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Research Article

Comparative study of electrolytes and metabolic changes during percutaneous nephrolithotomy: spinal vs. general anaesthesia

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is a common surgery for renal stones and it can be performed under spinal and general anaesthesia. There is always a debate upon the superiority of one of the above technique over other. This study was undertaken to study the metabolic changes associated with the use of above techniques. We also studied the blood loss associated with them.
Methods: 60 patients of either sex, aged between 25 to 60 years belonging to ASA physical status I or II undergoing PCNL were divided randomly into two groups and they received spinal (SA) and general anaesthesia (GA) as per standard protocol and study parameters were evaluated.
Results: Blood pressure was lower and heart rate was higher in SA group compared to GA group. Changes in pH, bicarbonate, serum sodium, serum potassium and serum lactate were insignificant. Blood loss was report to be lower in SA group.
Conclusions: In both the groups, patients were haemodynamically stable throughout the surgery and both the techniques were safe regarding hemodynamic changes and no significant advantage or disadvantage exists between the two. In both the groups there was a trend towards metabolic acidosis with increased lactate levels but it was not clinically significant with any of the anaesthetic technique. No changes were seen in electrolytes levels (Na and K) in any of the groups. Spinal anaesthesia was associated with lesser amount of blood loss and need for post-operative blood transfusion as compared to general anaesthesia.

Keywords: PCNL, Blood loss, Spinal, General anaesthesia

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) has become treatment of choice for large kidney calculi, staghorn calculi, and calculi that are multiple or resistant to shock wave lithotripsy.[1] The advantages of PCNL are lower morbidity rates, faster postoperative recovery and less blood loss.[2] Overall significant complications associated with PCNL, including acute loss of kidney function, colon injury, hydrothorax, perforation, pneumothorax, prolonged leak, sepsis, ureteral stone, and vascular injury.[3]

PCNL can be performed under various anaesthetic techniques such as: general, spinal, epidural, combined spinal-epidural,[4] renal capsular block along with skin infiltration and interpleural block.[5,6] GA is associated with risk of pulmonary complications and an overview of randomized trials indicates that regional anaesthesia reduces postoperative death and other serious problems.[7,8]

In past general anaesthesia was preferred over spinal anaesthesia but now with recent advances and after various studies it has been proved that spinal anaesthesia is feasible, safe, well tolerated and offers a reliable neuraxial block for patients subjected to PCNL with stable hemodynamic, good post-operative analgesia and acceptable patient and endoscopes satisfaction.

Present study was designed to compare metabolic and electrolyte changes during PCNL under general and spinal anaesthesia. The aim of the study was to compare the serum electrolytes (Na^+ and K^+), metabolic parameters (pH, HCO_3^-, lactate), blood loss, blood urea and serum creatinine changes during PCNL under spinal and general anaesthesia.

METHODS

This randomized, prospective, comparative study was conducted on 60 patients of either sex, aged between 25 to 60 years belonging to ASA physical status I or II undergoing PCNL. After getting approval from institutional ethical committee (human), an informed consent was taken from the patient.

Exclusion criteria were patient's refusal to participate in the study, patients with electrolyte imbalance or acid-base disturbances, patient with diabetes mellitus, cardiovascular disorders, hepatic diseases and morbid obesity, deranged renal function, pregnant or lactating females, patients known to have allergy to any drug under the study, patient with contraindication for spinal anaesthesia, patients on any drug known to affect hemodynamic and electrolyte, surgery extending beyond 2 hours and surgery where multiple puncture was done. A thorough medical history was obtained and complete pre-anaesthetic check-up of the patient was done and written informed consent was obtained.

The selected patients were divided into one of two groups using a computer generated random number table:

Group I: Patient received general anaesthesia as per standard protocol.

Group II: Patient received spinal anaesthesia as per standard protocol.

In group I, patients after premedication with intravenous glycopyrrolate (0.2 mg), midazolam (1 mg), fentanyl (2 µg/kg), were preoxygenated with 100% oxygen for 3 minutes. Induction was done with intravenous propofol (2 mg/kg), followed by vecuronium (0.1 mg/kg) and endotracheal intubation was performed. Anaesthesia was maintained with 60% nitrous in 40% oxygen, vecuronium and isoflurane as inhalational anaesthetic agent at 0.5 MAC. After completion of surgery, patients were reversed with neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg).

In group II, patients after preloading with lactated Ringer's solution (10 ml/kg), were placed in sitting position on the operating table. After taking proper sterile precautions, spinal anaesthesia was performed at L2-3 interspace, with 25 gauge Quinke's spinal needle, with hyperbaric bupivacaine 0.5% (0.3 mg/kg) with fentanyl (0.5 µg/kg) as an additive. Patients were put in Trendelenberg position (approx. 15-30 degree) for 10 minutes. A sensory block of T6 dermatomal level was achieved. Pin prick was used to check the sensory level in mid-clavicular line.

Intravenous fluid was given according to Holiday-Seager formula in both the groups. Glycine 3% was used as irrigation fluid in all cases. Rate of irrigation was 60-70 ml /min.

Hypotension was defined as fall in systolic blood pressure below 20% of baseline value or less than 90 mmHg and it was treated with bolus dose of 0.1 mg/kg of inj. mephentermine. Bradycardia was defined as a heart rate less than 55 beats/min and it was treated with inj. atropine 0.01 mg/kg bolus.

Arterial blood gas analysis was done to measure pH, $HCO3^-$ and lactate and venous blood was taken to measure hemoglobin, blood urea, serum creatinine serum Na+ and serum K+. Blood pressure (systolic/ diastolic/ mean) and heart rate were measured at 0 min (baseline) and every 5 minutes for 1st 30 minute, every 15 minutes till 2 hours and at 180 minutes. To measure electrolyte and metabolic parameters, samples were taken preoperatively, intraoperatively (1 hour after start of surgery) and postoperatively (1 day after procedure) period. Blood urea and serum creatinine were measured during preoperative and postoperative period. Duration of procedure, volume of irrigation fluid used and effluent fluid, amount of intravenous fluid given and number of percutaneous intervention during the procedures was noted.

Surgeon's opinion (surgeon's satisfaction score) about the quality of anaesthesia was recorded on a four point scale: 0 = poor anaesthesia; 1 = satisfactory anaesthesia; 2 = good anaesthesia; 3 = excellent anaesthesia. Requirement of blood transfusion in the postoperative period (blood was transfused in those patients whom Hb level was <8.5 gm%) was noted.

Data collected was subjected to statistical analysis to obtain the results. The statistical analysis was done using SPSS (Statistical Package for Social Sciences) version 15.0 statistical analysis software. The values were represented in Number (%) and Mean ± SD. Statistical test such as chi-square, student 't' test, paired 't' test used for analysis of parameters. A P value <0.05 was considered significant.

RESULTS

On comparing the baseline demographic and hemodynamic variables of the patient in both groups, it was found that there was no statistically significant difference between the two groups regarding age, sex, duration of procedure, ASA grade, SBP (systolic blood pressure), DBP (diastolic blood pressure), MAP (mean arterial pressure) and HR (heart rate). Furthermore, both the groups were also matched for baseline hemoglobin, metabolic parameters and serum electrolytes except serum creatinine which was higher in group I (1.18 ± 0.17) as compared to group II (1.06 ± 0.21) but all the values are within normal clinical range. Thus, we can say that these variables did not lead to confounding of the results.

Systolic blood pressure in group II were significantly lower (P <0.05) than that of group I at all-time intervals after 10 minutes. As compared to baseline, change in systolic blood pressure was significant in group II at all levels and in Group I at all levels except at 30 minutes, 60 minutes, 75 minutes, 90 minute, 105 minute and at post-operative time/180 minutes.

Diastolic blood pressure was significantly lower for group II at 25 minutes and 30 minutes. At other time intervals difference in diastolic blood pressure of both the groups was statistically non-significant (P >0.05). Comparison of change in diastolic blood pressure (from baseline) was statistically significant at all intervals. In group I at post-operative/180 minute diastolic blood pressure reached very near to baseline (difference 0.30 ± 7.36 mmHg).

MAP in group II were significantly lower (P <0.05) than that of group I at all-time intervals after baseline except at 75 minute, 105 minutes and 120 minutes. Comparison of change in MAP (from baseline) was statistically significant at all intervals in both groups except at post-op/180 minute in group I.

Comparison of heart rate in both the groups reveals that heart rate in group II was found to be significantly higher at all intervals between 5 minutes and 30 minutes. Thereafter no statistical significant difference in heart rate between the groups was found except at 120 minutes. In group I change in heart rate (from baseline) was found to be significant at 5, 10, 60 and 90 minutes intervals only while change in heart rate in group II was found to be significant at all intervals except at 20, 25, 30 and 45 minutes.

IV fluid required by group I subject was 1.76 ± 0.18 liters and that by group II subjects it was 1.73 ± 0.18 liters, difference in requirement of IV fluid in both the groups was statistically non-significant (P = 0.521). Amount of irrigating fluid in group I was 5.95 ± 0.51 liters as compared to 6.08 ± 0.51 liters in group II, difference in amount of irrigating fluid was statistically non-significant. Amount of affluent fluid in group I was 5.33 ± 0.58 liters as compared to 5.46 ± 0.51 liters in group II, this difference was statistically non-significant (Figure 2). Duration of procedure in both the groups was found to be statistically non-significant (P = 0.655). Therefore, the fluids used (intravenous and irrigation) and duration of surgery did not affect the final outcome of the study (Figure 1).

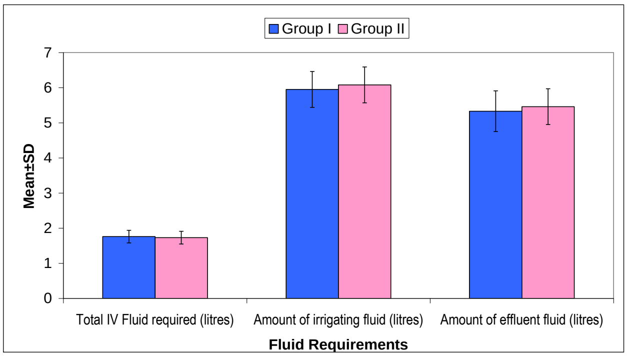

Figure 1: Fluid intake in both groups.

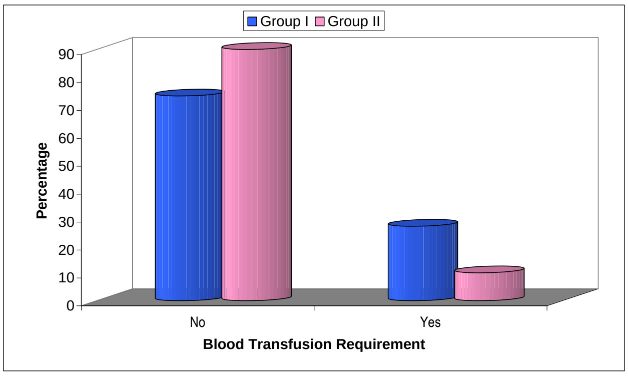

Figure 2: Requirement of blood transfusion.

Table 1: Comparison of change in haemoglobin level in study population.

	Group I (n=30) gm/dl			Group II (n=30) gm/dl		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. intra-op	-1.43 ± 0.67	11.592	<0.001	-0.85 ± 1.11	4.193	<0.001
Pre-op vs. post-op	-2.48 ± 0.66	20.667	<0.001	-1.62 ± 1.04	8.545	<0.001
Intra-op vs. post-op.	-1.05 ± 0.47	12.190	<0.001	-0.76 ± 0.33	12.646	<0.001

Before operation no statistically significant difference in haemoglobin levels in both the groups was found but at intra-operative and post-operative measurements, difference in haemoglobin levels of both the groups was found to be statistically significant. Table 1 shows that change in haemoglobin at different stages of operation was statistically significant in both the groups.

Difference in pH levels of both the groups was statistically non-significant at pre-operative stage and it was found that at intra-operative stage and post-operative stage difference in pH levels of both the groups remained statistically non-significant. Table 2 shows that change in pH at different stages of operation was statistically non-significant in both the groups.

Table 2: Comparison of change in pH level in study population.

	Group I (n=30)			Group II (n=30)		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. intra-op	-0.01 ± 0.03	2.093	0.045	-0.01 ± 0.03	2.774	0.010
Pre-op vs. post-op	-0.01 ± 0.03	2.097	0.045	-0.01 ± 0.04	1.980	0.057
Intra-op vs. post-op.	0.00 ± 0.03	0.388	0.701	0.00 ± 0.03	-0.362	0.720

Difference in bicarbonate levels of both the groups was statistically non-significant and pre-operative stage. It was also found that at intra-operative stage and post-operative stage too, difference in bicarbonate levels of both the groups was found to be statistically non-significant (Table 3).

Table 3: Comparison of change in bicarbonate level in study population.

	Group I (n=30) meq/l			Group II (n=30) meq/l		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. intra-op	-1.67 ± 0.59	15.440	<0.001	-1.45 ± 0.58	13.652	<0.001
Pre-op vs. post-op	-2.65 ± 1.07	13.517	<0.001	-2.23 ± 0.84	14.526	<0.001
Intra-op vs. post-op.	-0.97 ± 0.85	6.283	<0.001	-0.78 ± 0.78	5.452	<0.001

Difference in lactate levels of both the groups at pre-operative stage was statistically non-significant but difference in lactate levels of both the groups was at intra-operative stage (P = 0.003) and post-operative stage (P <0.001) was statistically significant (Figure 1). Change in lactate levels was statistically significant in group I but in group II change in lactate levels was statistically non-significant at different stages. Difference in serum urea levels of both the groups was statistically non-significant at pre-op stage and at post-operative stages (Table 4).

Table 4: Comparison of change in lactate level in study population.

	Group I (n=30) mg/dl			Group II (n=30) mg/dl		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. intra-op	0.12 ± 0.17	-3.827	0.001	-0.01 ± 0.22	0.135	0.893
Pre-op vs. post-op	0.19 ± 0.16	-6.335	<0.001	0.05 ± 0.20	-1.352	0.187
Intra-op vs. post-op.	0.07 ± 0.15	-2.596	0.015	0.06 ± 0.22	-1.418	0.167

Difference in serum sodium levels of both the groups was statistically non-significant at all the stages of procedure (pre-operative stage, intra-operative stage and post-operative stage (Table 5). Difference in serum potassium levels of both the groups was statistically non-significant at pre-operative stage, intra-operative stage and post-operative stage. Change in serum potassium levels of was statistically non-significant during different stages of procedure in both the groups (Table 6).

Table 5: Comparison of change in serum sodium levels in study population.

Time interval	Group I (n=30) meq/l	Group II (n=30) meq/l	Statistical significance	
	Mean ± SD	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op	140.57 ± 3.17	139.37 ± 1.87	1.787	0.079
Intra-op	139.27 ± 3.11	138.00 ± 1.72	1.953	0.056
Post-op	138.57 ± 3.14	137.43 ± 1.96	1.678	0.099

Table 6: Comparison of change in serum potassium levels in study population.

	Group I (n=30) meq/l			Group II (n=30) meq/l		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. intra-op	-0.05 ± 0.18	1.424	0.165	0.06 ± 0.41	-0.802	0.429
Pre-op vs. post-op	0.06 ± 0.22	-1.416	0.167	0.02 ± 0.53	-0.231	0.819
Intra-op vs. post-op.	0.10 ± 0.29	-1.939	0.062	-0.04 ± 0.36	0.572	0.572

Change in serum urea levels (pre-operative and post-operative) was statistically significant in both the groups. Difference in serum creatinine levels of both the groups was statistically significant at pre-operative stage and at post-operative stages (Table 7). Change in serum creatinine levels (pre-operative and post-operative) was statistically significant in group I (P = 0.004) and group II (P = 0.003) (Table 8).

Table 7: Comparison of change in serum urea level in study population.

	Group I (n=30) mg/dl			Group II (n=30) mg/dl		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. post-op	-1.93 ± 1.57	6.727	<0.001	-1.57 ± 1.28	6.714	<0.001

Table 8: Comparison of change in serum creatinine level in study population.

	Group I (n=30) mg/dl			Group II (n=30) mg/dl		
	Mean ± SD	**'t' value**	**'P' value**	**Mean ± SD**	**'t' value**	**'P' value**
Pre-op vs. post-op	-0.11 ± 0.20	3.166	0.004	-0.13 ± 0.22	3.249	0.003

The surgeon's satisfaction was excellent (53.33%) in group II as compared to only 6.67% in group I (Figure 3).

Blood transfusion was required in lower proportion (10%) of subjects in group II as compared to 26.67% in group I but this difference was statistically non-significant (Figure 3).

None of the above side effects in both the groups showed any statistically significant difference (Figure 4).

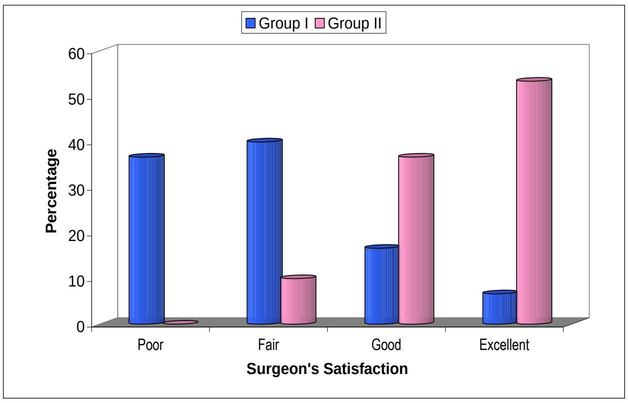

Figure 3: Surgeon's satisfaction.

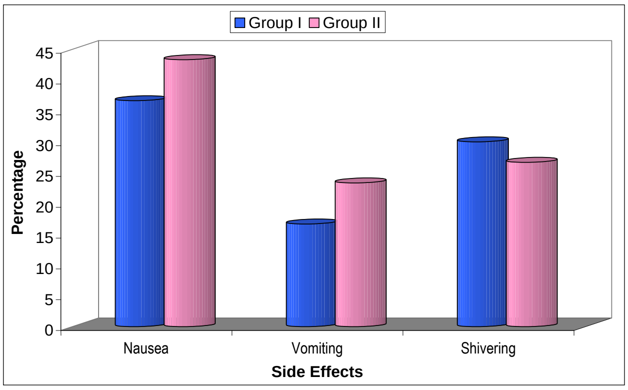

Figure 4: Side effects in both groups.

DISCUSSION

In order to find better anaesthetic technique for PCNL, we compared the two most commonly used techniques. We investigated the change in various parameters during PCNL under spinal and general anaesthesia (SA and GA).

While comparing the hemodynamic variables, we must keep in mind that there are inherent physiological changes associated with the two techniques of anaesthesia. In general anaesthesia, there is sympathetic stimulation at the time of intubation and extubation while in spinal anaesthesia; there is decrease in the blood pressure caused by decreased vasomotor tone due to sympathetectomy. Therefore, the hemodynamic variables may differ, especially in initial and late phases of procedure. However, in both the techniques, patients were hemodynamic stable and we can say that both the techniques were safe regarding hemodynamic changes and no significant advantage or disadvantage exists between the two.

Many studies have compared the changes in serum electrolytes during PCNL and they did not found any significant change in their levels.[9-11] However, some studies have reported hyponatremia and hypokalemia and explained these changes by renal tubular dysfunction due to mechanical irritation of kidneys and glycine 1.5% induced hyponatremia during PCNL.[2,12-14]

In our study, we compared the change in the two clinically most important electrolytes - sodium (Na) and potassium (K). Difference in serum sodium levels of both the groups was statistically non-significant at all the stages of procedure. Difference in serum potassium levels of both the groups was statistically non-significant during different stages of procedure in both the groups. We found in our study that SA and GA did not affect the levels of sodium and potassium significantly.

In our study we measured blood pH, serum lactate and bicarbonate levels as metabolic variables to assess the metabolic acidosis associated with irrigation, hypoperfusion and renal dysfunction. At baseline no statistically significant difference in metabolic parameters of both the groups was found.

Difference in pH and bicarbonate levels of both the groups was statistically non-significant at pre-operative stage and they did not change significantly during surgery.[9] Previous study did not find any significant changes in bicarbonate and base excess, but they found a significant fall in postoperative period. According to their study, only bicarbonate had negative correlation with the duration of irrigation. A study also showed a tendency to metabolic acidosis in their subjects.[2]

Change in lactate levels was statistically significant at different stages in general anaesthesia group but in spinal anaesthesia group change in lactate levels was statistically non-significant at different stages. This shows an increase in lactate levels during GA, the cause of which is unknown. However, the change in lactate levels did not cause significant changes in pH and bicarbonate levels. The unchanged lactate levels in SA may reflect better renal and hepatic perfusion during surgery.

Studies done to assess changes in blood urea and serum creatinine have found conflicting results with some studies showing no change in their levels.[2,9,10] while some studies reported rise in serum creatinine.[15] We also compared blood urea and serum creatinine levels in the two groups to assess the renal dysfunction associated with the procedure. Difference in blood urea and serum creatinine levels of both the groups was statistically non-significant at preoperative stage and at postoperative stage. Although, there is decline in blood urea and serum creatinine levels in both the groups which was statistically significant and similar in both groups but clinically insignificant and remains within normal clinical ranges in both groups.

We do not found any significant difference in the requirement of irrigation fluid in both groups. We found that the amount of fluid absorbed in both groups were almost same and the absorption of irrigation fluid did not differ in both group and may not be a confounding factor while assessment of blood loss. Similar results were found in other studies i.e. no significant difference in amount of irrigation fluid in patient undergoing PCNL under regional and general anaesthesia.[4,16] Because of large amount of fluids administered to patient during PCNL, there is a potential risk for hypothermia during the procedure.[17] Studies have reported that the major consequences of a postoperative decrease in core temperature are shivering, increase oxygen consumption, anxiety, peripheral vasoconstriction and delayed drug clearance.

Acute anemia due to blood loss or dilution is a potential complication of PCNL. The transfusion trigger in our study was hemoglobin less than 8.5 gm%. Both the group had similar amount of irrigation fluid absorbed and similar amount of intravenous fluids given. Thus, haemodilution was not a confounding factor while assessing the blood loss. Also, we have excluded the surgery requiring multiple skin punctures so that the blood loss can be compared. Change in hemoglobin at different stages of operation was statistically significant in both the groups. Blood transfusion was required in 10% of subjects who received spinal anaesthesia as compared to 26.67% in subjects who received general anaesthesia but this difference was statistically non-significant. However, as there is much concern regarding the hazards of blood transfusion nowadays and scarcity in blood supply, the 17% decline in blood transfusion found in spinal anaesthesia group in our study can have an important impact on the anaesthesia practice. Even this much blood saved by spinal anaesthesia can be used for other patients for saving their lives.

Blood transfusion rate reported in various studies has been between the ranges of 5% to 18%.[18-24] The higher incidence of blood transfusion found in our study may be associated with longer duration of procedure in our study, difference in the level of expertise of surgeons, longer duration of renal calculi which have led to fibrosis and difficult PCNL and finally, the level of haemodilution. In our study, we have used the difference in the irrigation and effluent fluid to assess the amount of fluid absorbed and degree of haemodilution. This method is not so accurate and may have led to false assessment of hemoglobin levels leading to misjudgment of requirement of blood transfusion.

A significantly higher proportion (53.33%) of surgeons' adjudged the overall satisfaction level as excellent in spinal anaesthesia group as compared to only 6.67% in general anaesthesia group. This is mainly because of the better operating conditions, decreased intraoperative blood loss seen in spinal anaesthesia group, decreased postoperative pain and decreased requirement of postoperative monitoring.

The postoperative adverse effects related to procedure and anaesthesia noted in our study were nausea which was 36.6% (11/30 patients) in group I and 43.33% (13/30 patients) in group II, vomiting which was 16.67% (5/30 patients) in group I and 23.33% (7/30 patients) in group II and shivering which was 30.0% (9/30 patients) in group I and 26.67% (8/30 patients) in group II. In both groups, the incidence of these side effects was statistically non-significant. The rate of postoperative nausea and vomiting in standard literature is 20-30% (Christian C, 2010) and in our study the rate is slightly higher and this may be related to procedure as the rate in both GA and spinal anaesthesia were similar.

In the current study, both the modalities of anaesthesia were found to be haemodynamically stable during the whole procedure. There was no significant difference in the pH, bicarbonate, blood urea and serum creatinine of the two groups. The electrolytes in the two groups also did not show any significant difference. The requirement for blood transfusion was higher in patients who received general anaesthesia as compared to those who received spinal anaesthesia. This has been attributed to the decrease intraoperative blood loss in the group who received spinal anaesthesia. This decrease intraoperative blood loss in turn translated into better surgeon satisfaction score for the spinal anaesthesia group. Hence, in our study, spinal anaesthesia was associated with better outcomes.

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Ethical approval: The study was approved by the institutional ethics committee

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