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Assessing the Efficacy of Ultrasound-Guided Erector Spinae Plane Block in Pyelolithotomy or Nephrectomy Patients

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ABSTRACT

Nephrectomy and pyelolithotomy are invasive surgical procedures often associated with significant postoperative pain, necessitating effective analgesia for optimal recovery. **Objectives:** To evaluate the efficacy of ultrasound-guided erector spinae plane block (ESPB) in patients undergoing nephrectomy or pyelolithotomy, with a focus on pain relief, dermatome coverage, and duration of analgesia. **Method:** This quasi-experimental study was conducted over 12 months in the Anesthesia Department of Sharif Medical City Hospital, Lahore, enrolling 66 patients. After receiving ESPB, postoperative pain was assessed using the Visual Analogue Scale (VAS) at rest, where 0 indicated no pain and 10 indicated the worst possible pain. Dermatomal coverage was evaluated via pinprick testing, and the time to first rescue analgesia was recorded. Data analysis was performed using SPSS version 25.0. **Results:** Out of the 66 patients, 47 were male and 19 female. VAS scores showed a significant reduction from 2.98 ± 1.31 at 24 hours to 0.87 ± 0.83 at 72 hours (p=0.000). Pain on movement significantly decreased (p=0.000), while sleep quality showed no significant improvement. The proportion of patients reporting adequate pain relief rose from 67.3% at 24 hours to 81.5% at 72 hours (p=0.000). Peak rescue analgesia demand occurred at 15–16 hours postoperatively (25 patients), indicating prolonged initial analgesia. **Conclusions:** It was concluded that the ultrasound-guided erector spinae plane block (ESPB) effectively manages pain, significantly reducing VAS scores over 72 hours. This method delivers high-quality analgesia with consistent dermatome coverage following pyelolithotomy and nephrectomy.

INTRODUCTION

Nephrectomy and pyelolithotomy are complex surgeries causing significant pain due to tissue manipulation, inflammation, and surgical trauma [1]. Postoperative pain intensity and duration vary due to surgical technique, patient factors, and comorbidities. Poor pain control reduces comfort, increases complications, prolongs hospital stay, and delays recovery. Additionally, in patients with existing or surgery-related renal impairment, careful analgesic selection and dosing are essential to avoid nephrotoxicity [2]. Normal clinical procedure for pain relief after pyelolithotomy and nephrectomy involves instituting multimodal analgesia, which integrates both pharmacological and non-pharmacological interventions in an attempt to lower morbidity and mortality [3]. Morphine and hydromorphone provide pain relief but have side effects and tolerance issues, which peripheral nerve blocks and epidurals help reduce by lowering opioid use [4]. The erector spinae plane block (ESPB) has proven effective in decreasing opioid administration after surgery and is applicable in several surgical procedures, which include

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thoracic, abdominal, and limb surgeries. [5]. ESPB is performed at lumbar or thoracic levels, where the erector spinae muscles are superficial, targeting the plane between these muscles and the vertebral transverse processes. Injection here blocks dorsal and ventral spinal nerves, providing relief for both visceral and somatic pain. [6]. Local anesthetic spread causes sympathetic blockade, leading to vasodilation and reduced pain signal transmission. ESPB effectively lowers pain scores and opioid use across surgeries, with analgesia duration varying by agent, dose, patient, and procedure [7]. ESPB provides prolonged analgesia lasting up to 24 hours and supports faster recovery through early mobilization, reduced hospital stay, and improved patient satisfaction. [8] Anatomical variations, such as erector spine muscle thickness and neurovascular proximity, can affect ESPB efficacy, highlighting the need for patient-specific planning [9]. Hematoma risk is a concern in coagulopathic or anticoagulated patients, warranting coagulation assessment and perioperative precautions. Improper spinal positioning may also hinder accurate needle placement and block success [10]. Though generally safe, ESPB carries risks of iatrogenic injury to neurovascular structures and pleura, especially at caudal thoracic levels; ultrasound guidance significantly reduces these risks by allowing real-time visualization [11, 12]. Complications like pneumothorax and systemic anesthetic toxicity, while rare, necessitate vigilance and adherence to dosing protocols, with readiness for interventions like lipid therapy [12]. Ultrasound aids in accurate needle placement, anesthetic spread, and avoidance of vital structures, improving safety and efficacy [13,14]. It also supports operator learning and standardization of technique, including in diverse clinical settings like Rawalpindi [15]. However, limitations remain regarding consistent evaluation of ESPB effectiveness and duration of postoperative analgesia [16]. Long-term follow-up is essential to assess the sustained effectiveness of ESP blocks, particularly after renal surgeries where dermatomal coverage remains unclear.

Despite the effectiveness of multimodal analgesia in managing postoperative pain after nephrectomy and pyelolithotomy, opioid-related side effects and variability in pain control highlight the need for safer and more effective regional techniques such as the erector spinae plane block (ESPB). However, limited evidence exists regarding its analgesic efficacy, duration of action, and safety profile specifically in renal surgeries, particularly in local clinical settings. This study aims to evaluate ultrasound-guided ESP blocks in kidney procedures in Rawalpindi, focusing on analgesic efficacy, duration, and safety. Findings aim to refine block techniques and guide evidence-based perioperative pain management.

METHODS

A quasi-experimental study was done in the Anesthesia Department of Sharif Medical City Hospital from September 2022 to May 2023 after taking approval from the ethical review board of Sharif Medical City Hospital (IRB # 507-22).After informed consent, all the patients underwent open nephrectomy or pyelolithotomy under general anesthesia through flank incision.A specific criterion of inclusion and exclusion was designed.Inclusion criteria were patients aged between 20 and 65 years, either male or female and who came under the ASA II category.ASA Physical Status classification is a universally applied system to assess and communicate the pre-anaesthetic medical condition of the patient and related comorbidities. It contributes to the perioperative risk evaluation and makes the preoperative evaluation uniform. In the present study, only ASA II patients were analyzed, which means such individuals with mild and well-controlled systemic diseases that do not affect normal activity. Study excluded the patients who were operated on with any other incision, had a history of allergy to local anesthetics, any skin pathology at the site of needle insertion, bleeding disorders, diabetes, liver disease, psychiatric illness, or any other comorbidity.The sample size of 66 patients with open nephrectomy was estimated using the prevalence of open nephrectomy was 78% [17], at a 10% margin of error and 95% confidence level with the following formula: $n=Z^2_{a/2}P(1-P)/d^2$.Patients were educated about the post-operative pain score preoperatively. All blocks were given in lateral decubitus position once the patient was given general anesthesia. We gave 0.25% bupivacaine at a dose of 1 ml/kg. After painting and draping, a 6-12 MHz linear ultrasound probe was placed parallel to the spine in a cephalocaudal orientation over the midline of the back between 10 to 12th thoracic vertebrae. The probe then slowly moves laterally until the transverse process of T11 is visible. Following this, the erector spinae is identified as being superficial to the transverse process. A 20-gauge spinal needle was advanced over the probe, in cephalad to caudal direction, using an in-plane approach. The needle is inserted until the tip touches the transverse process. Then the needle was withdrawn a little, and local anesthetic was injected. Before injecting the anesthetic, the plunger was withdrawn to confirm no intravascular injection was being given. The injection was then given slowly, and a separation of the plane between erector spinae and transverse process was observed, confirming the proper plane of injection. Postoperative pain at rest was evaluated using the Visual Analogue Scale (VAS) after the patient responded to verbal prompts and following the administration of the erector spinae plane (ESP) block. The VAS is a scale from 0 (no pain) to 10 (worst imaginable pain) [18]. Pain assessment was done at 24, 48, and 72 hours' post-surgery. To assess the degree of sensory blockade, the dermatomes were evaluated using the pinprick method

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within 30 to 45 minutes after the block was given during the early postoperative period. Satisfaction with pain management was measured in addition to objective assessment of pain using the Revised American Pain Society Patient Outcome Questionnaire (APS-POQ-R) at 24, 48, and 72 hours postoperatively. This validated, multidimensional instrument captures multiple dimensions of pain care, including pain intensity, relief, interference, and communication with the healthcare provider. In addition, time to first rescue analgesic (in hours) was noted for each patient to assess the duration of effective analgesia [19]. Patients' baseline information like Age (years), Gender, BMI (kg/m2), Surgical side (R/L), ASA classification and Surgical Procedure (Open nephrectomy/pyelolithotomy) were collected on a pre-designed performa. All the data were entered and analyzed by SPSS version 25.0. Descriptive analysis was conducted by calculating Frequencies, percentages and mean ± SD for study variables. The comparison of mean pain score among different intervals was done by using one-way ANOVA after checking normality of data by Kolmogorov-Smirnov. Statistical significance was determined at p-value<0.050.

RESULTS

A total of 66 patients were included in this study. The average age reported in the current study was 46.2 ± 11.8 years. There were male (71.2%), while 28.7% were female. Regarding surgical laterality, 45 patients underwent surgery on the left side, while 21 had right-sided procedures. Based on the ASA classification, 56.0% of patients were categorized as ASA I, and 43.9% as ASA II. The most common surgical procedure performed was pyelolithotomy (59.0%), followed by open nephrectomy (40.9%)(Table 1).

Table 1: Patient Demographics and Baseline Information (n=66)

Parameters	n (%)
Age	
Years	46.2 ± 11.8
Gender	
Male	47 (71.2%)
Female	19 (28.7%)
BMI	
(kg/m^2)	24. 3 ± 3.1
Surgical side (R/L)	21/45
ASA Classification	
ASA I	37 (56.0%)
ASAII	29 (43.9%)
Surgical Procedure	
Open nephrectomy	27 (40.9%)
Pyelolithotomy	39 (59.0%)

Post-procedure pain showed a significant reduction over time following the erector spinae block (ANOVA: F=64.3, p=<0.001). The VAS score at 24 hours was 2.98 ± 1.31, decreasing to 2.33 ± 1.07 at 48 hours, and further to 0.87 ± 0.83 at 72 hours. This progressive decline in pain scores indicates the sustained analgesic efficacy of the erector spinae block over three days postoperatively (Table 2).

Table 2: Comparison of Mean Pain Score and Different Time Interval among Patients

Post-Procedure Pain Levels (After the Erector Spinae Block)	Visual Analogue Score (Mean ± SD)	ANOVA (df), p-value
24 Hours	2.98 ± 1.31	64.3 (2), <0.001
48 Hours	2.33 ± 1.07	
72 Hours	0.87 ± 0.83	

The frequency of dermatome anesthesia achieved following the administration of the erector spinae block (ESB) was assessed across several levels. At the T8 level, anesthesia was observed in 17 participants (25.81%). At the T9 level, anesthesia was achieved in 57 patients, representing 87.09% of the total cohort. At the T10, T11, and T12 levels, complete anesthesia was observed in all 66 patients. At the lower levels, specifically at the L1 level, anesthesia was achieved in 43 patients, which accounted for 64.51% of the total participants (Table 3).

Table 3: Frequency of Each Dermatome Anesthetized

Dermatomes	Frequency (%)
T8	17 (25.81%)
T9	57 (87.09%)
T10	66 (100%)
T11	66 (100%)
T12	66 (100%)
L1	43 (64.51%)

Patient satisfaction with pain management, assessed over 72 hours, showed significant improvements in most parameters. Pain on movement in bed decreased from 2.95 ± 1.66 at 24 hours to 0.89 ± 0.80 at 72 hours (ANOVA: 38.21, p=<0.001), and pain during activity out of bed also declined significantly (ANOVA: 5.69, p=0.004). In contrast, sleep-related parameters (falling asleep and staying asleep) showed no significant variation over time (p=0.270 and p=0.954, respectively), suggesting minimal impact of pain management on sleep disturbances. Pain relief from treatment increased steadily from 67.3% at 24 hours to 81.5% at 72 hours (ANOVA: 31.9, p=<0.001), indicating effective pain control over time. These findings highlight progressive pain relief and improved mobility, though sleep disturbances remained unchanged (Table 4).

Table 4: Comparison of Patients' Satisfaction Scores Among Different Time Intervals

Patient Satisfaction Scores	Response at 24 (Hour)	48 (Hour)	72 (Hour)	ANOVA (df), p-value
Pain on movement in the bed (0-10)	2.95 ± 1.66	2.18 ± 1.47	0.89 ± 0.80	38.21 (2), <0.001
Pain while doing an activity out of bed (0-10)	2.42 ± 1.72	1.98 ± 1.49	1.56± 1.12	5.69 (2), 0.004

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Falling a sleep (0-10)	1.95 ± 1.41	2.27 ± 1.43	1.89 ± 1.46	1.31(2), 0.270
Staying a sleep (0-10)	2.46 ± 1.72	2.51 ± 1.72	2.42 ± 1.61	0.047(2), 0.954
Pain relief using pain treatment (0-100%)	67.3 ± 19.6	74.2 ± 15.6	81.5 ±13.7	31.9(2), <0.001

One Way ANOVA, Score Interpretation: 0=no pain, 10= worst pain, (0% = no relief, 100% = complete relief).

Only 5 patients required rescue analgesia within 4 hours, indicating good initial pain control. The need gradually increased, peaking at 15–16 hours with 25 patients. After 16 hours, the demand slightly decreased but remained notable (16 patients), suggesting the block's effect wanes around 15–16 hours postoperatively (Figure 1).

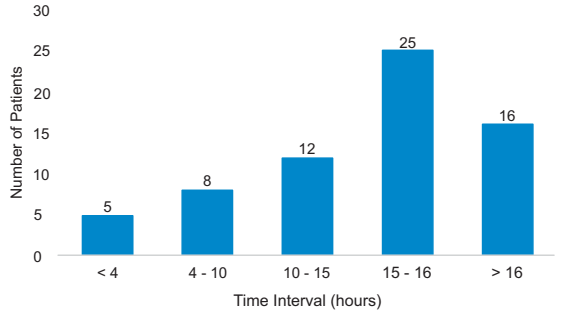

Figure 1: Distribution of Patients Based on the Time Interval Until Administration of Rescue Analgesia

DISCUSSION

Erector spinae block (ESB) has emerged as a promising alternative to traditional intravenous (IV) or inhalational anesthesia for pain management in open nephrectomy and pyelolithotomy. By directly targeting the nerves which transmit pain signals from the surgical site, ESB can provide effective pain management while minimizing systemic effects [20]. The study shows that ESB provides analgesic effects that are strong but also have a rapid onset; it reduces pain rapidly, which is helpful in clinical settings, for example, for acute trauma, emergency surgeries, or procedures requiring rapid pain relief. This immediate pain-relieving effect improves patient comfort, makes procedures easier to perform, and accelerates recovery after surgery. Moreover, ESB may help to decrease the systemic opioid consumption, together with the risks of respiratory depression and sedation. In addition, a randomized control trial by Elyazed showed that the ESB group (10 patients) had a lower rescue analgesia (pethidine) use compared to the control group (25 patients), with the requirement for rescue analgesia occurring after 12 hours and corresponding to 8 patients [21]. This aligns with the broader goal of continuous analgesia requirement, which aims to improve pain management by minimizing opioid exposure and related complications. Moreover, various studies have shown that erector spinae block provides a better analgesic effect than other types of block for renal surgeries. A randomized controlled trial has shown that erector spinae plane block provides non-inferior analgesia for pain at rest within 24 postoperative hours in comparison to thoracic paravertebral block for nephrectomy, which is consistent with the findings of this study [22]. An Indian study has also compared the post-operative analgesia of ultrasound-guided ESB with subcutaneous infiltration, showing that the first analgesia was given after 12 hours in ESB patients, while for the bupivacaine group first dose was needed after 30 minutes [23]. Ultrasound-guided ESPB reduces intravenous opioid consumption 24 hours after surgery, decreases postoperative analgesia requirements, and prolongs time to first rescue analgesia [24]. The erector spinae block (ESB) provides pain relief over several dermatomes, providing broader coverage than traditional nerve blocks or systemic analgesics. Research has shown 100% coverage in the T10, T11, and T12 dermatomes, 87.09% in T9, and 64.51% in L1, providing effective pain control distant from the site of incision. Such an extensive analgesic effect improves patient comfort during the postoperative period. Past studies indicate the efficacy of ultrasound-guided ESP blocks with 20 mL of 0.5% plain bupivacaine in the relief of pain in nine dermatomes with few complications [25]. With its efficacy and safety, the ESP block may prove to be a good choice for chest, abdominal, and limb surgery in Rawalpindi, which can decrease the requirement of strong opioids and enhance patient outcomes [26].

It is acknowledged that current research is limited by factors such as sample size and single-center study design. Nevertheless, existing data indicate that ESPB may serve as a safe and efficacious analgesic modality for lumbar surgical procedures. Future studies should include larger multi-center trials to confirm the safety and efficacy of ESPB in lumbar surgeries and optimize its clinical application.

CONCLUSIONS

Ultrasound-guided erector spinae plane block (ESPB) provides effective pain control, demonstrated by a significant decrease in VAS scores over 72 hours. Most patients required rescue analgesia only after 15 to 16 hours, indicating prolonged relief. This technique for managing perioperative pain in pyelolithotomy and nephrectomy offers high-quality, prolonged analgesia with consistent dermatome coverage and significantly reduced postoperative pain scores.

Authors' Contribution

Conceptualization: ST
Methodology: SN, AZ
Formal analysis: SN, MA
Writing and Drafting: ST, SA, HNA
Review and Editing: ST, SN, SA, AZ, HNA, MA

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

All the authors declare no conflict of interest.

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