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Original Research Article

Comparison of thoracic segmental spinal anaesthesia and lumbar spinal anaesthesia for percutaneous nephrolithotomy

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ABSTRACT

Background: Randomised controlled study aimed to compare low thoracic segmental spinal anesthesia (TSSA) and conventional lumbar spinal anesthesia (LSA) in percutaneous nephrolithotomy (PCNL).
Methods: Sixty adult patients undergoing elective PCNL were randomly assigned to two groups: T (TSSA) and L (LSA). Group T received TSSA (isobaric ropivacaine 0.75% 2.5 ml with dexmedetomidine 6mcg) at T10-T12, while Group L received LSA (hyperbaric ropivacaine 0.75% 4 ml with dexmedetomidine 6mcg) at L2-L4. Primary objectives of our study was to evaluate the feasibility and safety of TSSA for PCNL and to compare hemodynamic changes, block onset, and duration, and adverse effects. Secondary objectives were time to rescue analgesia, patient, and surgeon satisfaction. Data was analyzed using SPSS.
Results: All patients underwent surgery successfully under neuraxial anesthesia. Group T exhibited more stable hemodynamics with a significantly lower hypotension incidence compared to Group L (3.33% vs. 26.66%, p=0.03). Onset of sensory and motor block was quicker in the TSSA group (p<0.001) upper. Sensory block levels were T6 for both groups, but lower level in TSSA was levels L2 and L3, while LSA impacted all segments below T6. No neurological complications occurred, particularly in Group T, which had higher satisfaction scores from surgeons and patients.
Conclusions: TSSA is a safe and effective option for PCNL, providing better hemodynamic stability with lesser incidence of and reducing intra-operative hypotension compared to conventional LSA.

Keywords: Isobaric ropivacaine, Nephrolithotomy, Spinal anesthesia, Thoracic segmental

INTRODUCTION

Percutaneous Nephrolithotomy (PCNL) is considered as the surgical treatment of choice for removing renal stones that are too large (>20mm) or stones that cannot be removed using shockwave lithotripsy or ureteroscopy.[1-4] Spinal anesthesia(SA) is one of the preferred techniques for this, as it is associated with reduced venous pressure leading to less surgical blood loss, prolonged postoperative analgesia and reduced requirement of various anesthetic drugs.[5-7] PCNL requires neuraxial block from T6 to L2. Hence spinal anaesthesia can be given at low thoracic or lumber level to achieve adequate surgical anesthesia.

Ropivacaine is a local anesthetic (LA) with less cardiotoxic and neurotoxic side effects. It is available in isobaric and hyperbaric preparations.[8-11] Isobaric ropivacaine in low doses at lower thoracic level produces segmental block required for PCNL Surgery.[12]

We planned this study to compare low thoracic segmental spinal anesthesia (TSSA) with the conventional lumbar spinal anesthesia (LSA) using isobaric and hyperbaric ropivacaine respectively for PCNL surgeries. Primary objective of this study was to evaluate the feasibility and safety of TSSA for PCNL and compare this technique with LSA based on the observations such as hemodynamic variations, onset and duration of sensory

and motor block and adverse effects. Secondary objectives were time of rescue analgesia, patient and surgeon satisfaction score in these two groups.

METHODS

After Institutional Ethics Committee approval, the study was registered prospectively with Clinical Trial Registry of India (www.ctri.nic.in) with registration number CTRI/2022/06/043446 and was conducted in accordance with principles of the Declaration of Helsinki. This single-center, randomized controlled study was conducted on 60 patients undergoing PCNL, in the urology operation theatre of a tertiary care medical center from June 2022 to December 2022. This study was conducted at Jaipur National University (JNU) Hospital, Jaipur, Rajasthan.

Sample size calculation was done using the formula:

$$n = \frac{Z(Z_\alpha + Z_\beta)^2}{\delta/\sigma}$$

Where; $\alpha = 95\%$, $\beta = 2\%$, δ = difference between mean of two groups, σ = Standard Deviation of the group.

"R" software version 3.4.1 was used to determine the sample size based on a study by Gupta et al.[13] According to this formula, a minimum group size of 22 patients would be necessary. Therefore, in this study we took 30 patients in each group with 95% significance level and 2% power of size for the study.

In this study, patients of ASA1 and ASA2 category who were 20 - 50yrs old and gave written informed consent were included. Patients having BMI >37kg/m^2, pregnant and lactating females, patients with bleeding disorders, psychiatric and neurological disorders or with local site infections were excluded from this study. Patients were randomized into two groups-T and L, using a computer generated randomization and concealment was done using sealed envelope method.

The sealed envelope was opened by the anesthesiologist conducting the cases and the anesthesia technique was appropriately chosen. Patients were explained regarding the technique and intrathecal use of drugs and subsequently, written informed consent was taken. Pre-anesthesia checkup was done as per hospital protocols before scheduling patients for surgery and patients were kept fasting as per standard guidelines.

After receiving patients into operating room, written informed consent was checked, Intravenous cannulation with 18G cannula was done and IV fluid started (10 ml/kg in approximately 15 minutes). ASA standard monitoring comprising of pulse-oximetry, electrocardiogram, noninvasive blood pressure were applied and baseline vitals including heart rate, blood pressure, oxygen saturation were noted. All emergency medicines and anesthesia work station were checked. Intravenous (i.v) ondansetron 4 mg and midazolam 1mg was given to all patients as premedication. Spinal anesthesia was then administered via a median approach in sitting position using 25G quincke spinal needle (B. Braun, Melsungen, Germany). Group T patients were given isobaric ropivacaine 0.75% 2.5 ml with adjuvant dexmedetomidine 6mcg at the level of T10-T12 space. Group L patients were given hyperbaric ropivacaine 0.75% 4ml with adjuvant dexmedetomidine 6mcg at L2-L4 space.

Subsequently, patients were positioned supine in group T. In group L, patients were given supine position, pillow and head down tilt of 20 to 30 degrees for 5 to 10 minutes till establishment of spinal block level upto T6 dermatome.

Sensory block was assessed bilaterally using pinprick method by a 27 gauge short beveled needle in midclavicular line. Time to achieve sensory block till T6 was noted as onset time of sensory block. This extent of sensory block was considered to be adequate for starting the surgery. Time for achieving maximum motor block (after which no further progress occurred) was noted as the time of onset of motor block and was quantified. The block was considered as failed if sensory block till T6 was not achieved after 10 minutes. Patients with failed or inadequate block were planned to be given standard general anesthesia and were excluded from study.

This was followed by cystoscopic ureteric catheterization in lithotomy position and subsequently patients were made prone to obtain position for percutaneous access to the affected renal calyx. The duration of 3 segment regression of sensory block was noted. In our pilot study, the two segment regression time was at times overlapping with the surgery time and therefore it was decided to record the 3 segment regression time. Motor blockade was quantified using modified Bromage score till full recovery and duration of motor block noted.[14] Vital parameters were continuously monitored and recorded every 5 minutes till completion of surgery. Adverse events were noted and managed. Duration of surgery was noted. Hypotension was defined as more than 20% fall in systolic blood pressure from baseline and it was managed by giving i.v. fluids and mephentermine 6mg i.v. boluses. Heart rate below 55/min was counted as an episode of bradycardia and was treated with atropine 0.6 mg (iv). SPO2 less than 94% was considered as an episode of desaturation and was managed with oxygen supplementation using face mask. Injection fentanyl was kept ready as intraoperative rescue analgesia and its use noted. In the recovery room, vital parameters and sensory and motor block were noted every 15 min until the block regressed completely. Total duration of analgesia was noted from the time of spinal anaesthesia till onset of pain (VAS 3) and then postoperative rescue analgesia in the form of paracetemol 1gm infusion was given. Postoperative side-effects like PONV, backache,

headache and neurological sequelae, if any, were noted and managed on day 0, day 1 and day 2.[15]

An overall procedure satisfaction score was created to evaluate the patient and surgeon satisfaction individually. This was based on 4 criteria each. Patient Satisfaction scoring criteria (Absence of each of the following complaint was given 1 point): 1) Intraoperative pain, discomfort, 2) Postoperative pain, 3) Postoperative nausea vomiting, 4) Postoperative headache, backache. Surgeon satisfaction scoring criteria (presence of each of the following was given 1 point) are 1) Adequate relaxation during surgery, 2) Absence of intraoperative movements, 3) Absence of postoperative side effects, 4) Timely discharge from hospital. Following score was derived from above criteria. Good was rated as 4 points, adequate was rated as 3 points and poor rated as 2 or lees points.

Statistical analysis

Data obtained in this study were processed in Microsoft Excel 2007. Qualitative data was measured as percentages and proportions while quantitative data was measured as mean and standard deviation from mean (SD). Appropriate statistical tests of significance were applied for analysis of the data collected using IBM SPSS Statistics version 22. The Categorical data was presented as numbers (percent) and were compared among groups using Chi square test. The quantitative data was presented as mean and standard deviation and were compared by students t-test. P value <0.05 was considered statistically significant

RESULTS

All 60 patients enrolled in the present study showed adequate sensory and motor blockade and were included in the study. Table 1 shows that both groups were comparable in terms of age, weight, height, sex and ASA grading. Duration of surgery was comparable in both groups. There was no requirement of additional intraoperative analgesic supplement in any of the study patients. Patients of both groups showed stable heart rate throughout surgery (Figure 1). There were episodes of intraoperative bradycardia in two patients in each group and were easily managed with intravenous injection atropine 0.6 mg (Figure 4). There was a dip in systolic and diastolic blood pressure in the first 20 min in both group patients (Figure 2, 3). However, the dip was more in group L patients. There was a positive correlation between the number of segments blocked and hypotension. There were eight episodes of intraoperative hypotension in group L patients and only one hypotensive episode in group T (Table 3). Hypotensive episodes were easily managed with i.v. boluses of mephentermine 6 mg.

Table 1: Demographic profile.

	Group T		Group L		Result (p value)
	Mean	**SD**	**Mean**	**SD**	
Age (years)	41.57	9.95	42.53	9.12	0.696**
Weight (kg)	60.00	10.32	58.83	7.85	0.624**
Height (cm)	166.27	7.89	167.83	6.33	0.399**
Duration of surgery (min)	63.50	15.12	68.53	15.28	0.204**
Sex; M/F (n)	23/7		17/13		0.171**
ASA grade (I/II)	22/8		21/9		1.00 **

**Non significant

Table 2: Comparison of characteristics of block, surgeon and patient satisfaction score between two groups.

	Group T		Group L		Result (p value)
	Mean	**SD**	**Mean**	**SD**	
Onset of sensory block (min)	4.87	1.17	6.73	1.01	p<0.001 *
Onset of motor block (min)	7.10	1.56	9.07	1.26	p<0.001*
Duration of 3 segment regression (min)	104.17	8.00	144.93	8.12	p<0.001*
Duration motor block (min)	81.67	10.24	74.20	9.26	0.004*
Duration of rescue analgesia (min)	286.97	32.61	394.40	46.31	p<0.001*
Patient satisfaction score (good/adequate/poor)	30 / 0 / 0		20 / 10 / 0		0.002*
Surgeon satisfaction score (good/adequate/poor)	30 / 0 / 0		25 / 5 / 0		0.036*

*Significant

Observations about block characteristics, duration of rescue analgesia, surgeon and patient satisfaction score are mentioned in Table 2.

The duration of onset of sensory and motor block in Group T was significantly shorter (p value <0.001). In both groups upper level of sensory block of T6 was achieved. The lower level of sensory block in Group T was L2, L3 while complete sensory block of all segments

below T6 was achieved in Group L. Despite this none of the patients of group T required any additional analgesia for cystoscopy and ureteric catheterization. The duration of 3 segment regression of sensory block in group T was shorter than group L and there was a positive correlation with the lesser dose of ropivacaine used in group T (18.75 mg) than group L (30 mg). Complete motor block (Bromage score 3) was not seen in any of the patients of group T and only motor block of Bromage score 1and 2 was achieved. All patients of Group L had motor block of Bromage score 3. However time to achieve complete motor regression (B 0) was longer in isobaric group. The time of postoperative rescue analgesia was significantly more in group L (P <0.001) which could be explained by greater dose of local anesthetic used in this group.

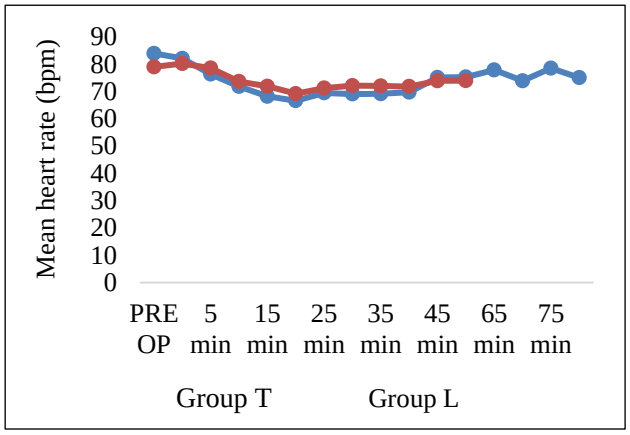

Figure 1: Intraoperative variations in heart rate.

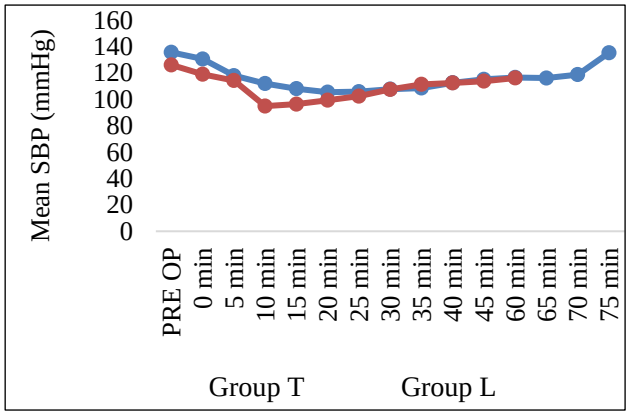

Figure 2: Intraoperative variations in mean SBP.

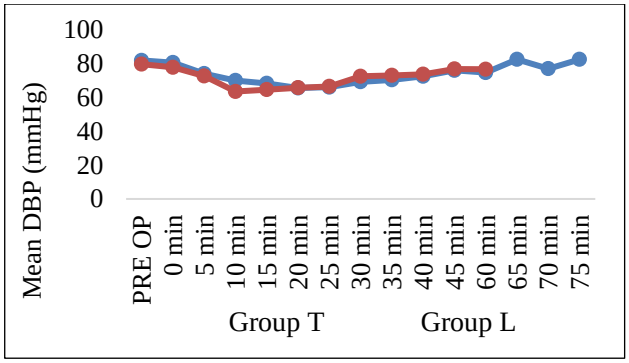

Figure 3: Intraoperative variations in mean DBP.

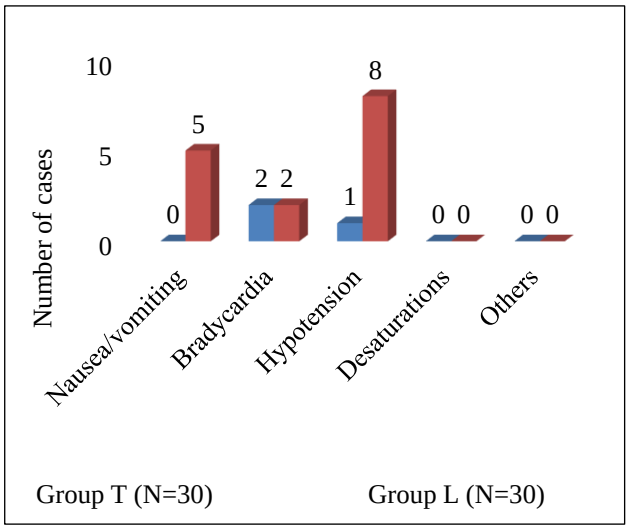

Figure 4: Perioperative adverse effects.

Perioperative adverse events noted in both groups were as shown in Table 3 and Figure 4. There were no postoperative side effects in the form of headache, backache etc. Noteworthy to mention that there were no intraoperative or postoperative neurological side effects in any patients administered thoracic spinal. All patients were discharged uneventfully on day 2 as per hospital protocol and were followed up for a week. The patient satisfaction score was good in all 30 patients of group T while in group L, 20 rated it as good and 10 rated it as adequate. Surgeon satisfaction was good in all patients of group T and among group L score was adequate in five and good in 25 patients (Table 2).

Table 3: Adverse effects.

Perioperative adverse effect	Group T (n=30)		Group L (n=30)		Result (p value)
	N	%	N	%	
Nausea/vomiting	0	0.00	5	16.67	0.062**
Bradycardia	2	6.67	2	6.67	0.605**
Hypotension	1	3.33	8	26.66	0.030*
Desaturations	0	0.00	0	0.00	-
Others (including postoperative adverse events)	0	0.00	0	0.00	-

*significant; **non significant.

DISCUSSION

In this prospective study, it was demonstrated that thoracic segmental spinal anesthesia provided better hemodynamic stability with lesser incidence of hypotension (as per definition) as compared to lumbar spinal anesthesia. Hemodynamic parameters studied were systolic and diastolic blood pressure and heart rate. There was minimal need for vasopressor and intraoperative fluids in group T patients. However, the incidence of bradycardia was equal in both groups. The onset of sensory and motor block was earlier in group T and the duration of sensory block in group T was shorter (3 segment regression time 104.17±8 minutes in group T vs 144.93±8.12 minutes in group L).[12] The duration of post operative analgesia was longer in group L as denoted by the time of rescue analgesia (394.40±46.31 minutes) than group T(286.97±32.61 minutes). These could be attributed to a larger dose of ropivacaine used in group L patients. Complete motor block was not seen in any patient of group T in which all patients had motor block of Bromage Score 1 or 2 while all patients of group L had motor block that was complete (Bromage Score 3). None of the patients of TSSA group required additional analgesia during cystoscopy and ureteric catheterization which requires sensory blockade of S3 dermatome. It could be because of transient sacral sensory block due to possible downward spread of intrathecal LA.[16] In the present study no incidence of any neurological sequelae was noted, particularly in group T.

Though there have been several studies on PCNL under LSA, there exists no published literature regarding the use of thoracic segmental spinal for PCNL.[5,6,14] As per studies by Karacalar et al, SA is considered an attractive alternative to GA for PCNL in adult patients as it inhibits stress hormone secretion better than GA, offering better hemostasis and lesser side effects (nausea, vomiting, postoperative pain) thus facilitating early discharge from hospital.[6] These studies demonstrated SA to be safe as well as cost-effective. TSSA is the performance of SA at thoracic levels as high as T4/T5 intervertebral space.[17-21] The technique is used as single-shot spinal anaesthesia, combined with epidural anaesthesia or thoracic continuous spinal anaesthesia, using local anaesthetic drugs like levobupivacaine, bupivacaine or ropivacaine with both isobaric and hyperbaric formulations.[18-27] Adjuvants to TSSA include opioids, dexmedetomidine, clonidine, ketamine etc.[23-29]

As per comparative study between TSSA and LSA by Imbelloni et al (2014), the greater extent of sympathetic block involving lower limbs in LSA resulted in vasodilatation of blood vessels and a greater reduction in preload.[30] In TSSA, sympathetic block is limited to a fewer dermatomes with minimal lower limb involvement resulting in lesser reduction in preload and blood pressure. Above study by Imbelloni also concluded that because of minimal motor involvement of lower limbs, the patients could ambulate faster with TSSA as compared to LSA. According to this study by Imbelloni, the use of SA at thoracic levels reduces the required dose of LA. The thoracic nerve roots are thinner as compared with lumbar nerve roots with reduced volume of cerebrospinal fluid at this level explaining the rapid onset of action as well as requirement of lower volume of LA. In our study, the drug dose and volume used in group T patients was much less (ropivacaine18.75 mg, 2.5 ml) than in group L (ropivacaine 30 mg , 4 ml) and onset of action of sensory and motor block was more rapid in group T patients.[30]

The greatest concern when SA is performed above the spinal cord termination level is accidental injury to spinal cord with transient or permanent neurological complication. The MRI studies have revealed that in thoracic region the spinal cord touches the duramater anteriorly and distance between posterior duramater and spinal cord is 5.19 mm at T2, 7.75 mm at T5 and 5.88 at T 10. At the lumbar level the cauda equine touches the posterior duramater.[31]A study performed by Imbelloni showed incidence of paraesthesia during TSSA ranges between 4% and 10% but no long term neurological sequelae have been reported. Similar results have been reported in thoracic segmental spinal anesthesia by several other investigators.[32-35]

This study had certain limitations as this was a preliminary study in ASA1-2 patients and included a small sample size. Whether this technique can be used in high risk patients requires further studies on a larger sample size. Although in this study, patients with upper pole kidney stones also were conveniently managed, further studies are needed with study population designated for upper pole stones to compare the efficacy of TSSA and LSA in this sub-group of patients.

CONCLUSION

Thoracic segmental spinal anesthesia with low dose of isobaric ropivacaine in combination with dexmedetomidine is a safe and effective anesthesia technique for PCNL as it provides better hemodynamic stability, rapid and effective sensory block with less motor blockade than lumbar spinal anesthesia with conventional doses. However, further research is warranted in heterogenous cohort groups using well-designed RCTs to establish the utility of this technique.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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