probe was kept parallel to the subcostal margin near the xiphoid process. With the probe near the xiphoid, the 23-gauge Quincke spinal needle (BD; Madrid, Spain) was advanced in-plane, passing just below the rectus abdominis muscle to the transversus abdominis plane. Ropivacaine (0.2%) 20 ml was injected under ultrasound guidance and was visualized as a hypoechoic layer transecting the TAP.

ESP block was performed in prone position; the T10 vertebra was located using a counting down approach under ultrasonography and marked. A linear ultrasound probe was placed parallel to the vertebral axis at T10 vertebral level. A hyperechoic shadow of the transverse process (TP) and erector spinae was defined. A 100 mm 22-gauge sonoplex (B Braun, Ultra 360, Bbraun, Aesculap, Japan) needle was used to enter the fascial plane on the anterior aspect of erector spinae muscle, aiming towards the transverse process until the needle reached the TP piercing all the muscles. The confirmation of the location of the needle tip was done by injecting normal saline solution. Separation of erector spinae muscle off the bony shadow of the TP could be seen on ultrasound imaging. After confirming correct needle tip position, injection ropivacaine (0.2%) 20ml was injected.

After giving the block, residual neuromuscular blockade was reversed with injection neostigmine 0.05mg/kg and injection glycopyrrolate 0.01mg/kg. When consciousness and spontaneous respiration were adequately restored, the patient was extubated and shifted to post anesthesia care unit. PCA pump with fentanyl was attached with concentration of 10mcg/ml of fentanyl. Dose of fentanyl delivered through PCA pump was 1 ml with lockout interval of 10 minutes and a 4-hour limit of 200 mcg. Along with it, paracetamol 1 gm intravenously was given every 8 hourly. If pain persisted even after the usage of PCA pump, tramadol 100 mg intravenously was given as rescue analgesic.

The pain intensity was assessed using Visual Analogue Scale (VAS) for first 24 hours. VAS scores to evaluate the quality of analgesia in static position when the patients were restricted in bed, and dynamic position when the patients were asked to cough, move his/her lower limbs and made to sit in bed starting 4 hours after the completion of surgery.

To measure quality of recovery, validated and psychometrically evaluated questionnaire QoR-15 from Stark and colleagues was used. It is a short form of the comprehensive 40-item questionnaire QoR-40. QoR-15 consists of fifteen questions to measure the quality of recovery under five domains: pain, physical comfort, physical independence, psychological support, and emotional state.[11] The subjects included in the study filled the questionnaire QoR-15 before their surgery. It was a baseline measure of health status. Patient then repeated the questionnaire 24 hours after surgery. A scale of 0 to 10

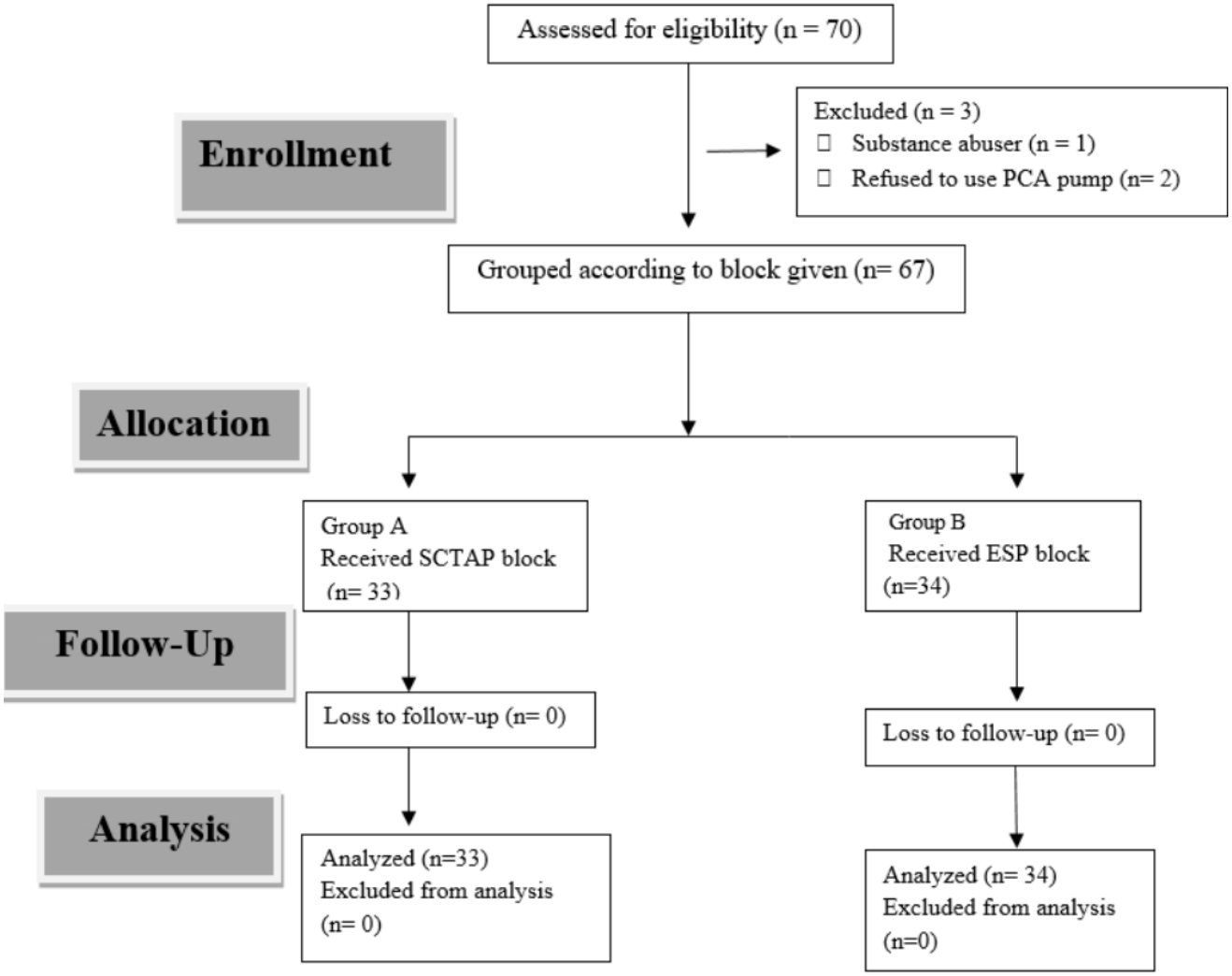

Diagram 1: Consort flow diagram PCA: Patient controlled analgesia; N: Number

is used with 0 representing the lowest, and 10 the highest score. Thus, the total score ranges from 0-150. A high score represents good recovery. Adverse effects if any were noted.

The primary outcome was to evaluate the fentanyl consumption in the first 24 hours, time of first post-operative analgesic request, total amount of prescribed rescue analgesic in PACU. The secondary outcome variables were quality of recovery, opioid related side effects, symptoms of local anesthetic toxicity (LAST), block related complications or other complications like nausea and vomiting, hypotension, bradycardia.

The collected data was organized, tabulated, and statistically analyzed using SPSS version 28.0 (SPSS, Chicago, Illinois) program for Windows. Continuous statistics for the quantitative data were presented as mean ± Standard deviation (SD), and categorical variables (quantitative data) were presented as absolute numbers and percentage. Data was checked for normality before statistical analysis. Normally distributed continuous variables were statistically analysed using the unpaired t test. Variables which were not normally distributed were compared by Mann-Whitney U test. Categorical variables were analyzed using the chi square test.

A p value < 0 05 was taken to indicate a significant difference.

3. Results

70 patients were initially enrolled, 67 finally followed up. 2 patients refused the usage of PCA pump, 1 substance abuser was excluded to avoid interference of excessive fentanyl/ tramadol consumption inconsistent with the pain scores of the patient (Diagram 1).

The two groups were comparable regarding age, sex, weight, or ASA physical status of the patient (Table 1). Duration of surgery and size of stone was also comparable

in both groups (Table 2). The static and dynamic VAS pain scores during first 24 hours post operatively were significantly lower in ESP block group as compared to SCTAP block group (Figures 1 and 2).

Mean total fentanyl consumption (Group A: 270.91 mcg ± 121.41; Group B: 34.41mcg ± 27.32) and total rescue analgesic (tramadol) consumption over first 24 hours (Group A: 93.94 mg ± 89.92; Group B: 5.88mgs ± 23.88) was significantly lower in ESPB group. Time of first analgesic request after extubation was significantly prolonged in ESPB (623.89 minutes ± 237.16) as compared to SCTAP block group (132.12 minutes ± 96.41) (Table 3).

Post operative quality of recovery, assessed using QoR 15 questionnaire, showed comparable preoperative scores in both groups (p value > 0.05). ESPB group patients scored higher in the domains of physical comfort and emotional condition compared to SCTAP group patients post-operatively. (p value < 0.001) (Figure 3).

In our study we observed that in ESPB group, 4 patients had nausea 1 patient had vomiting whereas in SCTAP group, 2 patients had nausea and 3 had vomiting which was treated with ondansetron 0.1 mg/kg i.v. P value was not found to be significant. No other side effects or complications related to the blocks given were seen in both the groups.

Table 1: Demographic data

	"Group A " (n=33)	"Group B " (n=34)	p value
Age (yrs) Mean ± SD	41.36 ± 12.52	46.14 ± 12.55	0.123
Sex (M: F)	22:11	24:10	0.729
ASA physical status grade (I: II)	25:8	20:14	0.140
Weight (Kg) Mean ± SD	67.88 ± 10.97	66.68 ± 11.45	0.662

Yrs: Years, SD: Standard Deviation, M:F- Male: Female, ASA: American Society of Anesthesiologists, Kg: Kilogram

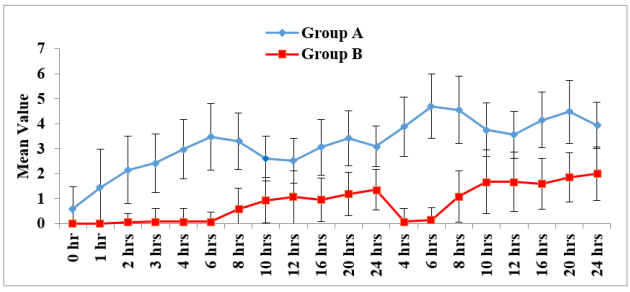

Figure 1: Comparison of mean VAS (static) at various time intervals between the two groups VAS: Visual Analogue Scale

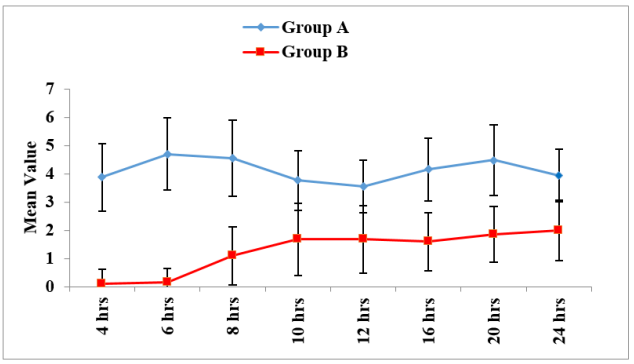

Figure 2: Comparison of mean VAS (dynamic) at various time intervals between the two groups VAS: Visual analogue scale

4. Discussion

Our study demonstrated that patients undergoing PCNL procedures who received ESPB required less opioids overall and took longer time to obtain an analgesic than those who received SCTAP block.

Both static and dynamic VAS pain scores were lower in ESPB group than SCTAP group in first 24 hours post-operatively. The total rescue analgesic (tramadol) consumption during first 24 hours post operatively was also lower in ESPB group.

Postoperative pain for intraabdominal surgeries is a combination of somatic and visceral pain. Visceral pain is transmitted via sympathetic fibers of the autonomic nervous system that form plexuses close to the viscera. Visceral pain is usually dull, diffuse, and poorly localized. It may be associated with numerous autonomic symptoms like nausea, vomiting and sweating. Nerve blocks of the abdominal wall generally treat more localized somatic pain, hence should be used as a part of multimodal analgesia.[12]

The oblique Sub costal TAP block, potentially gives analgesia for both upper and lower abdominal surgeries. Chen Ck et. al stated that subcostal TAP block significantly decreased the peri-operative opioid consumption in patients of laparoscopic cholecystectomy.[13]

Ozdemir et al. did a study where they compared ultrasound-guided ESPB and SCTAP in patients undergoing elective laparoscopic cholecystectomy. Comparisons were made between pain scores at rest and while moving, fentanyl usage, postoperative walking time, and length of hospital stay. It was found that in the ESPB group, VAS scores at rest and movement were lower (p value < 0.05) at all time intervals. Fentanyl requirement both intraoperatively and postoperatively was less in ESPB (p value < 0.0001) and Post Operative Care Unit (PACU) rescue analgesic need (p value < 0.05) were also lower.[10,14]

Gultekin MH et al. compared the efficacy of ESPB with Conventional Analgesia (CA) in pain management after percutaneous nephrolithotomy (PCNL) in 60 patients. They

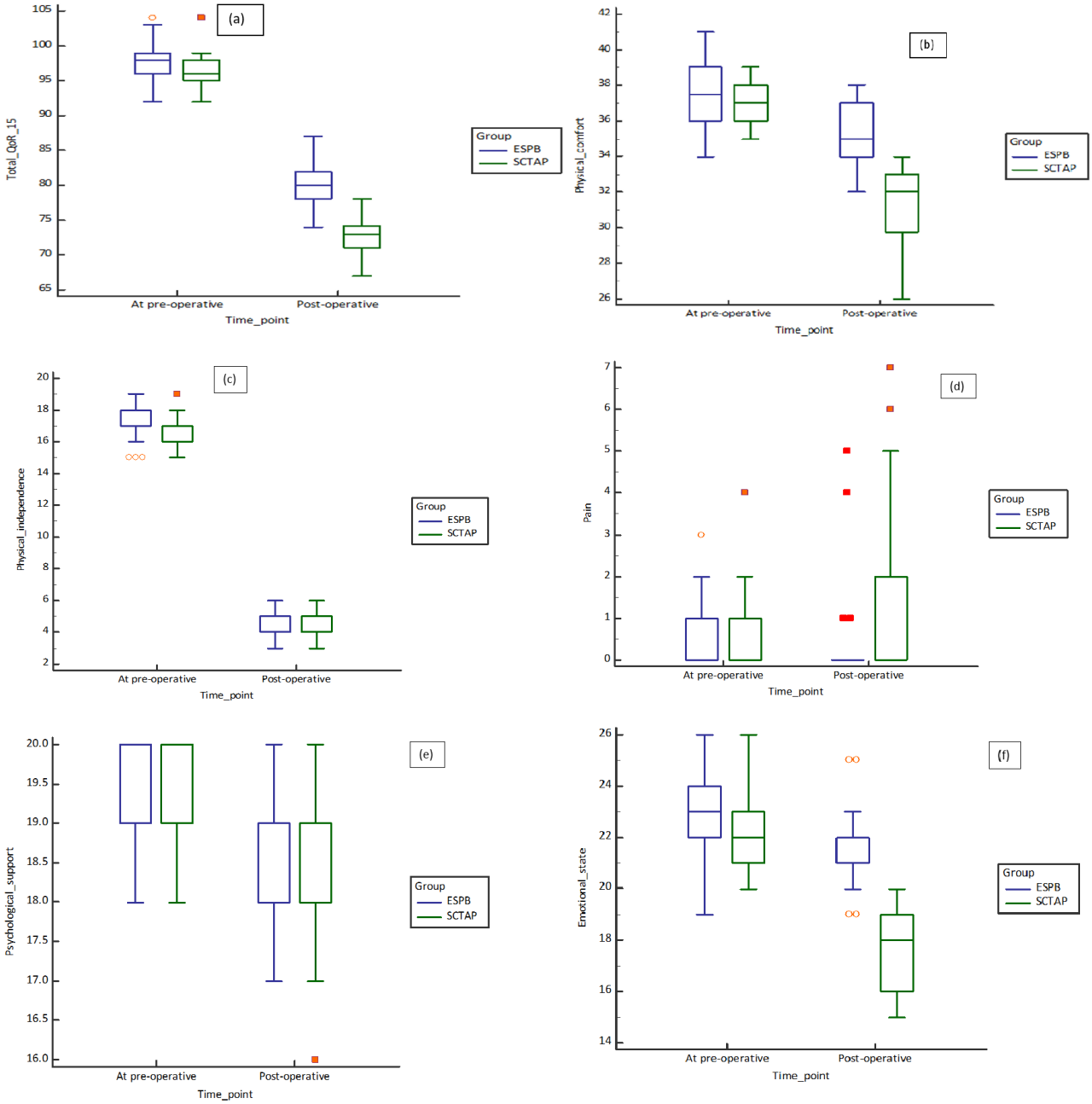

Figure 3: (**a**) Box Plots of the preoperative and postoperative 24 hours QoR15 score overall and for each domain, (**b**) Physical comfort, (**c**) Physical independence, (**d**) Pain, (e) Psychological support and (**f**) Emotional State. (**a-f**) Marker shows the median value; upper and lower caps show 75th and 25th percentile value. Middle line shows the median value; upper and lower caps show 75th and 25th percentile value; circle/square dots are outliers. ESPB- Erector spinae plane block, SCTAP- Subcostal transversus abdominis plane block

Table 2: Comparison of duration of surgery and size of stone between the two groups

	"Group A" "Mean ± SD"	**"Group B" "Mean ± SD"**	**"p value"**
Duration of surgery (minutes)	110.61 ± 22.42	114.35 ± 23.33	0.505
Size of stone (mm)	18.41 ± 6.33	18.04 ± 7.28	0.823

Student's t test
SD: Standard deviation, mm = Millimeter

Table 3: Total fentanyl consumption, total rescue analgesic consumption, time of first analgesic request between the two groups

	Group A			**Group B**			**p value**
	Mean ± SD	Min - Max	Median (IQR)	Mean ± SD	Min - Max	Median (IQR)	
Total Fentanyl Consumption over 24 hours (mcg)	270.91 ± 121.41	80 - 580	260 (165-370)	34.41 ± 27.32	0 - 120	30 (17.5 - 50)	<0.001
Total rescue analgesic consumption in 24 hrs (tramadol in mg)	93.94 ± 89.92	0 - 300	100 (0-200)	5.88 ± 23.88	0 - 100	0 (0-0)	<0.001
Time of first analgesic request after extubation (minutes)	132.12 ± 96.41	15 - 430	110 (50 - 200)	623.89 ± 237.16	160 - 1470	615 (465 - 760)	<0.001

Student's t test; Mann Whitney
SD: Standard deviation, Min: Minimum, Max: Maximum, IQR: Interquartile range, mcg: Microgram, hrs: hours, mg: Milligram

used 20 ml of 0.5% of bupivacaine and concluded that ESPB is a safe technique that provides effective postoperative analgesia in patients undergoing PCNL. The time to first rescue analgesic was longer in the ESPB group compared with the CA group (172.33 ± 180.5 minutes vs 84.33 ± 71.12 minutes), which was statistically significant (p = 0.016).[15]

In our study stated that the ESPB produced statistically significant reduction in post-operative pain when compared to the SCTAP block. Total fentanyl consumption in 24 hours post-operative period was 34.41 ± 27.32 mcg in ESPB group compared to 270.91 ± 121.41 mcg in SCTAP block (p value < 0.001).

VAS (both static and dynamic) pain scores were significantly lower at all time intervals in first 24 post-operative hours in ESPB group as compared to SCTAP Group (p value < 0.001).

In the present study, time interval of the first requirement of analgesic in PACU was significantly more in the ESPB group (623.89 ± 237.16 min) than SCTAP group (132.12 ± 96.41 min) which indicates that ESPB was providing more effective postoperative analgesia than SCTAP block. Ibrahim et al. and Gultekin et al. in their studies observed that the mean time to first analgesia was 166.6 min and 172.33 ± 180.5 min, respectively in ESPB group. The shorter duration of analgesia postoperatively when compared to the present study could be because the block was performed preoperatively in those studies.[15,16]

None of the patients in our study experienced failed ESPB or SCTAP blocks as evident by postoperative VAS Score. Previous research has highlighted various factors that can impact block success, such as differences in fascial anatomy, incorrect dermatomal targeting, and variations in the concentration and volume of local anesthetic used.[9,17,18] Our findings align with existing literature, demonstrating that both ESPB and SCTAP blocks significantly reduce the need for postoperative analgesics compared to control groups. This emphasizes their effectiveness in providing enhanced post-surgical pain relief.[14,19,20]

QoR15 questionnaire was used to assess and compare the post-operative quality of recovery between the two group. The ESPB group patients scored better in domains of physical comfort and emotional state compared to SCTAP group in the post-operative period (p value < 0.001).

Our study faced several limitations, primarily due to our small sample size. Conducting future studies with a larger sample would enhance the statistical power and reliability of our findings. Additionally, we did not evaluate long-term pain outcomes or duration of hospital stay, which are important factors in assessing the overall impact of ESPB and SCTAP blocks. Furthermore, the absence of a control group for comparison limits our ability to fully contextualize the effectiveness of these blocks compared to standard care. Addressing these aspects in future research could provide a more comprehensive understanding of their clinical benefits.

5. Conclusions

The ESP block, compared with the SCTAP block has better analgesia profile, delays the time for first post-operative analgesic requirement, and reduces the total opioid and rescue analgesic consumption. It can thus be used as a part of opioid sparing and multimodal analgesia regimens after PCNL surgeries.

6. Sources of Funding

None.

7. Conflict of Interest

None.

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