Original Article

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Intraoperative and Postoperative Outcomes after Percutaneous Nephrolithotomy under General and Spinal Anaesthesia: A Prospective Observational Study

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ABSTRACT

Introduction: Percutaneous Nephrolithotomy (PCNL) is still the best way to deal with large or complicated kidney stones. It clears stones more effectively and has fewer side effects than open surgery. It can be done with either General Anaesthesia (GA) or Spinal Anaesthesia (SA), and each has its own pros and cons.

Aim: To compare the outcomes of PCNL performed under GA and SA during and after surgery.

Materials and Methods: This prospective observational study was conducted in the Department of Anaesthesia, LN Medical College and JK Hospital, Bhopal, Madhya Pradesh, India, in collaboration with the Department of Urology from December 2019 to May 2021, involving 60 adult patients American Society of Anaesthesiology-Physical Status (ASA-PS) I-II receiving PCNL under GA or SA. Patients were allocated to either group (GA, n=30; SA, n=30) based on the anaesthesiologist's clinical assessment and the patient's appropriateness. Postoperative pain {Visual Analogue Scale (VAS) scores}, total analgesic use, time to initial rescue analgesia, recovery duration to an Aldrete score of nine, and patient satisfaction ratings were assessed. Stata 16.1 was used to analyse the data, and a p-value <0.05 was considered statistically significant.

Results: The mean age was 42.6±12.6 years (GA) and 34.3±11.5 years (SA). The average time to the first rescue analgesia was 97.87±8.8 minutes in the GA group and 444.13±90.3 minutes in the SA group (p-value <0.0001). Postoperative pain scores (VAS) were significantly lower in the SA group at all recorded time points (0, 2, 6, 8, 12, and 24 hours) compared to the GA group (p-value <0.0001). The average total analgesic dose in the first 24 hours was much higher in GA (225±19.7 mg) than in SA (102.5±41.7 mg, p-value <0.0001). It took longer for SA (162.3±51.5 minutes) to reach an Aldrete score of nine than it did for GA (76.6±6.0 minutes, p-value <0.0001). The average satisfaction score for the SA group was higher (8.43±0.56) than for the GA group (7.86±0.90, p-value=0.005).

Conclusion: Compared to GA, PCNL with SA provides superior postoperative analgesia, evidenced by lower pain scores, diminished analgesic requirements, and an extended duration until the first rescue.

Keywords: Analgesics, Haemodynamic, Pain, Patient satisfaction, Postoperative, Recovery of function

INTRODUCTION

Renal stones, also known as urolithiasis, are one of the most painful urological conditions that require hospitalisation [1]. The global prevalence of kidney stone disease is steadily increasing, largely due to sedentary lifestyles, dietary habits, and global warming [2]. Urolithiasis affects almost 12% of the world's population, and the rates of it coming back are between 10% and 23% per year, 50% within 5-10 years, and up to 75% in 20 years [1]. In India, approximately 10-12% of the population is anticipated to develop urinary stones during their lifetime, with a considerable percentage ultimately advancing to renal impairment [3,4].

The PCNL is now the best way to treat large or complicated kidney stones that don't respond to other treatments [5]. It is the preferred method for stones larger than 20 mm, staghorn calculi, and multiple renal stones, as it offers higher clearance rates than extracorporeal shock-wave lithotripsy and lower morbidity than open surgery [6].

There has been a lot of discussion about which anaesthetic method to use for PCNL. The procedure may be conducted under GA or Regional Anaesthesia (RA), encompassing Epidural Anaesthesia (EA), SA, or combined Spinal-epidural Anaesthesia (SEA) methodologies [7,8]. The choice primarily hinges on patient-specific factors, including co-morbidities and willingness to cooperate, alongside stone characteristics, surgical duration, and surgeon preference [8,9]. GA provides superior airway management, enhanced patient comfort, and facilitates extended procedures and multiple renal punctures [10]. But it can cause atelectasis, nausea or vomiting after surgery, drug-related reactions, and problems with blood vessels or the nervous system [11,12]. It is still better for children, older people, and people with neurological problems who need controlled breathing and immobility [6,12-16].

Conversely, SA, initially introduced for PCNL in 1988 [5], has demonstrated its safety and efficacy as an alternative, offering benefits such as diminished intra- and postoperative analgesic needs, reduced haemorrhage, expedited recovery, decreased costs, and the elimination of airway manipulation and systemic anaesthetic drug effects [7,8,16,17]. However, RA is constrained by contraindications, including patient refusal, local infection, coagulopathy, or drug allergy [18]. Although SA is becoming more common in PCNL, there isn't much comparative data available from Indian centres [10,16,17].

The increasing utilisation of GA and SA for PCNL necessitates a comparative analysis of their impacts on patient safety, pain management, and patient-centred outcomes in practical clinical environments. Current literature reveals differing physiological and recovery characteristics between the two techniques; however, data specific to the Indian population remains limited, despite the notable prevalence of nephrolithiasis in the country. Understanding the impact of anaesthesia selection on postoperative pain, recovery

duration, analgesic requirements, and overall patient satisfaction is essential for enhancing perioperative care. A direct comparison of GA and SA in PCNL is essential for context-specific clinical decision-making. The current study aimed to compare the intraoperative and postoperative outcomes of PCNL performed under GA and SA. The primary objective of the study was to compare postoperative pain (VAS scores), total analgesic requirement, and time to first rescue analgesia between the two groups. The secondary objectives were to compare recovery time (time to achieve an Aldrete recovery score of nine) and patient satisfaction scores between the anaesthetic techniques.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesiology, LN Medical College and JK Hospital, Bhopal, Madhya Pradesh, India, in collaboration with the Department of Urology from December 2019 to May 2021. It was approved by the Institutional Ethics Committee under Reference No.: LfNMC&RC/Dean/2019/Ethics/125, dated 28/11/2019. Before enrollment, written informed consent was obtained from all participants after explaining the purpose, procedure, potential risks, and benefits of the study.

Sample size calculation: For an observational study, the sample size was calculated using the standard formula

$$(n=4\times pq/d^2)$$

for comparing postoperative pain scores between GA and SA in patients undergoing PCNL, with a 95% confidence level ($Z\alpha/2=1.96$), 80% statistical power ($Z\beta=0.84$), a pooled standard deviation (σ) of 1.0, and an expected mean difference ($\mu_1-\mu_2$) of 0.8 [19].-The minimum sample size for each group was 27; however, to account for attrition, 60 participants (30 per group) were included in the final study population.

Inclusion criteria: Individuals between the ages of 18 and 60, regardless of sex, with ASA physical status I or II, who are scheduled for PCNL due to renal calculi of any size or location as determined by the attending urologist, were deemed eligible for inclusion.

Exclusion criteria: Patients were excluded based on the following criteria- refusal to participate, presence of coagulopathy, local infection at the spinal puncture site, known allergy to study medications, severe cardiopulmonary disease, anatomical deformities of the spine, uncontrolled hypertension, or an ASA physical status of ≥III. Individuals who were pregnant, had bleeding disorders, experienced neurological issues, or had any other contraindications to GA or SA were excluded from participation.

Study Procedure

All patients underwent PCNL in the standard prone position with fluoroscopic guidance. After placing a ureteric catheter through a cystoscope, an 18-gauge needle was used to puncture the desired calyx, and a guidewire was pushed into the pelvicalyceal system. After that, the tract was dilated step by step, and an Amplatz sheath was put in. The sheath was used to do a rigid nephroscopy, and a pneumatic lithotripter and stone forceps were used to break up and remove the stones. Nephrostomy tubes and ureteric catheters were put in place as needed at the end of the procedure. The total time of the operation was measured from the first cut in the skin to the last. In the study, 68 patients were screened. These 60 patients met the inclusion criteria and were enrolled, while eight were excluded owing to ineligibility or refusal.

The 60 participants were divided into two groups of 30 each based on the type of anaesthesia administered:

- Group GA underwent General Anaesthesia, while
- Group SA received Spinal Anaesthesia.

All individuals were pre-anaesthetically evaluated the day before surgery. On operation day, identity and consent were checked, and standard ASA monitors were used. Baseline haemodynamics were taken 10 minutes before anaesthesia.

The GA was induced with propofol (2-2.5 mg/kg), fentanyl (2 µg/kg), and vecuronium (0.1 mg/kg) and maintained with oxygen, nitrous oxide, and isoflurane (0.8-1.2%). Under aseptic conditions, 3 mL of 0.5% hyperbaric bupivacaine was injected at the L3-L4 interspace to block T6 for SA.

Postoperative outcomes included pain intensity (VAS score) at 0, 2, 6, 8, 12, and 24 hours, time to first rescue analgesia, total analgesic requirement during the first 24 hours, time to achieve an Aldrete recovery score of nine, patient satisfaction score, and incidence of postoperative side-effects such as nausea and vomiting [20].

STATISTICAL ANALYSIS

Microsoft Excel compiled and Stata 16.1 (StataCorp, Texas, USA) analysed data. Continuous variables were compared using the unpaired Student's t-test or Mann-Whitney U test, expressing mean±SD or median {Interquartile Range (IQR)}. Frequencies and percentages were used to compare categorical variables using Chi-square or Fisher's-exact tests. A p-value <0.05 indicated significance. The analysis evaluated GA and SA intra- and postoperative pain scores, analgesic need, and patient satisfaction.

RESULTS

The demographic and baseline clinical characteristics of patients who had GA and those who had SA were the same, with no statistically significant differences [Table/Fig-1]. This similarity indicates that both groups were well-matched at the trial's commencement, facilitating an equitable comparison of postoperative outcomes. Minor differences between groups are not clinically significant and do not affect the validity of the analysis.

Variables	Category	GA group (n=30)	SA group (n=30)	p-value#
Age (years)	18–30	6 (20.0%)	14 (46.7%)	0.070
	31–40	7 (23.3%)	7 (23.3%)	
	41–50	9 (30.0%)	7 (23.3%)	
	51–60	8 (26.7%)	2 (6.7%)	
	Mean±SD	42.63±12.63	34.26±11.52	0.097†
Gender	Female	7 (23.3%)	12 (40.0%)	0.165
	Male	23 (76.7%)	18 (60.0%)	
ASA Grade	I	21 (70.0%)	19 (63.3%)	0.602
	II	9 (30.0%)	11 (36.7%)	
Number of Renal Stones	1	7 (23.3%)	17 (56.7%)	0.056
	2	12 (40.0%)	11 (36.7%)	
	≥3	11 (36.7%)	2 (6.7%)	
Side Involved	Right	15 (50.0%)	16 (53.3%)	0.764
	Left	15 (50.0%)	14 (46.7%)	

[Table/Fig-1]: Demographic and baseline characteristics of study participants (N=60). Values presented as n (%).
#Chi-square test, †Independent t-test

The comparison of postoperative pain intensity, as measured by the Visual Analogue Scale (VAS), between patients who underwent PCNL under GA and those under SA [Table/Fig-2]. At all postoperative time points- from immediate recovery (0 hour) through 24 hours- VAS scores were consistently higher in the GA group compared with the SA group. The differences were statistically highly significant (p-value <0.0001) at every time interval.

The mean and median initial analgesic rescue time in group GA was 97.87 and 98 minutes [Table/Fig-3]. The SA group's mean and median initial analgesic rescue times were 444 and 473 minutes, respectively. Analgesic rescue time was significantly different between the two groups (p-value <0.0001).

Mean VAS Score			
Time (hours)	GA (Mean±SD)	SA (Mean±SD)	p-value†
0 hour	7.20±0.88	0.37±0.49	<0.0001*
2 hours	7.53±0.86	0.53±0.54	<0.0001*
6 hours	6.77±0.76	2.16±0.61	<0.0001*
8 hours	6.40±0.71	2.33±0.69	<0.0001*
12 hours	5.70±0.68	3.10±0.56	<0.0001*
24 hours	5.43±0.59	3.06±0.89	<0.0001*

[Table/Fig-2]: Visual Analogue Scale (VAS) score among study participants at various points of time points (N=60).
*Significant (p-value<0.05), †Independent t-test

Time (minutes)	GA (n=30)	SA (n=30)	p-value
<150 minutes	30 (100.0%)	0	<0.0001*#
150–299 minutes	0	2 (6.7%)	
300–449 minutes	0	28 (93.3%)	
Mean±SD	97.87±8.8	444.13±90.3	<0.0001*†
Median (IQR)	98 (92–102)	473 (382–502)	–
Range	84–118	202–592	–

[Table/Fig-3]: Distribution of study participants based on time for first rescue analgesia.Values presented as n (%).

The most GA and SA participants received 225 and 75 mg of analgesics in the first 24 hours [Table/Fig-4]. The mean analgesic dose provided to GA participants (225 mg) was more than double that given to SA participants (102.5 mg). The median analgesic dose in group GA (225 mg) was three times that of the SA group (75 mg). Participants in the two groups received significantly different amounts of analgesics (p-value <0.0001).

Analgesics (mg)	GA (n=30)	SA (n=30)	p-value
75	0	20 (66.7%)	<0.0001*#
150	1 (3.3%)	9 (30.0%)	
225	28 (93.3%)	1 (3.3%)	
300	1 (3.3%)	0	
Mean±SD	225.0±19.69	102.5±41.70	<0.0001*†
Median	225	75	–
Range	150–300	75–225	–

[Table/Fig-4]: Distribution of participants based on the total dose of analgesic required during the first 24 hours after PCNL (N=60). Values presented as n (%).
*Significant (p-value <0.05), #Chi-Square test, ,†Independent t-test

Participants in the SA group took twice as long to obtain an Aldrete score of nine (p-value <0.0001) [Table/Fig-5]. The median time for GA and SA individuals was 78.5 and 185 minutes, respectively.

Duration (minutes)	GA (n=30)	SA (n=30)	p-value
<150	30 (100.0%)	4 (13.3%)	<0.0001*#
150–299	0	21 (70.0%)	
≥300	0	5 (16.7%)	
Mean±SD	76.6±6.0	162.3±51.5	<0.0001*†
Median	78.5	185	–
Range	62–86	135–341	–

[Table/Fig-5]: Distribution of study participants based on the time to reach Aldrete score of nine (N=60). Values presented as n (%).
*Significant (p-value <0.05), #Chi-square test †Independent t-test

The SA group had a substantially higher mean patient satisfaction score (8.43±0.56) compared to the GA group (7.86±0.90) (t=2.91, p-value=0.005). SA patients (46.7%) scored 9 or above, while half of both groups scored 8 [Table/Fig-6].

Side-effects for GA and SA patients has been presented in [Table/Fig-7]. In the GA group, 12 (40.0%) patients patient had nausea, compared to 7 (23.3%) in the SA group. GA patients had a greater rate of postoperative nausea (p-value=0.039). In the GA group, seven patients (23.3%) vomited, compared to three patients (10.0%) in the SA group. The difference was also significant (p-value=0.041).

Satisfaction score	GA (n=30)	SA (n=30)	p-value
6	3 (10.0%)	0	0.045*#
7	5 (16.7%)	1 (3.3%)	
8	15 (50.0%)	15 (50.0%)	
9	7 (23.3%)	14 (46.7%)	
Mean±SD	7.86±0.90	8.43±0.56	0.0050*†
Median	8	8	–
Range	6–9	7–9	–

[Table/Fig-6]: Distribution of study participants based on the satisfaction score (N=60). Values presented as n (%).
*Significant (p-value<0.05), #Chi-square test, †Independent t-test

Side-effects	GA (n=30)	SA (n=30)	Total (N=60)	p-value
Nausea				
No	18 (60.0%)	23 (76.7%)	41 (68.3%)	0.039*#
Yes	12 (40.0%)	7 (23.3%)	19 (31.7%)	
Total	30 (100%)	30 (100%)	60 (100%)	
Vomiting				
No	23 (76.7%)	27 (90.0%)	50 (83.3%)	0.041*#
Yes	7 (23.3%)	3 (10.0%)	10 (16.7%)	
Total	30 (100%)	30 (100%)	60 (100%)	

[Table/Fig-7]: Side-effects among participants. Values presented as n (%).
*Significant (p-value <0.05), #Chi-square test,

DISCUSSION

The PCNL is still the best way to treat large or complicated kidney stones. As minimally invasive techniques improve, there is still debate about the best way to give anaesthesia [6,14]. GA and RA each possess unique advantages and disadvantages [20,21].

Patient recovery after surgery is categorised into three phases: early, intermediate, and late. Phase I of recuperation begins soon after surgery. The patient stays in a critical care unit until they recover respiration, consciousness, blood pressure, and activity. Aldrete successfully achieved a high score early in phase 1 recovery. This score measures breathing, circulation, consciousness, colour, and activity. Step-down PACU transfers are available to patients scoring 9 or above [20].

Participants in the present study found that in SA group took twice as long to obtain an Aldrete score of nine (p-value <0.0001). GA and SA individuals had median times of 78.5 and 185 minutes, respectively. Bupivacaine, a typical long-acting local anaesthetic, blocks sensory and motor functions for hours. This prolonged recovery time can be attributed to the extended sensory and motor blockade produced by long-acting local anaesthetics such as levobupivacaine, despite patients being fully conscious and haemodynamically stable [22,23]. Conversely, patients undergoing GA exhibited expedited recovery owing to the brief half-life of intravenous and inhalational agents. Previous research has consistently shown that GA facilitates faster postoperative recovery compared to regional techniques. Tangpaitoon T et al., (2012) observed that patients undergoing GA exhibited quicker recovery in the initial stages, whereas those receiving EA experienced reduced pain and required lower doses of morphine [24]. At one hour (3.12 compared to 6.88) and 4 hours (3.42 compared to 5.07), the pain scores were significantly lower. Kumawat T et al., (2016) observed that GA promoted earlier ambulation and decreased Post-anaesthesia Care Unit (PACU) duration, while EA was associated with delayed motor recovery and a prolonged time to regain full limb strength [25]. Conversely, research on SA demonstrated a comparable trend: Meena M et al., (2017) found improved intraoperative haemodynamic stability, notably reduced VAS scores, and a lower 24-hour analgesic requirement (76 mg compared to 140 mg) in the SA group, although they also noted

delayed mobilisation resulting from ongoing motor block [26]. Virkar N et al., (2016) supported the current study's finding by showing that the combined spinal-epidural group experienced delayed ambulation, a significantly lower need for postoperative analgesia, and a reduced incidence of nausea and vomiting (14% compared to 48%) relative to GA [27]. So, SA impedes early recovery due to motor blockade; however, it provides enhanced postoperative comfort, effective pain relief, and improved haemodynamic stability, rendering it a superior option for pain management despite its impact on initial mobility.

In the current study, the mean time to first rescue analgesia was 97.87±8.8 minutes for the GA group and 444.13±90.3 minutes for the SA group, which is a very big difference (p-value <0.0001). None of the patients who had SA needed pain relief in the first three hours after surgery, but all of the patients who had GA did within 150 minutes. The extended analgesic duration in SA is due to the residual effects of intrathecal local anaesthetics. A study documented analogous findings, indicating that 30% of GA patients necessitated rescue analgesia within one hour, and the remaining 70% within two hours, whereas no patient in the combined spinal-epidural cohort required analgesia before three hours [27]. Mehrabi S et al., (2013) observed that SA patients who had PCNL had longer postoperative pain relief and needed rescue analgesia later than GA patients. The scientists attributed this difference to SA's extended sensory blocking and reduced stress response [28]. Nouralizadeh A et al., (2009) found that SA offered effective intraoperative and postoperative analgesia in paediatric PCNL patients using adult-sized tools. The scientists found that SA relaxes muscles and prolongs postoperative pain-free intervals, lowering opioid use [29]. The present study found that RA patients had a longer pain-free period and delayed needs for rescue analgesia than GA patients.

The SA gives longer postoperative analgesia after PCNL than GA. Intrathecal local anaesthetics prolong nociceptive suppression into the postoperative period due to their protracted sensory blockage. Spinal or mixed spinal-epidural patients experience a delayed onset of pain, require fewer rescue analgesic doses, and have lower initial postoperative pain scores. Spinal anaesthetic reduces narcotic exposure, nausea, and recovery time while making patients more comfortable. Postoperative analgesia was standardised across all participants through the administration of intravenous diclofenac (75 mg per dose) whenever the VAS score surpassed 4. The total diclofenac requirement within the first 24 hours was documented for comparative analysis between groups.

In the present study, patients under GA experienced greater postoperative pain intensity and necessitated increased diclofenac administration within the initial 24 hours compared to those under SA. Comparable trends are frequently documented in the literature. Mehrabi S et al., (2013) found that patients undergoing GA required an average of 158.6 mg of tramadol daily, compared to 100 mg for those receiving EA, indicating enhanced postoperative analgesia with regional techniques [28]. Meena M et al., (2017) assert that neuraxial anaesthesia induces prolonged sensory blockade, resulting in extended postoperative comfort and diminished necessity for rescue analgesics in the RA cohort (p-value <0.001) [26]. Numerous studies have demonstrated that regional anaesthesia significantly reduces postoperative analgesic consumption following PCNL. Tangpaitoon T et al., noted that regional EA diminished early postoperative pain and morphine consumption compared to GA [24]. According to Mehrabi S et al., SA increased pain-free time and delayed the use of rescue medicine because it blocked more senses for a longer time and caused less stress [28]. Nouralizadeh A et al., discovered that SA offered superior intraoperative stability and prolonged postoperative analgesia, even in pediatric PCNL utilising adult-sized instruments, thereby reducing opioid consumption [29]. Karacalar S et al., noted that SEA utilised fewer analgesics and offered superior postoperative comfort compared to GA [30]. Numerous studies indicate that RA or SA diminishes nociceptive transmission, extends postoperative analgesia, and decreases analgesic requirements, thereby enhancing patient comfort during early recovery.

In the present study, Postoperative Nausea and Vomiting (PONV) were significantly lower in the SA group (nausea: 23.3% vs. 40%, vomiting: 10% vs. 23%; both p-value <0.05). Less PONV directly led to higher patient satisfaction scores, which were much higher in the SA group (p-value=0.005). A study noted that 50% of patients receiving GA experienced PONV, in contrast to merely 14% in the combined spinal-epidural cohort [27]. Similarly, previous studies noted reduced PONV and increased satisfaction with RA [21,25]. Another study observed a higher incidence of nausea in GA patients [30], while other studies reported markedly reduced PONV and increased satisfaction with RA [24,31]. Moawad HES and El Hefnawy AS noted greater satisfaction under GA, attributing it to the discomfort associated with extended prone positioning and heightened awareness during SA [32]. Overall, the present study aligns with the majority of previous research on the subject. It suggests that SA, by reducing pain and side-effects, enhances patients' comfort after surgery.

Limitation(s)

Although the sample size was statistically justified, the study was conducted at a single tertiary care centre, which may limit its generalisability. Blinding of participants and anaesthesiologists was not feasible, potentially introducing performance bias. The 24-hour postoperative follow-up restricted evaluation of delayed complications and long-term analgesic outcomes. Moreover, only one anaesthetic regimen was used in each group, limiting comparison with multimodal or adjuvant techniques. Larger multicentric studies with extended follow-up are recommended to validate these findings.

CONCLUSION(S)

The present study indicates that SA offers enhanced postoperative analgesia for patients undergoing PCNL in comparison to GA. Patients undergoing SA demonstrated lower pain levels, delayed need for rescue analgesia, and reduced total analgesic use, indicating improved postoperative comfort and nociceptive management. Motor blockage resulted in a delayed Aldrete score recovery of nine; however, surgical safety and clinical outcomes remained unaffected. SA demonstrated a reduced incidence of side-effects and enhanced patient satisfaction, thereby improving its postoperative profile. Both methods effectively stabilised the patient during surgery and facilitated stone removal, while SA contributed to a rapid postoperative recovery. SA is a safe, effective, and well-tolerated alternative to GA for PCNL, particularly in managing postoperative pain and enhancing patient satisfaction.

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