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Original Article

Anaesthesia Section

Ultrasound-guided Erector Spinae Plane Block for Postoperative Analgesia in Patients undergoing Open Nephrectomy: A Randomised Controlled Study

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ABSTRACT

Introduction: Open nephrectomy poses a challenge for the anaesthesiologist due to its large subcostal incision and association with both somatic and visceral pain. While various methods exist for postoperative pain management, a single modality approach remains largely ineffective in adequate pain management. Epidural analgesia, intravenous Patient Controlled analgesia pumps, and ultrasound-guided peripheral nerve blocks are commonly used.

Aim: To evaluate the efficacy of ultrasound-guided Erector Spinae Plane Block (ESPB) as a part of multimodal analgesia for postoperative pain in patients undergoing open nephrectomy, to enhance recovery after surgery.

Materials and Methods: This randomised controlled study was conducted at Himalayan Institute of Medical Sciences, Dehradun, Uttarakhand, India, on 48 patients undergoing open nephrectomy. They were randomly assigned to two groups: Group I received ultrasound-guided ESPB, while Group II did not receive a block before anaesthesia reversal. In the Post-Anaesthesia Care Unit (PACU), all patients were kept on intravenous Patient Controlled Analgesia (PCA) morphine, and pain was assessed using the Numeric Rating Scale (NRS) scoring. The time of first analgesic requirement and the total morphine consumption in the first 24 hours were recorded. Patient satisfaction and quality of sleep at night were evaluated using a Likert scale. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 25.0. Categorical data were assessed using the Chi-square test, while the Independent t-test/Mann-Whitney test was used to determine the association between continuous data. A p-value of <0.05 was considered statistically significant.

Results: There were no significant differences found between the two groups in terms of age (p-value=0.999) and ASA grade (p-value=0.336). The total morphine consumption was lower in the ESP group (11 versus 17.58 mg, p-value <0.0001) compared to the control group. The NRS scores during the follow-up period in the ESP group were consistently lower compared to the control group. The average number of analgesia attempts and demand for rescue analgesia were higher in the control group compared to the ESPB group. A higher proportion of ESPB patients agreed (p-value=0.002) that the overall pain management was good. More patients in the ESPB group agreed that they had slept well at night (41.7% versus 12.50%, p-value=0.023).

Conclusion: Ultrasound-guided ESPB was more effective in reducing postoperative pain, facilitating enhanced recovery, and significantly reducing the requirement for opioids in the postoperative period after abdominal surgery such as open nephrectomy.

Keywords: Interventional, Morphine, Pain, Ultrasonography

INTRODUCTION

Postoperative pain after a major surgery continues to be a challenging aspect, and pain relief is well recognised as an essential human right [1]. Open nephrectomy, due to its large subcostal incision, is associated with both somatic and visceral pain. Multimodal analgesia acts synergistically to alleviate pain and enhance recovery after surgery [2]. Regional anaesthetic techniques play a significant role in interventions for Enhanced Recovery After Surgery (ERAS) to reduce the stress response and the use of opioids [3].

A few studies have explored the provision of postoperative analgesia in open nephrectomy cases using thoracic paravertebral block [4-7] and Erector Spinae Plane Block (ESPB) [8,9]. While the efficacy of thoracic paravertebral block in surgeries is undoubtedly better than the single modal approach with opioids, the fact that the application of thoracic paravertebral block is so close to the pleura has led to the search for a better technique [5]. Studies detailing the efficacy of ESPB have not been extensively conducted in such a significant patient pool.

This study uses multimodal analgesia techniques and intravenous PCA efficiently, while emphasising safe anaesthesia practice. The primary objective was to compare total postoperative analgesic consumption. The secondary objective was to evaluate analgesic efficacy using the NRS pain score and patient satisfaction.

MATERIALS AND METHODS

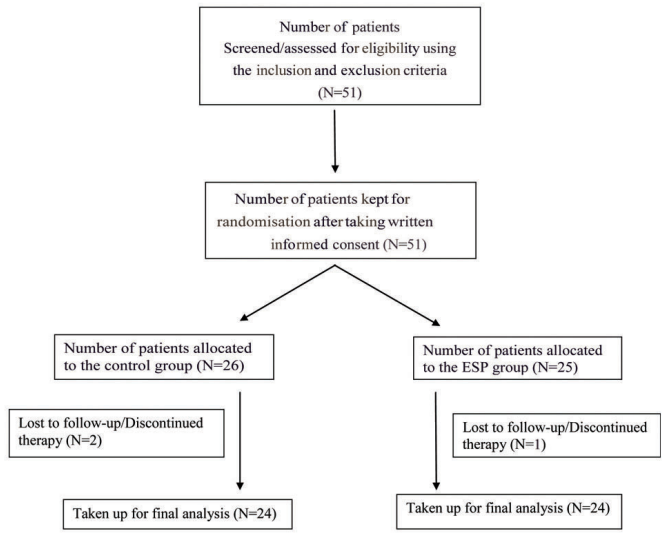
This was a double-blind, randomised controlled study conducted at the Department of Anaesthesiology, Himalayan Institute of Medical Sciences, Dehradun, India. The study took place over a period of one year from September 2020 to September 2021. The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation registered with the Institutional Research Board (IRB Number-SRHU/HIMS/ETHICS/2021/62). The study was registered with the Clinical Trial Registry India (https://www.ctri.nic.in) with enrollment number CTRI/2020/09/027996.

Inclusion criteria: A total of 48 patients from the American Society of Anaesthesiologists (ASA) with a physical status of Grade-I and II, aged between 18 and 60 years, undergoing elective open nephrectomy under General Anaesthesia (GA) were included in the study.

Exclusion criteria: Patients with a documented history of hypersensitivity/allergy to local anaesthetics, signs or symptoms of local site infection, history of bleeding disorders, severe kidney dysfunction, or a Body Mass Index (BMI) above 30 kg/m^2 were excluded from the study.

Sample size: Based on a similar study with a power of 0.90 and an alpha error of 0.05, 48 patients were required in each group to detect significance [4]. To account for potential dropouts, 51 patients were included.

Randomisation was performed by assigning a number to each group using a computer-based system [Table/Fig-1]. Block randomisation was utilised to ensure equality. The specific numbers were sealed in opaque envelopes, and patients were asked to choose one. The envelope chosen by the patient was then handed over to an anaesthesiologist who matched it with the computer-generated list, thereby assigning the patient to either group.



[Table/Fig-1]: CONSORT flow diagram.

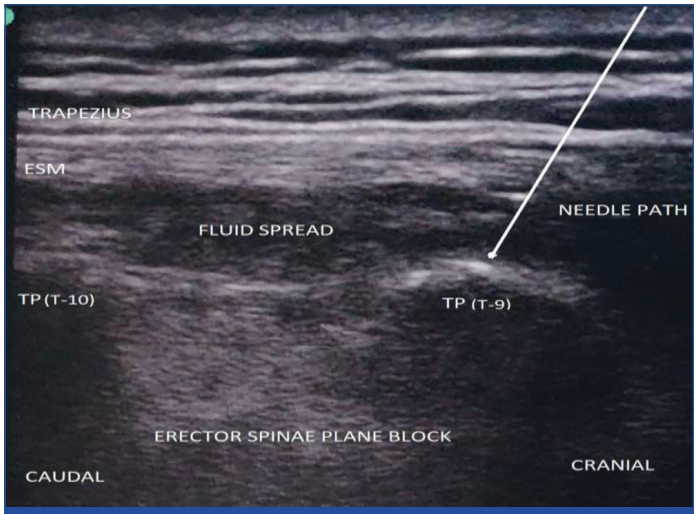
During the preanaesthetic visit, all patients provided written informed consent. Each patient was familiarised with the procedure, NRS, Likert scale [10] (assessing the quality of sleep and overall pain management), and the use of a PCA pump (PCA-B. Braun Melgusen AG pump).

All eligible patients received premedication with Tab. Alprazolam (0.25 mg) and Tab. Ranitidine (150 mg) orally [11], the night before the surgery. GA was standardised for all patients.

After surgery, all patients were transferred to PACU, where a PCA pump with Morphine (0.5 mg/mL) and a lockout of 15 minutes, set to deliver a maximum of 4 mg in one hour, was attached. Rescue analgesia in the form of intravenous injection of Paracetamol 1g was available. The assessing anaesthesiologist in the PACU and the participants were unaware of the group allocation.

The following steps were taken:

1. Ultrasound-guided (M TURBO FUJIFILM Sonosite, Inc. 21919 Bothell, WA 98021 USA) Probes: Linear 13-6 Hz) ESPB was performed by a trained anaesthesiologist with more than one year of experience in ultrasound imaging for nerve blocks. In Group I patients, thoracic ESPB at the T9 level was performed in the lateral position before reversing GA. A linear transducer was positioned three centimeters lateral to the midline, longitudinally, to visualise the back muscles, including the trapezius muscle above and the erector spinae muscle below, along with the T9 transverse processes and the pleura between them.
2. A 22 Gauge 10 cm needle (Stimuplex Ultra 360 22 G 100 mm needle) was inserted in a cranial to caudal direction within the plane technique toward the transverse process, crossing all the muscles until it touched the tip of the transverse process. Confirmation of the needle tip position was achieved by the visible spread of fluid, thus elevating the erector spinae muscle away from the transverse process, as shown in [Table/Fig-2]. Subsequently, 30 mL of 0.5% Ropivacaine was injected.
3. No block was administered to the second group of patients (control group).



[Table/Fig-2]: TP (T-9, T-10)-transvers process of 9th and 10th thoracic vertebra.
ESM: Erector spinae muscle

Postoperatively, patients were transferred to the PACU, where monitoring and documentation of parameters such as heart rate, blood pressure (systolic/diastolic/mean), and oxygen saturation were performed. An intravenous PCA pump was attached. The intensity of pain was assessed using the NRS scoring system at 30 minutes after the block, followed by assessments at 2, 4, 6, 8, 12, 18, and 24 hours. A PCA pump was used as an analgesic supplement so that patients could self-administer morphine if required. The number of times the patients pressed the PCA delivery button was counted as a measure of analgesic attempts. At the end of 24 hours, patients were asked about their overall pain management and whether they slept well at night using the Likert scale. Satisfactory responses were denoted by "strongly agree," and dissatisfaction was denoted by "strongly disagree."

STATISTICAL ANALYSIS

Data collation and analysis were performed using MS Excel (R) Office 365, GraphPad Prism 8.4.2, and SPSS version 25.0. Descriptive statistics were used to present proportions and percentages for categorical variables, and mean and standard deviation were used for continuous data variables. The Mann-Whitney U test/Student's t-test (independent group/unpaired data), paired t-test (for paired data), and Friedman statistic based on the uniformity of the data were used for the comparison of continuous variables. A p-value of <0.05 was considered significant.

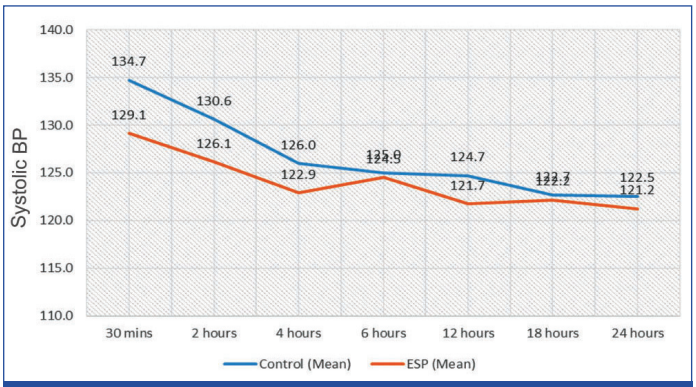
RESULTS

Demographic data were comparable in both groups, as shown in [Table/Fig-3].

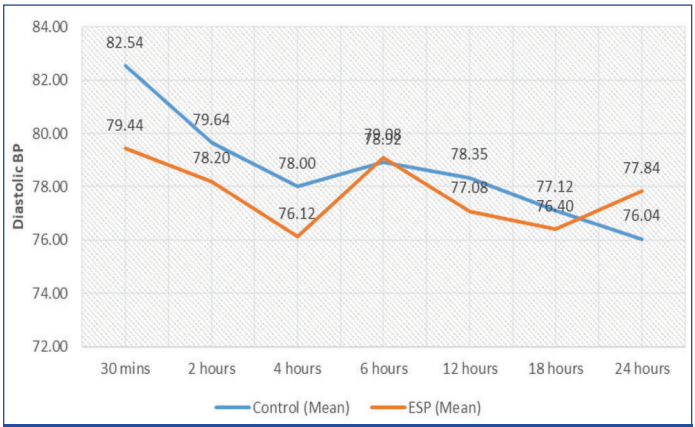
Parameters	Control (N=24)	ESPB (N=24)	p-value (paired t-test)
Age (years) (M±SD)	48.62±10.28	47.84±12.62	0.999
ASA Grade-I/II	8/16	11/13	0.336
Gender M/F	14/10	18/6	0.169
Duration of surgery (Min) (M±SD)	111.57±27.67	121.80±31.55	0.003
Duration of GA (Min) (M±SD)	111.15±28.12	137±33.85	0.249

[Table/Fig-3]: Demographic data for control and ESPB group.
GA: General anaesthesia; p<0.05 statistically significant

Both the control and ESP groups showed a statistically significant decrease in SBP, DBP, MAP, and heart rate during the 24-hour follow-up period, as demonstrated in [Table/Fig-4-7]. The parameters in the ESP group were consistently lower compared to the control group during the follow-up period. The differences at various follow-up time points between the two groups were not statistically significant. The difference in SpO_2 at various follow-up time points between the two groups was also not statistically significant, as shown in [Table/Fig-8].



[Table/Fig-4]: Systolic blood pressure.
*control (p-value <0.0001) and ESP groups (p-value=0.0007)

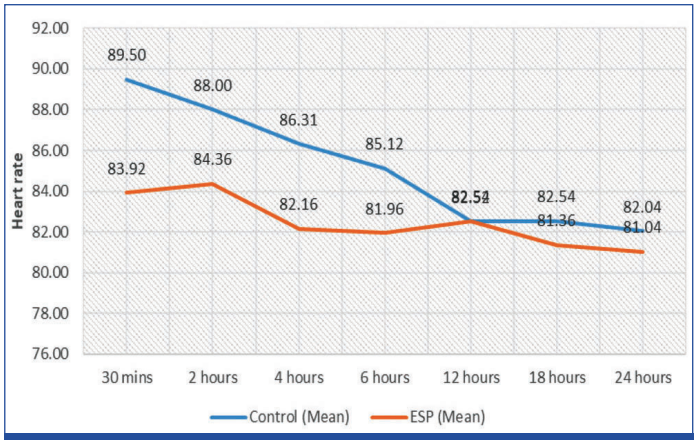


[Table/Fig-5]: Diastolic blood pressure.
*control (p-value=0.0134) and ESP groups (p-value=0.4441)

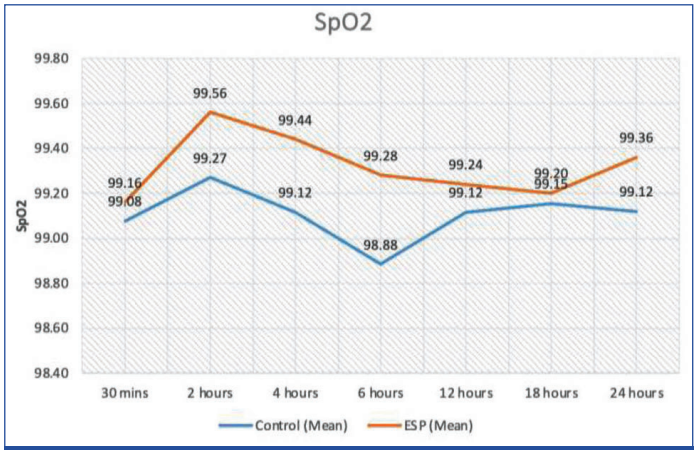
[Table/Fig-6]: Mean blood pressure.
*control (p-value <0.0001) and ESP groups (p-value=0.0254)

The ESPB group demonstrated lower morphine intake compared to the control group (11 versus 17.58, p<0.0001), as shown in [Table/Fig-9].

As shown in [Table/Fig-10], both the control group (p-value <0.0001) and ESP group (p-value=0.0175) showed a significant decrease in NRS scores during the follow-up period. The NRS scores in the ESPB group consistently decreased compared to the control group during the follow-up period. The difference at various follow-up time



[Table/Fig-7]: Heart rate.
*control (p-value=0.0005) and ESP groups (p-value=0.1770)



[Table/Fig-8]: SpO_2 control (p-value=0.4161) and ESP groups (p-value=0.1143).

Total morphine (mg) consumption	Control (n=24)	ESPB (n=24)	p-value (Mann-whitney U)
Mean±Std. Dev. (Standard deviation)	17.58±4.624	11±2.396	<0.0001*

[Table/Fig-9]: Morphine consumption for control and ESPB group.
*-statistically significant

NRS score	Control (Mean)±Std. Dev.	ESP (Mean)±Std. Dev.	p-value* (Friedman statistic)
30 min	5.58±1.50	3.44±1.29	<0.0001*
2 hours	4.81±1.27	3.20±0.87	<0.0001*
4 hours	4.69±1.49	3.08±1.12	<0.0001*
6 hours	3.88±1.66	3.28±1.49	0.1863
12 hours	3.77±1.42	3.44±1.29	0.4186
18 hours	3.73±1.31	2.96±1.14	0.0435*
24 hours	3.69±1.32	2.64±1.04	0.0036*
p-value	<0.0001	0.0175	

[Table/Fig-10]: NRS score trends for control and ESPB group.
*-statistically significant

points (except at 6 and 12 hours) between the two groups was statistically significant.

[Table/Fig-11] shows that the time to first analgesic need was significantly longer in the ESP group compared to the control group (157.6 versus 73.54, p<0.0001), and the average number

Variables	Control Mean±Std. Dev.	ESP Mean±Std. Dev.	p-value* (Mann-whitney U test)
Time of first analgesia (minutes)	73.54±64.95	157.6±60.32	<0.0001*
Analgesia attempts	27.96±6.785	19±5.964	<0.0001*

[Table/Fig-11]: Time to first analgesia and analgesia attempts.
*-statistically significant

of analgesic attempts was significantly higher in the control group compared to the ESP group (27.96 versus 19, p<0.0001).

A significantly lower proportion of subjects in the ESP group required rescue analgesia compared to the control group (4.17% vs. 29.17% in the controls, p-value=0.0215), as shown in [Table/Fig-12].

Rescue analgesia PCM doses	Control n (%)	ESPB n (%)	p-value (Man whitney U)
None required	17 (70.83)	23 (95.83)	
Required	7 (29.17)	1 (4.17)	0.0215*
One	2 (8.33)	1 (4.17)	
Two	2 (8.33)	0	
Three	3 (12.50)	0	
Grand total	24 (100)	24 (100)	

[Table/Fig-12]: Rescue analgesia for control and ESPB group.
PCM: Paracetamol
*-Statistically significant

[Table/Fig-13] shows that a higher proportion of patients in the control group disagreed with the statement that they had slept well at night (37.5%, p-value=0.001), whereas a significantly higher proportion of patients in the ESP group agreed that they had slept well at night (41.7%, p-value=0.023). The results were statistically significant (Overall p-value=0.001).

Quality of sleep	Control n (%)	ESP n (%)	p-value	p-value Overall (Man-whitney U)
Strongly disagree (1)	0	0	-	0.001
Disagree (2)	9 (37.5)	0	0.001	
slightly disagree (3)	6 (25)	2 (8.3)	0.121	
Slightly agree (4)	4 (16.7)	5 (20.8)	0.712	
Agree (5)	3 (12.5)	10 (41.7)	0.023	
Strongly agree (6)	2 (8.3)	7 (29.2)	0.064	

[Table/Fig-13]: Quality of sleep/adequate sleep in the night (Likert scale).

It was observed that a significantly higher proportion of ESP patients agreed (54.2%, p-value=0.002) with the statement that the overall pain management was good. On the other hand, a higher proportion of patients in the control group disagreed (33.3%, p-value=0.004) with the statement [Table/Fig-14]. The results were statistically significant (Overall p-value=0.002).

Overall pain management good	Control n (%)	ESP n (%)	p-value	p-value Overall (Mann-whitney U)
Strongly disagree (1)	1 (3.8)	0	0.326	0.002
Disagree (2)	8 (33.3)	0	0.004	
slightly disagree (3)	7 (29.2)	2 (8.3)	0.064	
Slightly agree (4)	3 (12.5)	4 (16.7)	0.683	
Agree (5)	3 (12.5)	13 (54.2)	0.002	
Strongly agree (6)	2 (8.3)	5 (20.8)	0.220	

[Table/Fig-14]: Overall pain management good (Likert scale).

No complications related to the block, such as local anaesthetic systemic toxicity/allergy, infection at the needle insertion site, pleural puncture, pneumothorax, vascular puncture, or failed block, were observed in any patient in the study.

DISCUSSION

This study demonstrated that the ESPB group (with multimodal pain management) was associated with better postoperative analgesia outcomes. This was evident from the significantly lower pain levels, better subjective outcomes related to postoperative analgesia, significantly lower morphine consumption, fewer attempted analgesic administrations, and longer time to first analgesia requirement. The need for rescue analgesia was also remarkably lower in the ESPB group. These effects were achieved without major impairments in cardiovascular parameters (blood pressure and heart rate).

In terms of pain relief, the ESPB group showed excellent pain control with lower scores on the NRS, leading to enhanced recovery after surgery. Ratnayake A et al., conducted a study on ESPB in open radical nephrectomy via a rooftop incision and concluded that patients reported effective dynamic analgesia with minimal need for rescue analgesia, as well as early ambulation and enhanced recovery [12]. Kim S et al., found that intermittent ESPB as part of multimodal analgesia is an effective method for managing postoperative pain in patients undergoing open nephrectomy [8]. Hamed MA et al., conducted a study on patients undergoing total abdominal hysterectomy and found that the ESPB group had a significantly lower fentanyl consumption and VAS pain scores in the first 12 hours compared to the control group. They concluded that bilateral ESPB is an effective option for postoperative analgesia [13]. However, the present study differed from the aforementioned studies. In this study, the ESPB group received a single-time block with i.v. PCA (Morphine) for 24 hours, with intermittent boluses administered when the patient required them, without a continuous background infusion. Despite this difference, similar results were found, as the ESPB group demonstrated lower morphine intake compared to the control group.

ESPB, performed under ultrasound guidance, is an interfacial plane block achieved by injection of local anaesthesia between the plane of the erector spinae muscle and transverse process. This plane is easily recognisable and relatively distant from major vascular or neural structures. The local anaesthetic disperses in the paravertebral space and blocks both dorsal and ventral nerve roots with a single puncture [14].

Ropivacaine, a long-acting aminoamide local anaesthetic, was used in the study. Since only a small fraction of ropivacaine is excreted unchanged in urine, dosage adjustment based on renal function is not a necessary, making it an optimal choice for open nephrectomy [15]. Abdul Jalil RM et al., compared the efficacy of two concentrations of ropivacaine (0.5% versus 0.2%) in TAP blocks and found them to be comparable in terms of postoperative analgesia for patients undergoing appendectomy [16]. Another study by Forero M et al., suggested that using 0.5% ropivacaine (20 mL) for ESP block at the T9 level is reasonable [14]. Kadam VR et al., demonstrated that limiting the total dose of ropivacaine to below 3 mL/kg is unlikely to result in any adverse effects following a single injection [17].

Patient satisfaction, measured using the Likert scale, was significantly higher in the ESP group compared to the control group (p-value <0.001). The Likert scale is recognised as an international method of assessing patient satisfaction after hospital treatment. In the questionnaire regarding analgesia, patient satisfaction was significantly higher in the ESP block group compared to the non-ESP block group.

However, Tulgar S et al., highlighted some findings that showed ESPB failure with a lack of analgesic effectiveness in some patients who received ESPB for various surgeries. This could be attributed to intestinal distention following laparoscopic procedures and differences in pain sensitivity among patients [18]. No block-related complications were observed in any patient in the study.

Limitation(s)

The limitations of this study include the potential modification of the timing of the block. Additionally, the patient follow-up period was limited to 24 hours and could have been extended to 48 hours or longer.

CONCLUSION(S)

Ultrasound-guided ESPB, as a form of multimodal analgesia, can be considered to reduce the incidence of postoperative pain

and enhance recovery after open nephrectomy. It significantly reduces the requirement for opioids and decreases the side-effects associated with opioids. Patients also report better satisfaction with overall pain management and improved quality of sleep after 24 hours of open nephrectomy compared to those who did not receive the block. ESPB can be a novel alternative to conventional techniques for postoperative pain management and can be used as part of multimodal analgesia in patients undergoing abdominal and thoracic surgeries to improve patient outcomes.

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