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Original Article

Anaesthesia Section

Efficacy of Thoracic Segmental Spinal Anaesthesia in Percutaneous Nephrolithotomy: A Retrospective Observational Study

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ABSTRACT

Introduction: Percutaneous Nephrolithotomy (PCNL) is a minimally invasive procedure for the treatment of renal stone disease, usually performed under General Anaesthesia (GA). Regional anaesthesia, specifically Thoracic Segmental Spinal Anaesthesia (TSSA), offers a suitable alternative to mitigate complications associated with GA. TSSA in PCNL has an advantage over conventional lumbar spinal anaesthesia in terms of better haemodynamic stability, attributed to the lesser amount of local anaesthetic drug required. However, its clinical utility is yet to be fully explored.

Aim: To investigate the feasibility and efficacy of TSSA in patients undergoing PCNL by analysing their medical records.

Materials and Methods: A retrospective observational study was conducted on 250 patients from January 2022 to July 2023 at GNRC Medical, Guwahati, India. Patients aged 20-70 years with American Society of Anaesthesiology (ASA) I and II classification, undergoing PCNL with renal stones ≤40 mm, were included. TSSA was administered at the T9-T10 intervertebral space. Intraoperative parameters, degree of motor and sensory block, post-operative analgesia, patient and surgeon satisfaction were recorded. Descriptive statistics of the study were analysed in Microsoft excel and presented as mean with standard deviation or as numbers and percentages.

Results: The patients in the study had a mean age of 41.08 years, Body Mass Index (BMI) of 25.52 kg/m^2, stone size of 25.73 mm, and surgical duration of 74.92 minutes. TSSA was associated with minimal intraoperative hypotension (6%) and bradycardia (8.9%), zero incidences of neurological complications, and did not require conversion to GA. Complete stone clearance was achieved in 89.6% of cases. Post-operative analgesia was excellent in 179 (71.6%) patients as they did not require any rescue analgesia within the first 24 hours. Patient and surgeon satisfaction were notably high.

Conclusion: TSSA emerges as a safe and efficient alternative to GA in selected cases of PCNL. Patient and surgeon satisfaction, along with minimal post-operative complications, support its consideration and usage. However, the choice of anaesthesia should be individualised based on procedural complexities and patient characteristics.

Keywords: Analgesia, Bupivacaine, Haemodynamics, Paresthesia

INTRODUCTION

Percutaneous Nephrolithotomy (PCNL) is a minimally invasive procedure used for the removal of renal stones after fragmentation by a lithotripter. It is indicated for renal stones larger than 20 mm, staghorn calculi, extra-corpeal shock wave lithotripsy-resistant stones, and in cases of upper ureteric stones and 10-20 mm renal stones when other treatment modalities are not available [1]. Conventionally, PCNL has been performed under General Anaesthesia (GA). Regional anaesthesia presents a viable alternative that can help circumvent complications associated with GA while providing enhanced post-operative analgesia [2].

Recently, Thoracic Segmental Spinal Anaesthesia (TSSA) has gained favour among anaesthesiologists and has been successfully used in various cases of the thorax and upper abdomen. However, literature about its usage in urological procedures is quite limited [3-5]. Within the anatomical context of the thoracic spine and based on the available literature, TSSA holds promise as a potential anaesthetic technique for carefully selected PCNL cases [6]. TSSA offers distinct advantages over lumbar spinal anaesthesia, primarily attributable to minimal drug volume requirement and early motor recovery [7]. Successful implementation of TSSA provides stable haemodynamics with an optimal surgical field and maximum patient comfort but necessitates the expertise of the surgical team and patient acceptance of the anaesthetic modality. The present study aimed to conduct a retrospective observational analysis of the feasibility and efficacy of TSSA in PCNL surgery.

MATERIALS AND METHODS

This retrospective observational study included 250 patients from January 2022 to July 2023 at GNRC Medical, North Guwahati, India. After obtaining ethical committee approval (Reg No-ECR/778/Inst/AS2015/RR-22), all data were extracted, analysed, and interpreted from medical records between 15th November to 5th December 2023. The sample size was limited by the number of patients with complete medical records.

During this period, 314 patients underwent PCNL surgery under TSSA. A total of 250 patients were included in the study based on the inclusion and exclusion criteria.

Inclusion criteria: The study included patients aged between 20 and 70 years with ASA I and II classification who underwent PCNL with renal stones measuring less than or equal to 40 mm under TSSA.

Exclusion criteria: Cases with cardio-respiratory illness, intraoperative equipment failure, and incomplete clinical data were excluded from the study.

Procedure

The pre-operative work-up consisted of obtaining a clinical history, conducting routine baseline investigations, and a urology work-up (conventional intravenous urography/computed tomography-intravenous pyelography) for PCNL. Pre-anaesthetic check-up was conducted on the pre-operative day.

Patients were counseled about the nature of TSSA and instructed to express their pain using the Visual Analogue Scale (VAS).

Patients were assured that any discomfort or concern would be duly addressed during the peri-operative period. Informed consent was obtained from the patient. Upon arrival in the Operating Theatre (OT), standard monitoring was initiated, and intravenous access was established. Spinal anaesthesia was administered at the T9-T10 intervertebral space with the patient in a sitting position, using a 25 g spinal needle and 1.5 mL of bupivacaine (0.5% heavy) with 60 micrograms of buprenorphine. The patient was immediately placed in a supine Trendelenburg position for 10 minutes (20-30 degrees). The sensory block level was assessed using the pinprick method every two minutes until the desired block level was attained (T6-L2), and the time was recorded.

The motor block was assessed by the Modified Bromage scale. If the desired block level was not achieved after 20 minutes, it was considered a failed block, and GA was administered. Ureteric catheterisation was performed for retrograde pyelography using 2% lignocaine jelly, and then the patient was positioned prone with the head and neck resting on a soft head ring. Percutaneous renal access was achieved under fluoroscopic guidance in the prone position for stone disintegration by a lithotripter. A Laryngeal Mask Airway (LMA) was kept as a rescue airway device. Midazolam 1-2 mg was administered for conscious sedation. If the patient experienced pain and discomfort during the procedure, intravenous fentanyl was administered at 1 mcg/kg up to a maximum of two doses. If discomfort persisted, GA was administered. Blood pressure and Heart Rate (HR) were monitored every two minutes after spinal anaesthesia for the first 15 minutes, then every 15 minutes until the end of the surgery, and mean blood pressure and HR were noted.

Hypotension was defined as Systolic Blood Pressure (SBP) <90 mmHg or 20 percent from baseline and was treated with fluid and phenylephrine (50 micrograms). Bradycardia, defined as a HR <50 beats per minute, was treated with atropine (0.01 mg/kg). At the end of the surgery, sensory and motor blocks were evaluated, and the patient was examined for any pleural or visceral injury. The number of blood units transfused was recorded. At the end of the surgery, the patients were shifted to the Post-operative Care Unit (PACU). The haemodynamic parameters and time to complete regression of spinal anaesthesia were documented. The Visual Analog Scale (VAS) was monitored at the end of the surgery and then at 1, 2, 4, 6, 12, and 24 hours post-surgery in the PACU. If the VAS score was ≥4, intravenous paracetamol was administered.

The time to first rescue analgesia and total dose of paracetamol given in 24 hours were noted. Stone clearance was assessed by fluoroscopy and Kidney Urinary Bladder (KUB) X-ray after surgery. Surgeons were queried about the ease of positioning, stone detection and clearance, and overall comfort following surgery, and their responses were recorded using a five-point Likert scale (1- very poor, 2-poor, 3- satisfactory, 4-good, 5- excellent). Similarly, patients were asked about their overall satisfaction, and their responses were recorded using a five-point Likert scale. All peri-operative complications and adverse events such as Post-operative Nausea and Vomiting (PONV), pruritus, and shivering were recorded during the first 24 hours.

STATISTICAL ANALYSIS

The data was collected in a preset proforma and processed using Microsoft excel (version 2312, Build 17126.20132). The descriptive statistics of the study were calculated. The quantitative data are presented as mean and standard deviation, and the qualitative data are expressed as numbers and percentages.

RESULTS

The demographic profile of the population in the study has been presented in [Table/Fig-1] and includes age (41.08±12.24 years), male: female ratio (179:71), BMI (25.52±3.82), stone size (25.73±6.10), duration of surgery (74.92±15.62 minutes). Data on the puncture site and the number of punctures have been presented in [Table/Fig-2]. PCNL was completed in a large proportion of the patients with a single puncture (85.6%) in the sub-costal region (74.8%). Data on intraoperative haemodynamics, and sensory and motor block recovery have been presented in [Table/Fig-3]. Patients had a faster recovery from motor block (89.7 minutes) than sensory block (131.8 minutes). The incidence of hypotension and bradycardia, requiring phenylephrine and atropine within the first 15 minutes, incidence of intraoperative blood transfusion, conversion to General Anaesthesia (GA), and percentage of patients who had full stone clearance were presented in [Table/Fig-4].

Parameters	Mean	SD
Age (years)	41.08	12.24
BMI (kg/m²)	25.52	3.82
Sex ratio: Male/female	71.6: 28.4 (179/71)	
Stone size-largest diameter (mm)	25.73	6.10
Duration of surgery (minutes)	74.92	15.67

[Table/Fig-1]: Distribution according to demographic profile (n=250).
BMI: Basal metabolic index

Parameters		n (%)
Puncture site	Intercostal	63 (25.2%)
	Subcostal	187 (74.8%)
Number of punctures	Single	214 (85.6%)
	Two or more	36 (14.4%)

[Table/Fig-2]: Distribution according to puncture characteristics (n=250).

Parameters	Mean	SD
MAP at 15 minutes	85.36	8.63 mmHg
Heart Rate (HR) at 15 minutes	67.91	10.79 bpm
Sensory recovery time	131.8	11.74 minutes
Motor recovery time	89.7	8.08 minutes

[Table/Fig-3]: Haemodynamics measured at 15 minutes and block recovery time (n=250).
MAP: Mean arterial pressure

Parameters	No. of patient
Vasopressor supplementation	15 (6%)
Atropine supplementation	21 (8.9%)
PRBC transfusion	19 (7.6%)
Conversion to General Anaesthesia (GA)	0
Full stone clearance	224 (89.6%)

[Table/Fig-4]: Incidence of vasopressor and atropine supplementation, Packed Red Blood Cells (PRBCs) transfusion, conversion to GA, full stone clearance (n=250).

The majority of the patients had stable intraoperative haemodynamics with hypotension in 6% of patients and bradycardia in 8.9%. A complete clearance of stone was seen in 89.6% of patients. Notably, none of the patients required conversion to GA. Time to administration of the first rescue analgesia was presented in [Table/Fig-5]. Impressively, 179 (71.6%) patients didn't require any rescue analgesia in the first 24 hours. The incidence of complications is listed in [Table/Fig-6]. Postoperative Nausea and Vomiting (PONV) (2.4%), shivering (5.3%), and headache (3.2%) were seen in a small group of patients. There were no instances of pleural injury,

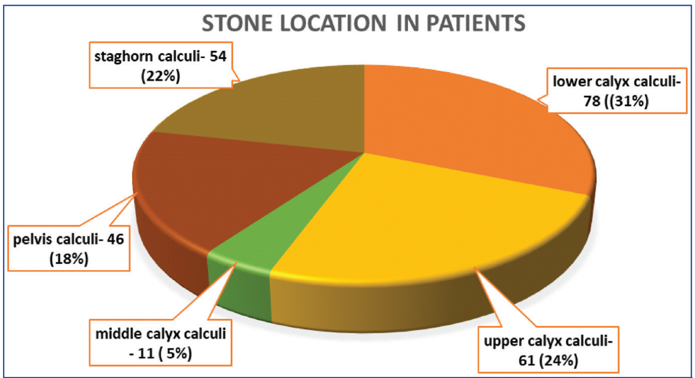
Time period	No. of patients (%)
0-12 hours	19 (7.6%)
12-18 hours	32 (12.8%)
18-24 hours	20 (8%)
No analgesia in 24 hours	179 (71.6%)

[Table/Fig-5]: Administration of first rescue analgesia with VAS ≥4 (n=250).

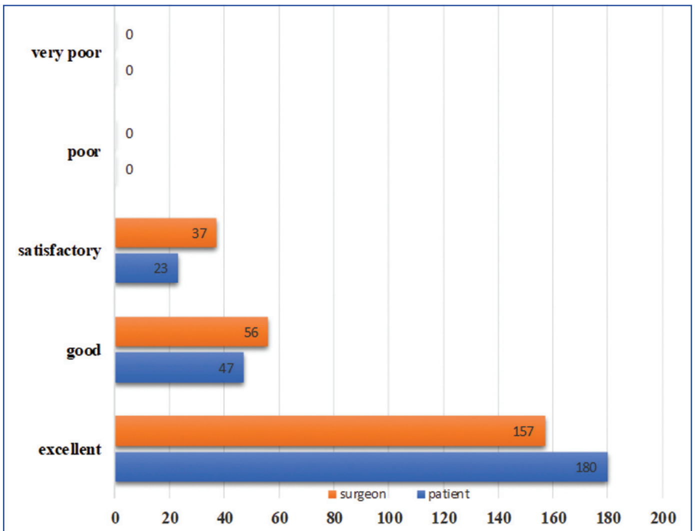
neurological complications, or visceral organ injury. [Table/Fig-7] shows the stone location in the patient. In terms of satisfaction, in the majority of the cases, both the patients (180) and surgeon (157) were highly content and rated the experience as excellent [Table/Fig-8].

Complications	No. of patients (%)
Headache	8 (3.2%)
PONV	6 (2.4%)
Shivering	13 (5.32)
Neurological complications	0
Visceral organ injury	0
Pleural injury	0

[Table/Fig-6]: Incidence of complications (n=250).
PONV: Post-operative nausea and vomiting



[Table/Fig-7]: Pie chart showing stone's location (n=250).



[Table/Fig-8]: Satisfaction scores of the surgeon and patients (n=250).

DISCUSSION

PCNL is evolving continuously with its modality of anaesthesia aiming at increasing efficiency and reducing morbidity. It is usually performed under GA due to its better airway management, tidal volume control, haemodynamic stability, flexibility of anaesthesia duration, and patient comfort through unawareness while maintaining immobility [8]. However, GA in PCNL has various disadvantages too. Malik I and Wadhwa R in their review, highlighted the inherent risks of GA, such as airway stimulation, polypharmacy, and pulmonary and vascular complications. Hazards related to the prone position and pressure causing accidental endotracheal tube kinking and extubation, post-operative visual loss, and neuronal injury leading to limb weakness have also been reported in their study [9].

PCNL can be done with the same efficacy with regional anaesthesia as under GA. Regional anaesthesia offers the distinct advantages of less PONV, better analgesia in the post-operative period, reduced hospital stays with better surgeon and patient satisfaction, and overall providing cost-effective and quality healthcare [2,10-12]. TSSA is the performance of spinal anaesthesia within the thoracic region, documented as high as T4-T5 interspace [13]. TSSA has been used for several procedures, such as laparoscopic cholecystectomy, major orthopaedic surgery, upper abdominal cancer surgery, and breast surgery [14-17].

In this retrospective observational study, it was found that TSSA for PCNL provided stable haemodynamics with less hypotension and bradycardia requiring minimal vasopressor and vagolytic drugs. TSSA has also been found to be effective and safe in this study achieving complete stone clearance in 90% of the cases with fewer incidences of PONV, headache, and no instances of neurological injury. Quality post-operative analgesia was achieved, and both the surgeon and patient rated their satisfaction scores as excellent in most of the cases.

In the thoracic region, the CSF volume is less, and nerve roots are smaller. So, a small amount of local anaesthetic efficiently produces a nerve blockade, resulting in an excellent surgical field to the relative dermatome level [18,19]. In TSSA, the sympathetic block produced is limited, and the incidence of hypotension and bradycardia is lower [20]. The use of a hyperbaric local anaesthetic further potentiates the sensory block and lasts longer than the motor block [15]. The key concern with TSSA is the possibility of iatrogenic cord injury. A greater depth of the posterior subarachnoid space at the thoracic level as evident in MRI studies makes TSSA safer with less chance of cord injury [21,22]. Literature on the use of TSSA for urological procedures is very limited [3-5].

In the current study, TSSA provided stable haemodynamics in most of the patients. Hypotension was reported in 6% of patients, and 8.9% experienced bradycardia. The sensory block lasted longer than the motor block, and complete recovery occurred at a mean time of 131 minutes (sensory) and 89 minutes (motor). Singhal G et al., in their randomised controlled study of 60 patients undergoing PCNL surgery, evaluated the feasibility and safety of TSSA in comparison to conventional lumbar spinal anaesthesia [3]. They used isobaric ropivacaine (0.75%) 2.5 mL with dexmedetomidine 6mcg in the thoracic group and hyperbaric ropivacaine (0.75%) 4ml with Dexmedetomidine in the lumbar group. They reported a minimal incidence of hypotension (3.33%) and bradycardia (6.67) in the thoracic spinal group. Imbelloni LE et al., conducted a prospective observational trial on 369 patients undergoing laparoscopic cholecystectomy [23]. Their study concluded that low-dose bupivacaine (7.5 mg) with a thoracic puncture strategy provided better haemodynamic stability, less hypotension (15%), and bradycardia (2.6%) than conventional lumbar spinal anaesthesia (bupivacaine 15 mg). The mean (SD) duration of the sensory block was 164 minutes (29 minutes), and the motor blockade was 72 minutes (18 minutes). Imbelloni LE and Gouveia MA in a randomised controlled trial, compared the use of thoracic spinal anaesthesia with low-dose isobaric and low-dose hyperbaric bupivacaine for orthopaedic surgery in 200 patients [15]. They reported longer sensory blocks with early motor recovery using hyperbaric bupivacaine. 4% of patients had bradycardia, and 12.5% had hypotension.

The current study reported minimal post-operative analgesia requirement, with 71% of patients receiving no analgesia (VAS score <4) during the first 24 hours of stay. 2.4% of patients in our study had PONV. Paliwal N et al., conducted a prospective RCT to study segmental thoracic spinal anaesthesia versus GA for breast cancer surgery [16]. The thoracic spinal group reported low opioid consumption, with only 17.85% of patients needing rescue analgesia. PONV was more in the GA group, and only one patient had episodes of nausea in the spinal group. Satisfaction scores for both the surgeon and patient were higher in the thoracic spinal group. Elakany MH and Abdelhamid SA studied the advantages of segmental thoracic spinal over GA for breast cancer surgery [17]. Apart from stable haemodynamics, analgesia consumption (0%) and PONV(10%) were lower in the thoracic spinal group. None of the patients of the thoracic spinal group required conversion to GA.

In the present study, 89.6% of patients had complete clearance of renal stones. Mehrabi S and Karimzadeh Shirazi K studied the complications in a case series of 160 patients who underwent PCNL under spinal anaesthesia [24]. Ten patients (6.3%) needed a blood transfusion, and six complained of headache, dizziness, and mild backache, which improved with analgesics and bed rest. In the present study, 3.8% had mild headaches, and 7.6% required a blood transfusion. Pleural injury and visceral injury were not seen in any of the patients. Kamal M et al., in their retrospective analysis of 1160 patients undergoing PCNL under spinal anaesthesia, reported a complete stone clearance rate of 90% [25]. The present study with 250 cases found a favourable safety profile, with no patients experiencing paresthesia or other neurological complications. Imbelloni LE et al., evaluated the incidence of paresthesia and neurologic complications after a lower spinal thoracic puncture in 300 patients [26]. Paresthesia occurred in 6.6% of the patients and was transient with no permanent neurologic sequelae. Similarly, Patel K and Salgaonkar S; Kejriwal AK et al., reported no incidence of neurological injury in their studies with TSSA [5,27]. Singhal G et al., and Abraham A and Das V in their studies with spinal and TSSA rated the experience of surgeons and patients as good to excellent in most cases [3,28]. This study reported similar results in close to 90 percent of the cases. The surgeon attributed his satisfaction to reduced bleeding, fewer complications, and early mobility, while the anesthesiologist could avoid complications related to GA, leading to a smoother post-operative period. Patients experienced less pain, early mobility, and reduced economic burden.

Limitation(s)

This was a retrospective observational study, while offering valuable insights, has several limitations to consider. The single-center study design limits generalisability to other institutions with different protocols and patient populations. The absence of a control group using a different anaesthesia modality hinders direct comparison of outcomes. The lack of a detailed cost analysis restricts the understanding of the potential economic benefits of TSSA in PCNL. These limitations highlight the need for well-designed randomised controlled prospective studies to establish the clinical utility of TSSA in PCNL.

CONCLUSION(S)

In conclusion, TSSA is a safe and effective anaesthetic modality for use in uncomplicated procedures of limited duration. In our study, analysis of data showed that patients had stable intraoperative haemodynamics with good post-operative analgesia and minimal complications and also rated the experience as excellent in the majority of cases. Thus, TSSA can be used in cases of PCNL with good effect, but its administration should be limited based on the patient's preferences, the surgical position, the surgeon's expertise, and the estimated duration of the procedure as determined by the case profile. GA remains the gold standard when the procedure is expected to be complicated and prolonged.

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