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Comparative impact of general and epidural anesthesia on postoperative outcomes in percutaneous nephrolithotomy

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ABSTRACT

Aims: This study aimed to compare the effectiveness and safety of epidural anesthesia (EA) versus general anesthesia (GA) in patients undergoing percutaneous nephrolithotomy (PCNL).

Methods: This retrospective observational study included 50 patients who underwent PCNL under either EA or GA. The groups were compared regarding demographic data, intraoperative and postoperative parameters, including hemodynamic stability, bleeding, complications, Visual Analog Scale (VAS) pain scores, and postoperative analgesic requirements.

Results: No significant differences were found between groups in terms of demographics, stone location, or size. Fluid requirement was significantly higher in the EA group ($p<0.01$). Although intraoperative bleeding and hypotension were more frequent in the GA group, differences were not statistically significant. Peak heart rate at the 10th minute was significantly higher in the GA group ($p<0.05$), and systolic and diastolic blood pressures were lower at some time points ($p<0.05$). Oxygen saturation was significantly higher in the GA group at the 5th minute only ($p<0.01$). Postoperative VAS scores were significantly lower in the EA group ($p<0.01$), and analgesic need was higher in the GA group. Ephedrine use was greater in the EA group ($p<0.05$), with no significant difference in atropine use or catheter site.

Conclusion: EA is a safe and effective alternative to GA for PCNL procedures, as it provides superior postoperative pain control, reduces analgesic requirements, and maintains hemodynamic stability. Although EA is associated with higher fluid and ephedrine requirements, its overall benefits make it a viable option for appropriately selected patients.

Keywords: Epidural anesthesia, general anesthesia, hemodynamic stability, percutaneous nephrolithotomy, postoperative pain control

INTRODUCTION

Urinary stone disease is a common health problem affecting 1% to 20% of the global population, with a higher prevalence in men.[1,2] Over the past four decades, the need for open surgery in kidney stone treatment has markedly declined, with minimally invasive techniques such as extracorporeal shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), retrograde intrarenal surgery (RIRS), and laparoscopic approaches emerging as effective alternatives. Introduced by Fernström and Johansson[3] in 1976, PCNL has since become the standard surgical treatment for renal stones, replacing open surgery in many cases. Advances in technology and surgical experience have further refined the PCNL technique, leading to fewer complications, shorter hospital stays, and improved clinical outcomes.[4,5]

PCNL can be performed safely under general anesthesia (GA) or regional techniques such as spinal (SA), epidural (EA), or combined spinal-epidural anesthesia (CSEA). While GA ensures airway protection and facilitates hemodynamic control, it carries potential risks including neuroendocrine stress responses, airway trauma, pulmonary complications, allergic reactions, nerve injuries, and postoperative nausea

and vomiting.[6,7] In contrast, regional anesthesia preserves spontaneous breathing and airway reflexes, provides effective postoperative analgesia, facilitates early mobilization, reduces the risk of thromboembolism, and shortens hospital stay.[7,8] In addition, it has also been shown to be superior to GA in reducing postoperative mortality and serious complications.[9,10]

The literature shows that EA provides a similar duration of anesthesia in patients undergoing PCNL while avoiding the disadvantages of GA. Therefore, this study aims to compare the effects of EA and GA in patients undergoing PCNL on surgical outcomes, hemodynamic changes, pain levels, analgesic requirements within the first 24 hours post-surgery, and the frequency of complications.

METHODS

Ethics

The study included 50 patients who underwent PCNL surgery, with 27 receiving GA and 23 receiving EA, all managed by the same surgical and anesthesia teams. This study has been approved by the Clinical Researches Ethics Committee of Haseki Training and Research Hospital (Date: 05.02.2014, Decision No: 55). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Participants

This retrospective observational study included patients who underwent PCNL for renal calculi at the Urology Clinic of a Training and Research Hospital between June 2012 and June 2014. Patients aged between 18 and 75 years and had an ASA score of ≤III, were included in the study. Exclusion criteria included patients with serious cardiac conditions such as bradycardia, advanced heart block, sick sinus syndrome, cardiogenic shock, significant heart failure (ejection fraction <30%), symptomatic mitral or aortic valve disease, or cardiac tamponade. Additional exclusion criteria were hypovolemia, liver failure, acute intermittent porphyria, coagulopathies, progressive neurological diseases, and, in the EA group, failure to achieve a sensory block level of T6 within 30 minutes of the injection.

Procedure

All data were collected retrospectively from patient files and subjected to detailed analysis. Review of patient records revealed that all patients received standard monitoring and were administered intravenous midazolam (0.05 mg/kg) for premedication. In the GA group, patients received 1 mcg/kg fentanyl, 7 mg/kg thiopental, and 0.6 mg/kg rocuronium intravenously. Following endotracheal intubation, ventilation was adjusted to a tidal volume of 7 ml/kg, and anesthesia was maintained with sevoflurane at approximately 1 MAC using a Dräger Primus anesthesia machine, titrated according to the patient's cardiac response. In the EA group, records indicated that the epidural space was accessed at the L3–L4 level using a 16G Tuohy needle. A mixture of 200 mg 2% prilocaine, 25 mg 0.25% bupivacaine, and 25 mcg fentanyl was administered. If regression of the sensory block from the T6 level occurred or the VAS score exceeded 3 during surgery, an additional 5–20 ml of 0.25% bupivacaine was given via the epidural catheter.

Data recorded during and after surgery for two groups of patients were analyzed from medical records. The systolic, diastolic, and mean arterial pressures, heart rate (HR), and SpO_2 values of both groups at the baseline, as well as at the 5^{th}, 10^{th}, 15^{th}, 20^{th}, 40^{th}, 60^{th}, and 75^{th} minutes, were extracted from the patient records. Hypotension was defined as a 20% decrease in blood pressure or systolic arterial pressure ≤90 mmHg. It was observed that in cases of hypotension, rapid fluid replacement was administered, and, when necessary, 5 mg/ml ephedrine was used. In the event of bradycardia, which was defined as a HR of <45 beats per minute, 0.5 mg of atropine was administered.

Intraoperative adverse events and complications were recorded from patient files. Preoperative and first postoperative hour hemogram results were analyzed. Visual Analog Scale (VAS) scores at 1, 4, 12, and 24 hours postoperatively were retrospectively evaluated. Surgical access was categorized as either subcostal or intercostal.

This study was derived from data from the author's doctoral thesis titled "Comparison of GA and EA in PCNL surgery" completed 12 years ago. The analyses in the thesis were conducted in accordance with the statistical approaches of the time. However, in this article, the same data set was re-analyzed using current statistical methods, and the findings were re-evaluated for scientific accuracy and validity. This restructured the study in accordance with current scientific standards.

Statistical Analysis

The data analyses were performed using the Statistical Package for the Social Sciences (SPSS) 18 package program. Descriptive statistics are expressed as the mean and standard deviation for normally distributed continuous variables, and as numbers and percentages for categorical variables. Continuous variables were analyzed using the "Independent samples test" between groups, while "Chi-square analysis" was used to compare categorical variables. For intraoperative physiological parameters, including HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and oxygen saturation (SpO_2), between-group comparisons were conducted at multiple predefined time points. To control for the increased risk of type I error associated with multiple comparisons, Bonferroni correction was applied. Accordingly, the adjusted level of statistical significance was set at $p<0.0056$ (0.05 divided by nine time points). Statistical significance was otherwise accepted at $p<0.05$.

Sample Size

With an effect size of 0.72, a total sample of 50 patients (23 EA, 27 GA), and a significance level of 0.05, the power of our study was calculated as 80.42% using G*Power 3.1.7 (University of Kiel, Kiel, Germany), indicating adequate statistical power to detect significant group differences.

RESULTS

Age, gender, height, weight, body-mass index (BMI), ASA scores, and stone characteristics (location and size) were comparable between the EA and GA groups, with no statistically significant differences observed ($p>0.05$) (Table 1).

Anesthesia duration, intraoperative hemorrhage, side effects, and surgeon comfort were similar between the groups, with no statistically significant differences (p>0.05). However, fluid requirement was significantly higher in the EA group (p<0.01) (Table 2).

Table 1. Comparison of study groups in terms of demographic data, ASA Scores, and stone characteristics

	EA group (n=23)	GA group (n=27)	p-value
Age (years) mean±SD	45.91±14.04	43.44±11.73	0.138#
Height (cm) mean±SD	170.78±8.33	171.44±10.95	0.383#
Weight (kg) mean±SD	76.35±12.69	77.30±12.19	0.544#
BMI (kg/cm²) mean±SD	26.43±5.77	26.37±4.26	0.470#
ASA (n/%)			
1	15 (65.2%)	18 (66.7%)	0.277*
2	6 (26.1%)	9 (33.3%)	
3	2 (8.7%)	0 (0%)	
Placement of stones (n/%)			
Medium	1 (4.3%)	1 (3.7%)	
Inferior	7 (30.4%)	8 (29.6%)	0.622*
Pelvis	5 (21.7%)	11 (40.7%)	
Staghorn	5 (21.7%)	4 (14.8%)	
Inferior+pelvis	5 (21.7%)	3 (11.1%)	
Stone size mean±SD	2.51±1.31	2.56±0.85	0.687#

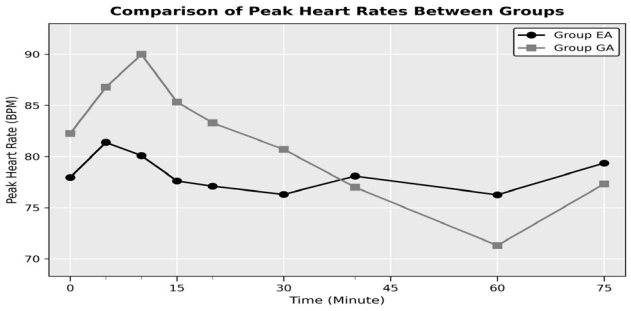
Data presented as mean (±SD) or number (n/%) of patients. ASA: American Society of Anesthesiologists, BMI: Body-mass ındex, EA: Epidural anesthesia, GA: General anesthesia, SD: Standard deviation. The p-value refers to the difference between the groups. p<0.05 is statistically significant. *Chi-square test, #Independent Sample-t test.

Table 2. Comparison of anesthesia duration, amount of fluid administered, postoperative hemorrhage, side effects, and surgeon comfort between groups

	EA group (n=23)	GA group (n=27)	p-value
Anesthesia duration (minute) mean±SD	77.83±26.23	78.15±17.10	0.621#
Amount of fluid administered (ml) mean±SD	1913.04±417.02	1659.26±510.09	<0.01#
Intraoperative hemorrhage (n/%)			
No	21 (91.3%)	22 (81.5%)	0.556*
Yes	2 (8.7%)	5 (18.5%)	
Side effects (n/%)			
None	16 (69.6%)	19 (70.4%)	
Nausea	1 (4.3%)	0 (0%)	0.335*
Hypotension	3 (13%)	7 (25.9%)	
Bradycardia	1 (4.3%)	1 (3.7%)	
Nausea and vomiting	2 (8.7%)	0 (0%)	
Surgeon comfort (n/%)			
Poor	1 (4.3%)	0 (0%)	
Moderate	2 (8.7%)	0 (0%)	0.154*
Good	20 (87%)	27 (100%)	

Data presented as mean (±SD) or number (n/%) of patients. EA: Epidural anesthesia, GA: General anesthesia, SD: Standard deviation. The p-value refers to the difference between the groups. p<0.05 is statistically significant. *Chi-square test, #Independent Sample-t test.

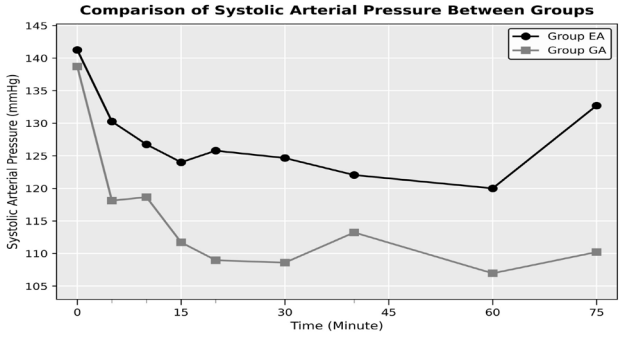
In the comparison of HR between the EA and GA groups, HR was nominally higher in the GA group at the 10th minute (p<0.05), while no significant differences were observed at the remaining time points, with comparable values between groups from the 30th minute onward (Figure 1). However, after Bonferroni correction for multiple comparisons (adjusted α=0.0056), the 10th-minute difference did not remain statistically significant.



Time (Minute)	Group EA	Group GA	P-value
0 Minute	77.96 ± 10.37	82.26 ± 13.09	0.201
5 Minute	81.39 ± 12.10	86.78 ± 14.08	0.152
10 Minute	80.09 ± 12.31	90.00 ± 15.78	0.016
15 Minute	77.61 ± 9.79	85.33 ± 18.19	0.064
20 Minute	77.09 ± 10.74	83.30 ± 17.43	0.131
30 Minute	76.30 ± 11.24	80.70 ± 17.05	0.281
40 Minute	78.09 ± 11.89	77.00 ± 15.08	0.776
60 Minute	76.26 ± 19.66	71.30 ± 18.64	0.367
75 Minute	79.36 ± 15.23	77.32 ± 11.52	0.601

Figure 1. Comparison of peak heart rates between groups
EA: Epidural anesthesia, GA: General anesthesia

Compared to the EA group, the GA group showed a significantly greater decline in SBP at the 5th, 15th, 20th, and 30th minutes (p<0.05). While differences diminished between the 40th and 60th minutes (p>0.05), at the 75th minute, the SBP in the EA group increased again, while the GA group remained at a lower level. At this point, the difference between the groups became highly significant (p<0.001) (Figure 2). However, after Bonferroni correction for multiple comparisons (adjusted α=0.0056), significant between-group differences persisted at the 20th, 30th, and 75th minutes, whereas the differences at the 5th and 15th minutes did not remain statistically significant. Notably, at the 75th minute, SBP increased in the EA group while remaining lower in the GA group, resulting in a highly significant difference (p<0.001).

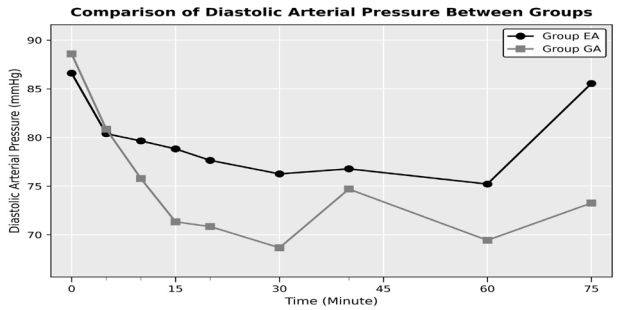


Time (Minute)	Group EA	Group GA	P-value
0 Minute	141.25 ± 20.23	138.7 ± 16.95	0.711
5 Minute	130.26 ± 15.94	118.11 ± 21.37	0.028
10 Minute	126.74 ± 16.54	118.65 ± 21.53	0.162
15 Minute	124.0 ± 18.84	111.70 ± 18.79	0.026
20 Minute	125.78 ± 19.10	108.96 ± 19.30	<0.01
30 Minute	124.65 ± 16.94	108.59 ± 17.38	<0.01
40 Minute	122.04 ± 15.94	113.22 ± 15.26	0.061
60 Minute	120.0 ± 21.35	106.95 ± 21.17	0.091
75 Minute	132.7 ± 15.27	110.21 ± 12.34	<0.001

Figure 2. Comparison of systolic arterial pressure between groups
EA: Epidural anesthesia, GA: General anesthesia

A statistically significant difference was found between EA and GA groups in terms of DBP at the 10th, 15th, 20th, 30th, and 75th minutes (p<0.05). Notably, at the 75th minute, the difference was highly significant (p<0.001). While DBP values remained more stable in the EA group during these periods,

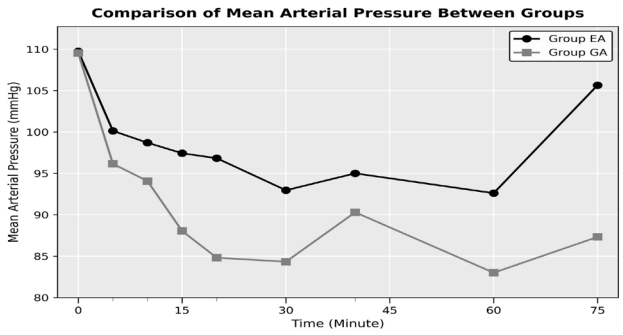
more pronounced decreases were observed in the GA group. However, no significant difference was detected between the groups at the 0th, 5th, 40th, and 60th minutes (p>0.05) (Figure 3). After Bonferroni correction for multiple comparisons across nine time points (adjusted α=0.0056), only the difference at the 75th minute remained statistically significant (p=0.001), whereas the differences observed at earlier time points did not retain statistical significance.



Time (Minute)	Group EA (Mean ± SD)	Group GA (Mean ± SD)	P-value
0 Minute	86.61 ± 14.17	88.59 ± 12.05	0.819
5 Minute	80.39 ± 13.13	80.85 ± 17.97	0.298
10 Minute	79.65 ± 10.48	75.78 ± 16.72	0.026
15 Minute	78.83 ± 13.92	71.33 ± 13.57	0.01
20 Minute	77.65 ± 14.12	70.85 ± 14.7	0.01
30 Minute	76.26 ± 14.89	68.67 ± 13.34	0.01
40 Minute	76.78 ± 12.93	74.7 ± 13.27	0.128
60 Minute	75.22 ± 21.9	69.44 ± 18.58	0.067
75 Minute	85.55 ± 12.54	73.26 ± 11.27	0.001

Figure 3. Comparison of diastolic arterial pressure between groups
EA: Epidural anesthesia, GA: General anesthesia

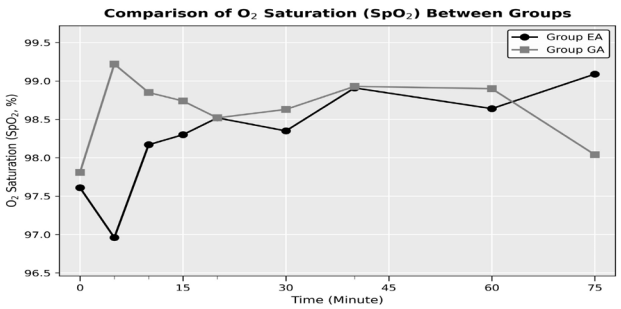
MAP showed an early decrease in both groups at the 5th minute; however, this reduction was more pronounced in the GA group, resulting in a significant difference between the groups at this time point (p<0.05). MAP was also significantly lower in the GA group at the 10th, 15th, 20th, 30th, 40th, 60th, and 75th minutes (p<0.05), with the most marked differences observed at the 30th and 75th minutes (p<0.001). In contrast, MAP values in the EA group demonstrated a more stable pattern throughout the intraoperative period. No significant difference was observed between the groups at baseline (0th minute) (p>0.05) (Figure 4). After Bonferroni correction for multiple comparisons across nine time points (adjusted α=0.0056), only the differences at the 15th, 20th, and 75th minutes remained statistically significant (all p<0.001), whereas the remaining time-point differences did not retain statistical significance.



Time (Minute)	Group EA	Group GA	P-value
0 Minute	109.74 ± 15.19	109.52 ± 14.60	0.344
5 Minute	100.13 ± 14.26	96.15 ± 19.53	0.047
10 Minute	98.70 ± 13.30	94.07 ± 20.65	0.030
15 Minute	97.43 ± 15.93	88.04 ± 15.35	<0.01
20 Minute	96.83 ± 17.26	84.81 ± 17.33	0.001
30 Minute	92.96 ± 19.00	84.33 ± 14.35	0.011
40 Minute	95.00 ± 14.35	90.30 ± 13.74	0.056
60 Minute	92.61 ± 25.66	83.00 ± 21.53	0.024
75 Minute	105.64 ± 13.11	87.32 ± 12.05	<0.001

Figure 4. Comparison of mean arterial pressure between groups
EA: Epidural anesthesia, GA: General anesthesia

When SpO_2 values were compared at different time points between the EA and GA groups, no statistically significant differences were observed at 0, 10, 15, 20, 30, 40, 60, and 75 minutes (p>0.05). However, at the 5th minute, the SpO_2 value in the GA group (99.22±1.05) was significantly higher than that in the EA group (96.96±3.82), and this difference was statistically significant (p<0.01) (Figure 5). After Bonferroni correction for multiple comparisons across nine time points (adjusted α=0.0056), this difference remained statistically significant (p=0.001), while no significant differences were observed at the remaining time points.



Time (Minute)	Group EA	Group GA	P-value
0 Minute	97.61 ± 1.92	97.81 ± 1.77	0.650
5 Minute	96.96 ± 3.82	99.22 ± 1.05	<0.01
10 Minute	98.17 ± 1.55	98.85 ± 1.06	0.191
15 Minute	98.30 ± 2.47	98.74 ± 1.16	0.590
20 Minute	98.52 ± 1.78	98.52 ± 1.12	0.583
30 Minute	98.35 ± 1.74	98.63 ± 1.07	0.839
40 Minute	98.91 ± 1.47	98.93 ± 1.03	0.565
60 Minute	98.64 ± 1.62	98.90 ± 1.05	0.672
75 Minute	99.09 ± 1.81	98.04 ± 1.06	0.261

Figure 5. Comparison of O_2 saturation (SpO_2) between groups
EA: Epidural anesthesia, GA: General anesthesia

Postoperative analgesic requirement was significantly lower in the EA group compared to the GA group (p<0.01), with fewer patients needing single or multiple doses. VAS scores were also significantly lower in the EA group at all measured time points (p<0.01). No significant differences were found between the EA and GA groups in terms of hematocrit values, nephrostomy access site, or atropine use (p>0.05). However, ephedrine was required significantly more often and in higher total doses in the EA group, while no patients in the GA group received ephedrine (p<0.05) (Table 3).

DISCUSSION

Due to the specific risks associated with GA, regional anesthesia techniques are increasingly preferred in PCNL to reduce anesthesia-related morbidity and postoperative complications, without compromising procedural efficacy.[6,7,11,12] Spinal anesthesia is considered safe and feasible, particularly in elderly patients with cardiopulmonary comorbidities;[13] however, its limitations in prolonged procedures and the challenges of conversion to GA in the prone position present practical concerns. EA, via catheter placement, offers the advantage of extending anesthesia intraoperatively and is a safe and effective alternative, especially in patients at high risk for difficult intubation or GA-related complications.[6,14] This study aimed to compare surgical, hemodynamic, and postoperative analgesia-related outcomes in patients undergoing PCNL under GA or EA.

In our study, the EA and GA groups were homogeneous in terms of demographic characteristics and anesthesia

Table 3. Comparison of study groups in terms of hematocrit levels, postoperative VAS scores, analgesic use, atropine and ephedrine administration, and PCNL catheter access site

	EA group (n=23)	GA group (n=27)	p-value
Preoperative HCT (mean±SD)	39.56±5.91	41.09±4.84	0.327#
Postoperative HCT (mean±SD)	35.51±5.66	36.43±4.78	0.542#
Change in HCT (ΔHCT) (mean±SD)	4.04±3.06	4.66±2.73	0.457#
Postoperative VAS (mean±SD)			
1st hour	0.26±0.68	3.19±1.90	<0.001#
4th hour	0.83±1.30	3.19±1.77	<0.001#
12th hour	0.57±1.08	3.07±1.83	<0.001#
24th hour	0.61±0.94	3.00±1.88	<0.001#
Use of post-op analgesia, n (%)			
None	15 (65.2%)	1 (3.7%)	<0.001*
1 dose	6 (26.1%)	6 (22.2%)	
2 doses	2 (8.7%)	11 (40.7%)	
3 doses	0 (0%)	6 (22.2%)	
4 doses	0 (0%)	2 (7.4%)	
6 doses	0 (0%)	1 (3.7%)	
Atropine use			
No, n (%)	19 (82.6%)	26 (96.3%)	0.256*
Yes, n (%)	4 (17.4%)	1 (3.7%)	
Amount (mg), mean±SD	0.15±0.35	0.01±0.09	0.068#
Ephedrine use			
No, n (%)	18 (78.3%)	27 (100%)	0.037*
Yes, n (%)	5 (21.7%)	0 (0%)	
Amount (mg), mean±SD	2.61±5.61	0.00±0.00	0.030#
PCNL catheter access site, n (%)			
Subcostal	21 (91.3%)	27 (100%)	0.401*
Intercostal	2 (8.7%)	0 (0%)	

Data presented as mean (±SD) or number (n/%) of patients. EA: Epidural anesthesia, GA: General anesthesia, HCT: Hematocrit, PCNL: Percutaneous nephrolithotomy, SD: Standard deviation, VAS: Visual Analog Scale. The p-value refers to the difference between the groups. p<0.05 is statistically significant. *Chi-square test, #Independent Sample-t test.

risk, ensuring comparability. Consistent with previous studies,[6,9,15–17] no significant differences were observed regarding anesthesia duration, postoperative hemorrhage, side effects, or surgeon comfort, suggesting that both techniques provide similar clinical outcomes and effectively support the surgical procedure.

EA has been associated with earlier mobilization and faster return to oral intake, though its effect on hospital stay varies across studies.[9,18] While some studies have reported significantly shorter hospital stays with regional anesthesia,[6,18,19] our study showed a shorter stay in the EA group; however, statistical analysis showed that this difference did not reach significance.

A study comparing hemodynamic responses during PCNL under GA and subarachnoid block (SAB) has shown that, although baseline values are similar, patients under GA exhibit significantly higher HR, SBP, DBP, and MBP from the early intraoperative period onward, indicating more pronounced and sustained cardiovascular responses compared to SAB.[16] Some studies have similarly reported that HR is significantly higher in the GA group, with these differences being particularly evident in the early stages.[20,21] Our study indicates that GA leads to an initial rise in HR over the first 30 minutes, which diminishes over time. This early rise may result from decreased systemic vascular resistance and reduced right atrial filling due to sympathetic blockade caused by neuraxial anesthesia. In contrast, EA is known to suppress sympathetic tone, leading to neurogenic bradycardia, contributing to initial bradycardia. However, fluid resuscitation and ephedrine administration likely restored sympathetic activity in the EA group, leading to HR levels comparable to those in the GA group.

Our study reveals significant differences in hemodynamic stability between GA and EA groups. While SBP, DBP, and MBP remained more stable in the EA group, the GA group exhibited marked decreases, particularly during the early intraoperative period. These fluctuations in the GA group are likely due to the vasodilatory effects of general anesthetics, whereas EA provides a more controlled sympathetic blockade, reducing blood pressure variability. The pronounced differences observed, especially at the 75th minute, underscore the sustained stabilizing effect of EA. These findings suggest that EA may offer superior hemodynamic control and be particularly advantageous in patients at risk for hypotensive episodes.

A review of current literature shows no evidence regarding the impact of the anesthesia method on SpO_2 levels in patients undergoing PCNL. The findings of our study indicate that while SpO_2 levels were generally comparable between patients receiving EA and GA, higher SpO_2 values were observed in the GA group during the early postoperative period (5th minute). Overall, SpO_2 remained stable in both groups, no clinically significant hypoxemia was detected, and both anesthesia techniques were deemed safe in maintaining adequate SpO_2.

While a study reports similar perioperative hemoglobin levels and no transfusion requirements between EA and GA groups,[15] another study has shown greater hemoglobin decline and blood loss in the GA group compared to SAB group.[16] In our study, both preoperative and postoperative HCT levels and ΔHCT were assessed, showing no statistically significant variation between groups. Although intraoperative bleeding was higher in the GA group, this difference was not statistically significant, and no patient required a blood transfusion. These findings indicate the hematological safety of both techniques during the perioperative period.

Multiple studies have demonstrated the efficacy of EA in reducing postoperative pain and analgesic requirements.[9,14,15,17,22] A study reported significantly lower pain scores in the EA group at the 1st and 3rd postoperative hours. However, no significant difference in pain scores was observed between the groups after the 12th postoperative hour.[15] Singh et al.[9] found significantly lower 24-hour analgesic use in the EA group in a randomized controlled trial of PCNL patients, and a meta-analysis by Liu et al.[22] confirmed reduced pain and analgesic needs with regional anesthesia. Consistent with these findings, our study showed significantly lower VAS scores at all time points. Additionally,

it was observed that the majority of patients in the EA group did not require postoperative analgesics, whereas the need for multiple doses of analgesia was significantly higher in the GA group. The present findings imply that EA is more effective in postoperative pain management, leading to reduced pain perception and a decreased requirement for additional analgesic medication.

Studies have shown that hypotension during SA or CSEA in PCNL is generally manageable with fluid therapy, though vasopressor support may be required, and significant MBP reductions have been observed compared to GA.[16,17,23] In line with the literature, our study found significantly higher fluid requirements and ephedrine use in the EA group, while no ephedrine was needed in the GA group. These results indicate that EA may cause greater susceptibility to hypotension due to sympathetic blockade, whereas GA appears to maintain more stable vascular tone.

The study's constraints include conducting it at a single center, a comparatively small cohort, and no prolonged follow-up period. Furthermore, the awareness of the surgical and anesthesia teams regarding which patients received which anesthesia could introduce observational bias. Although the data of the present study were collected between 2012 and 2014, both EA and GA remain commonly used and well-established options in current PCNL practice. Recent literature indicates that the comparative evaluation of these techniques continues to be relevant, as anesthesia choice may still affect perioperative hemodynamics, postoperative pain, complication profiles, and overall recovery. While advances in perioperative monitoring and management have occurred over time, they have not fundamentally changed the physiological mechanisms underlying EA and GA.[15,17,22] Accordingly, the patterns observed in our study-such as differences in postoperative analgesia, intraoperative hemodynamic parameters, and perioperative medication requirements-are generally in line with contemporary findings reported in the literature. Therefore, despite the historical nature of the data, the results of this study may still contribute to the ongoing discussion regarding anesthetic selection in PCNL procedures.

However, the similarity in demographic and clinical characteristics between the groups enhances the reliability of the findings. The detailed examination of hemodynamic parameters at various time points allowed for a comprehensive assessment of the cardiovascular effects of the anesthesia techniques. Additionally, the superiority of EA in postoperative pain management was clearly demonstrated.

Limitations

This study has several limitations that should be acknowledged. First, the retrospective, single-center design and relatively small sample size (n=50) carry an inherent risk of selection bias and may limit the generalizability of the findings. Second, although the fundamental physiological mechanisms[15,17,22] of the anesthetic techniques remain unchanged, the data were collected between 2012 and 2014; therefore, recent advances in enhanced recovery protocols may limit direct comparisons with contemporary perioperative practice. Finally, the study evaluated immediate postoperative outcomes and lacked a long-term follow-up to assess delayed complications or extended quality of recovery. Future prospective, randomized, multicenter trials with larger cohorts are warranted to confirm and extend these findings.

CONCLUSION

EA appears to be a safe and effective alternative to GA for PCNL, offering comparable surgical outcomes and greater hemodynamic stability. Its advantages include superior postoperative pain control and reduced analgesic requirements, along with sufficient anesthetic duration for managing large or complex stones. EA is particularly beneficial in patients for whom GA is contraindicated or endotracheal intubation is challenging. Although EA offers several advantages, including improved postoperative analgesia and hemodynamic stability, it is also associated with increased intraoperative fluid and vasopressor requirements. Therefore, careful patient selection and vigilant intraoperative hemodynamic monitoring are essential when EA is chosen, particularly in patients with limited cardiovascular reserve. While bleeding and hypotension rates were similar between groups, close monitoring of hemodynamic parameters remains essential. Overall, EA represents a favorable anesthetic option for selected patients, and these findings should be confirmed in larger, multicenter, and long-term studies.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study has been approved by the Clinical Researches Ethics Committee of Haseki Training and Research Hospital (Date: 05.02.2014, Decision No: 55).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: ST, EÖ; Design: ST, EÖ; Data Collection and/or Processing: ST, ABK; Analysis or Interpretation of Data: ST; Literature Research: ST, ABK; Writing Manuscript: ST; Critical Revision for Important Intellectual Content: ST, EÖ.

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