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Safety and efficacy of general anesthesia versus spinal anesthesia in percutaneous nephrolithotomy

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the preferred treatment for the removal of large kidney stones, sized >20 mm. However, there is still an ongoing debate concerning the best anesthesia for PCNL. **Aims and Objectives:** The objective of this study was to assess and compare the efficacy and safety of spinal anesthesia (SA) versus general anesthesia (GA) in PCNL. **Materials and Methods:** A prospective randomized study included eighty-two patients who were enrolled to receive either SA or GA for PCNL. The study assessed patients' characteristics, vital parameters, requirements for additional analgesia, and patient satisfaction. In addition, intraoperative and post-operative complications were documented. Patients' satisfaction was also analyzed. **Results:** In both groups, the vital parameters were consistently maintained at safe levels during the procedures. Patients in the SA group exhibited a lower analgesia consumption on the 1st post-operative day compared to the GA group ($P<0.05$). Post-operative hypotension was higher in the SA group than in the GA group (17% vs. 7%). Patients in the GA group reported higher patient satisfaction scores than the SA group (mean $4.39+0.59$ vs. $3.81+0.64$). **Conclusion:** Both SA and GA are safe and effective in PCNL. SA is associated with fewer complications and reduced postoperative analgesia consumption. However, GA tends to offer higher satisfaction levels for patients. Each method of anesthesia has its own advantages and disadvantages. The final choice between general and SA should be based on the patient's condition and surgical team preference.

Key words: General anesthesia; Spinal anesthesia; Percutaneous nephrolithotomy; Hypotension; Analgesic; Patient satisfaction

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INTRODUCTION

Nephrolithiasis remains a common health problem around the globe. Its prevalence is 7–13% in North America, 5–9% in Europe, and 1–15% in Asia. Percutaneous nephrolithotomy (PCNL) is the treatment of choice for large renal calculi, staghorn calculi, and calculi which fail treatment with extracorporeal shockwave lithotripsy and ureteral endoscopy.[1-3] There are variations to PCNL, including position, imaging modality, dilation method, and anesthesia method.[3,4] PCNL can be performed under spinal anesthesia (SA) or general anesthesia (GA).[5,6] Nowadays, PCNL is usually performed under GA from a urological perspective, the particular advantages of GA in PCNL procedure include its feasibility to control tidal volume, secure patient airway especially in the prone position, and extensibility of anesthesia time.[1,3] The feasibility of controlling tidal volume minimizes renal mobility secondary to respiration while the extensibility of anesthesia time allows the surgeon to create multiple punctures with subsequently increased efficacy of the procedure, especially in cases with large stone burden. Moreover, GA is more comfortable for the patients and the ability to carry out prolonged operation in a prone position without limitation

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of airway is another advantage.[3,4] Nevertheless, GA does come with occasional side effects, including drug allergies, lung atelectasis, and post-operative vomiting as well as nausea.[4,7] On the other hand, SA was reported as having some advantages over GA, such as lower post-operative pain, lower dose requirement for analgesic drugs, and avoidance of the side effects from multiple medications during GA. Some studies have also shown that GA costs more than SA and has a higher rate of complications. The complications usually occur when the patient's position is altered from supine to prone. These complications include brachial plexus injury, spinal cord injury, and lung injury.[8,9] A limited number of prospective randomized trials have been carried out to establish which one of these procedures is better at decreasing perioperative complications.[7,10] Hence, the influence of the type of anesthesia on the effectiveness of PCNL remains uncertain. This study aimed to assess and compare the efficacy as well as safety of GA and SA in patients undergoing PCNL.

Aims and objectives

To assess and compare the efficacy and safety of spinal anaesthesia versus general anaesthesia in percutaneous nephrolithotomy.

MATERIALS AND METHODS

From April 2022 to March 2023, a prospective randomized study was carried out. The study included a total of 82 patients of either sex with ASA I, II, or III who underwent PCNL. The study protocol was approved by an institutional ethics committee. All patients underwent pre-operative evaluation including detailed history, physical examination, pre-operative urine analysis, urine culture, serum creatinine level, complete blood count and liver function tests, electrocardiography (ECG), and plain chest X-rays.

To identify stone characteristics, intravenous urography and/or non-contrast computed tomography were performed. Patients under chronic treatment with analgesics or corticosteroids, patients with contraindications to SA (coagulopathy, local infection...), allergy to opioids or local anesthetic solutions, and patients with substantial respiratory, hepatic, spinal, cardiovascular, or psychiatric disorders were excluded from participation in the study. Patients with horseshoe kidneys, concomitant pelviureteric junction obstruction, concomitant ureteric stones, and those unwilling to participate in randomization were additionally omitted from the study. Subsequently, after obtaining informed consent, all eligible patients were enrolled in a prospective randomized protocol; the patients were assigned to receive either general anesthesia or spinal anesthesia, with forty-one patients in each group. Randomization was executed by opening a sealed envelope at the operation theater (OT) on the day of surgery. The day before surgery, the study protocol: Spinal and general anesthesia procedures were explained to each patient. All patients received 10 mg of diazepam orally on the night of surgery. On arrival of the patients to the theatre suite, and after routine monitoring, a peripheral intravenous cannula (18G) was inserted. Lactated Ringer's solution was infused at a rate of 8 mL/kg to replenish the overnight fasting hours. Patients of both groups were premedicated with fentanyl 1 mg/kg and midazolam 0.05 mg/kg. All patients received intravenous third-generation cephalosporin, 2 h before surgery and for the next 1 day thereafter. In the SA group, spinal anesthesia was done by injecting 3–4 mL of heavy bupivacaine 0.5% plus 25 mg/kg fentanyl at L3–4 intervertebral space in a sitting position using a 25-gauge spinal needle. The head of the bed was tilted down for 5–10 min to check the level of anesthesia. Conscious sedation during PCNL was obtained with intravenous midazolam 1–2 mg. In the GA group, induction of GA was induced with propofol 2–3 mg/kg and vecuronium 0.1 mg/kg to facilitate tracheal intubation. Anesthesia was sustained with isoflurane (1–2%) and a mixture of 60% air in oxygen. Controlled ventilation was employed by the ventilator to sustain an ET CO_2 (end-tidal carbon dioxide) tension of approximately 35 mmHg. Throughout the surgery, continuous monitoring included ECG, pulse oximetry, non-invasive blood pressure, as well as $ETCO_2$. For patients in the GA group, neuromuscular blockade was reversed with (0.04 mg/kg) neostigmine and (0.02 mg/kg) glycopyrrolate at the surgery end. The duration of the surgery was 2 h.

PCNL procedure

The patient, positioned in a modified lithotomy stance, underwent the insertion of a 5-French open-tip ureteric catheter using a 19-ch cystoscope. Renal punctures were performed by the urologist during surgery under fluoroscopic guidance in all patients. All procedures were carried out in a prone position. A 22-ch. drainage nephrostomy tubes and ureteric catheter were routinely left for 4 h after PCNL.

Quantifiable outcomes encompassed pre-operative parameters such as ASA status, patients' demographics, body mass index (BMI), and surgery time. Intra-operative parameters included recording of pulse, and blood pressure at 5, 10, 15, and every 30 min till the surgery was completed.

Statistical analysis

For continuous variables, the data underwent normal distribution testing utilizing the Shapiro–Wilk test (applicable for a sample size >50). For comparison, the Mann–Whitney U-test or independent-sample t-test was used to compare

both groups. Fisher's exact test or Chi-square test was used to compare categorical variables. For all tests, statistical significance was considered when P<0.05. For comparing the safety and efficacy of SA versus GA, software R version (2023.06.1+524) for statistical analysis was used.

RESULTS

In the present study, 82 patients were enrolled (27 males and 14 females in the GA group vs. 24 males and 17 females in the SA group) and male predominance was observed. The mean age of the patients at the time of presentation was 43.36±10.18 years in GA group versus 43.63±11.26 years in the SA group. BMI kg/m^2 for the GA group was 24.27±0.95 while for the SA group was 23.68±1.19. In both groups, most patients were classified as ASA Grade II, followed by Grade I and Grade III. No considerable variance was observed among the groups in terms of ASA grade and patients' demographic characteristics. However, a statistical variation was noted among the groups in relation to BMI (P=0.019) (Table 1).

Intra-operative mean blood pressure was comparable in both groups at 5 min, 10 min, 15 min, and 30 min. Blood pressure values for all the time points and all the levels (high, low, and mean) showed higher values in the GA group compared to the SA group. However, among the groups, no statistical variation was observed at different time intervals (Table 2).

Hypotension was seen in 3 (7%) in the GA group and 7 (17%) patients in the SA group. There was no statistically considerable variance observed in terms of post-surgery analgesic requirements, hypotension, patient satisfaction, and blood loss during surgery, except for the need for postoperative pain control in the first 24 h, which exhibited a statistical variance (P=0.00). No patients had other complications such as arrhythmia or respiratory trouble throughout monitoring. All procedures in SA were accomplished without the need to conversion to GA. In the SA group, the patients reported higher overall satisfaction scores compared to the general anesthesia (GA) group patients (mean 4.39±0.59 vs. 3.81±0.64, P=9.705e-05), although no statistical variation was identified (Table 3).

Table 1: Patient demographic and duration of surgery

Parameter	General anesthesia group (n=41) (%)	Spinal anesthesia group (n=41) (%)	P-value
Sex			
Male	27 (66)	24 (59)	0.4243
Female	14 (34)	17 (41)	
ASA			
Grade I	18 (44)	15 (36)	-
Grade II	23 (56)	24 (58)	-
Grade III	0 (0)	2 (4)	-
Age	(43.36±10.18)	(43.63±11.26)	0.9704
BMI	(24.27±0.95)	(23.68±1.19)	0.01903*
Surgery time	(111.56±5.92)	(117.12±3.32)	1.148e-05

*Significant, BMI: Body mass index

Table 2: Blood pressure count for different time points during surgery

Parameter	General anesthesia Group (n=41) (Mean±SD)	Spinal anesthesia Group (n=41) (Mean±SD)	P-value
5 min			
High	(128.10±4.77)	(115.80±7.91)	3.211e-12
Low	(79.66±2.53)	(75.51±4.38)	1.889e-06
Mean	(103.88±3.41)	(95.66±5.85)	7.759e-11
10 min			
High	(126.73±5.11)	(115.22±7.37)	6.746e-11
Low	(80.10±2.72)	(76.10±2.94)	1.842e-08
Mean	(103.41±3.56)	(95.66±4.96)	8.018e-12
15 min			
High	(125.22±5.81)	(115.70±7.87)	1.392e-07
Low	(80.05±2.88)	(76.44±3.15)	1.486e-06
Mean	(102.63±3.93)	(96.07±5.31)	1.528e-08
30 min			
High	(126.39±5.35)	(116.63±6.41)	3.934e-09
Low	(79.27±2.48)	(76.39±3.23)	5.424e-05
Mean	(102.83±3.64)	(96.51±4.56)	2.482e-08

SD: Standard deviation

Table 3: Requirements during operations and patient satisfaction

Parameter	General anesthesia group (n=41) (%)	Spinal anesthesia group (n=41) (%)	P-value
Hypotension			
Yes	3 (7)	7 (17)	0.4386
No	38 (93)	34 (83)	
Analgesic need			
After surgery (min)	(37.56±7.84)	(46.34±6.13)	1.654e-06
In 24 h PCT (g)	(3.17±0.44)	(2.90±0.37)	0.004527
Blood loss	(320±14.66)	(222.44±11.79)	4.232e-15
Patient satisfaction (Score 1–5)	(4.39±0.59)	(3.81±0.64)	9.705e-05

DISCUSSION

PCNL is a widely accepted minimally invasive surgical procedure used for the treatment of large renal as well as upper ureteric calculi.[1-3] Several new techniques of PCNL such as mini-PCNL and tubeless PCNL were reported to decrease morbidity, analgesic requirement, and duration of hospitalization.[11] The method of anesthesia was reported to minimize morbidity following PCNL. In comparison to regional SA, the drawbacks of GA

include a rise in anaphylaxis incidence owing to the use of multiple medications and a greater likelihood of vascular, pulmonary, as well as neurological complications. In addition, challenges related to the endotracheal tube are encountered during the transition from lithotomy to the prone position. During supracostal puncture, patients with PCNL under regional anesthesia can follow verbal commands and control respiration for the prevention of pulmonary events.[10]

The benefits of SA, in comparison to GA, have been evident in various procedures, including radical retropubic prostatectomy[12] and unilateral total hip arthroplasty.[13] In recent reports, PCNL conducted under regional SA has been suggested to offer benefits. This is attributed to the fact that regional SA contributes to a superior postoperative quality of life owing to faster post-operative recovery. It is noteworthy, however, that most of these reports were not part of controlled studies.[7,10] Many studies conducted comparisons between regional and GA in PCNL procedures with conflicting results. In a prospective randomized study comparing combined spinal epidural block versus GA, Singh et al.,[10] reported less need for analgesics and shorter hospital stays in the spinal epidural group. These superior results of spinal epidural block have been supported by other reports.[7]

In the context of this study, subjects in the SA group exhibited reduced post-operative analgesia consumption. Kuzgunbay et al.,[4] compared the safety as well as the effectiveness of PCNL among thirty-seven subjects who went through the procedure under combined spinal epidural anesthesia and forty-five subjects under general anesthesia. Parameters such as stone surface area, age, change in hemoglobin, operative time, hospital stay, and stone-free rates showed no significant variations between the two groups. The conclusion drawn was that under spinal regional anesthesia, the PCNL procedure was equally safe and effective as PCNL under GA. Another study by Karacalar et al.,[7] testified superior outcomes with the combined spinal epidural block in comparison with GA, including aspects such as shorter duration of post-operative use of analgesic medication, less post-operative pain, and higher patient satisfaction. There were no significant differences in itch, vomiting, bradycardia, and hypotension between both groups, but a higher nausea rate was observed in the GA group. But found no difference between GA and spinal epidural anesthesia regarding operative time, post-operative hemoglobin level, hospital stay, success rate, and post-operative complications.[4]

Andreoni et al.,[14] noted the positive impact of a subarachnoid SA's single dose pre-operatively combined with GA in a research study involving nine subjects who received PCNL treatment, and this was compared to a group of eleven subjects who went through GA alone. This technique can decrease postoperative pain, nausea rates, and post-operative analgesic medication usage and allows earlier ambulation. Karacalar et al.,[7] reported the superior results of spinal epidural block compared to GA in some aspects such as patient satisfaction, less postoperative pain, and shorter duration of post-operative analgesic medication usage. Vomiting, itch, hypotension, and bradycardia were not different between both groups but a higher rate of nausea was found in the GA group.[7]

Mehrabi et al.,[15] evaluated 160 patients who were submitted to PCNL in the prone position under SA. 6 patients developed mild-to-moderate headache, dizziness, and low back pain. 10 patients (6.3%) received blood transfusions. Among these patients, 18 patients had hypotension controlled by intravenous ephedrine. Complications from the procedure were acceptable. They concluded that PCNL under SA is an alternative technique to GA. In contrast, hemodynamic instability during changing the patient's position from supine to prone was not found in several reports.[16,17] However, more patients' satisfaction was reported with spinal epidural block.[5,7] Complications associated with GA, including neurological, vascular, and pulmonary issues, particularly when the patient is going through a transition in position to prone from lithotomy, have been notified.[18,19] On the other hand, SA is usually associated with hypotension resulting from sympathetic block, especially during changing into a prone position.[20,21]

In a recent retrospective study involving 1004 subjects, complications were assessed for grades and compared between SA and GA.[22] The GA group exhibited a higher incidence of complications based on the modified Clavien classification. However, not all complications were directly related to anesthesia. In the present research study, there was no considerable variation observed among the two groups with respect to the overall post-operative complication rates and no major issues were notified in either group. However, a higher rate of patient satisfaction was reported in the GA group. This outcome contradicted most of the published research studies[7,23] and could be explained by potential discomfort experienced by patients in the SA group due to a prolonged stay in a prone position,[24] coupled with an awareness of significant noise in the OT. In addition, many patients held misconceptions about spinal needles, leading them to prefer GA to escape spinal needle puncture.

Limitations of the study

Number of the patients involved in the study is less.

CONCLUSION

PCNL under SA is as effective as PCNL under GA. The benefits of SA over GA include lesser early postoperative pain, reduced complications, and decreased usage of analgesics without increasing complications. Nevertheless, it is worth noting that GA tends to provide higher satisfaction levels for both surgeons and patients.

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SVY- Definition of intellectual content, literature survey, implementation of study protocol and manuscript revision; **KPD-** Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **AKB**- Design of study, data collection, statistical analysis and interpretation, manuscript preparation and submission of article.

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