

Effects of Normal Saline Irrigation on Serum Electrolytes during Percutaneous Nephrolithotomy: Our Experience at a Tertiary Care Centre

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ABSTRACT

Introduction: Percutaneous nephrolithotomy (PCNL) is a surgical procedure done for the treatment of renal stones. PCNL has the advantages of decreased blood loss, reduced post-operative pain, faster recovery, and minimal scar tissue formation. The procedure involves continuous irrigation of kidney with the use of irrigation fluid for better vision, to wash away the stone fragments and blood clots. Normal saline (0.9% NaCl) is the most commonly used irrigation solution. This study was to evaluate electrolyte and metabolic changes in patients undergoing PCNL using Normal Saline as irrigation solution and to correlate these changes with duration of irrigation and volume of irrigation fluid infused.

Material and methods: It was a prospective study in 40 patients undergoing pcnl surgery done in urology ot in our institute over a period of 1 year. Serum Sodium, Potassium, Chloride, Ph, bicarbonate and hemoglobin levels were recorded in Preoperative (baseline), Intraoperative (30 mins after irrigation) and in Postoperative periods.

Results: The mean age of the patient was 43.75 years. Most of the study subjects (n=32, 80.00%) were under ASA 1 status followed by ASA 2 status (n=8, 20.00%). There was a statistically significant difference in relation to pH, sodium bicarbonate, sodium, chloride distribution between the pre-operative, intra-operative and post-operative periods with a p value of <0.05. There was no statistically significant difference in relation to serum potassium and hemoglobin distribution between the pre-operative, intra-operative and post-operative periods with a p value of >0.05. The relationship in values between irrigation duration and Ph, Bicarbonate is statistically significant. The relationship in values between irrigation duration and sodium, potassium, chloride and hemoglobin levels is not statistically significant. The relationship in values between irrigation volume and pH, Bicarbonate value is statistically significant. The relationship in values between irrigation volume and sodium, potassium, chloride and hemoglobin levels is not statistically significant.

Conclusion: We conclude that when normal saline was used as an irrigation solution in percutaneous nephrolithotomy, mean pH and serum bicarbonate levels decreased consistently and linearly leading to metabolic acidosis with the increase in irrigation duration and irrigation volume. Also there was a tendency for hyponatremia and hyperchloremia postoperatively.

Keywords: Percutaneous Nephrolithotomy, Electrolytes, Postoperative, Fluid Absorption

for the treatment of renal stones. PCNL is advantageous because it is associated with less blood loss, postoperative pain is less, recovery is faster and minimal scarring. Stone fragments and clots produced during the procedure are washed off using an irrigation fluid. The most common irrigation fluid used is Normal saline 0.9%¹. The irrigation fluid may be absorbed either by a direct intravascular route through opened veins or by intraperitoneal resorption if the peritoneum is opened. If large volumes of irrigation fluid are absorbed, it may lead to electrolyte imbalance, fluid overload, hemodynamic instability and neurological problems. Apart from normal saline, mannitol, distilled water and glycine are also used for irrigation during PCNL^{2,3}.

Aim

Our study aimed to evaluate electrolyte and metabolic changes in patients undergoing PCNL with Normal Saline as irrigation fluid and to correlate these changes with the duration of irrigation and volume of irrigation fluid infused.

MATERIAL AND METHODS

Forty patients who underwent PCNL in our hospital over one year were enrolled after taking informed consent and approval from the institutional ethical committee. Patients with ASA Grade III & IV, patients with existing electrolyte or acid-based disturbances, patients with abnormal renal function, pregnant or lactating females, patients who were on any drug affecting electrolyte levels, patients less than 18 years or more 60 years of age were excluded. Serum potassium, chloride, sodium, pH & bicarbonate values were monitored preoperatively (baseline), intraoperatively (30 mins after starting irrigation) and postoperatively.

STATISTICAL ANALYSIS

Descriptive statistics were done for all data and were

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a procedure done

reported in terms of mean values and percentages. Suitable statistical tests of comparison were done. Continuous variables were analysed with the paired t-test and ANOVA Two Factor without Replication Test. Categorical variables were analysed with Fisher Exact Test and Chi-Square Test. Correlation analysis was done using Pearson's "r". p-value < 0.05 was considered statistically significant. The data was charted on Microsoft Excel 2019 and analysed using SPSS version 20.

RESULTS

On analysing age distribution, most of the study subjects (n=15, 37.50%) were clustered in the 51-60 years age group, followed by 41-50 years age group (n=11, 27.50%). The mean age was 43.75 years. Most of the patients (n=25, 62.50%) were males followed by females (n=15, 37.50%). Among the study patients, there was a statistically significant difference with pH distribution between the preoperative (mean 7.38±0.03), intra-operative (mean 7.35±0.02), and postoperative (mean 7.33±0.05) periods with a p-value of <0.05 as per ANOVA two factor without replication test. ANOVA two factor without replication test also showed a statistically significant difference in sodium bicarbonate levels (in mmol/l) between the preoperative (mean 21.75±1.05), intra-operative (mean 21.22±0.65) and postoperative (mean 20.43±1.26) periods with a p-value of <0.05. The serum sodium levels (in meq/l) were also significantly different between the preoperative (mean 140.60±3.03), intra-operative (mean 141.00±1.28) and postoperative (mean 138.85±3.26) periods with a p-value of <0.05. Among the study patients, there was no statistically significant difference in serum

potassium (in meq/l) distribution between the preoperative (mean 4.08±0.34), intra-operative (mean 4.04±0.20), and postoperative (mean 4.34±0.33) periods with a p-value of >0.05 as per ANOVA two factor without replication test. The difference in serum chloride levels (in meq/l) in the preoperative (mean 104.45±5.07), intra-operative (mean 106.08±4.46) and postoperative (mean 106.56±1.74) periods was statistically significant with a p-value of <0.05. There was an insignificant difference in Haemoglobin levels (gm/dl) between the preoperative (mean 12.18±1.40) and postoperative (mean 11.92±1.38) periods with a p-value of >0.05 as per paired t-test [Table 1]. On analysing irrigation duration distribution, in most of the patients, the duration of irrigation was ≤ 20 mins (n=14, 35.00%) followed by 31-40 mins (n=11, 27.50%). The mean irrigation duration was 29.50 minutes. On analysing irrigation volume distribution, most of the study subjects (n=24, 60.00%) were clustered in the ≤ 10000 ml group, followed by the 11000-15000 ml group (n=9, 22.50%). The mean irrigation volume was 11038 ml. When irrigation duration was cross-matched against postoperative parameters, the mean irrigation duration was 29.50 mins, the mean pH was 7.34, the mean bicarbonate level was 20.43 mmol/l, the mean sodium level was 138.35 meq/ml, the mean potassium level was 4.14 meq/ml, the mean chloride level was 106.08 meq/ml and mean haemoglobin level was 13.92 gm/dl. The irrigation duration and changes in pH were correlated statistically significantly as the p-value was 0.0001 with a negative correlation as per Pearson's coefficient of -0.57. The relationship in values between duration of irrigation and bicarbonate level was also statistically significant as the p-value was 0.0039 with

	Preoperative	Intraoperative	Postoperative	p-value
Mean pH	7.38±0.03	7.35±0.02	7.33±0.05	<0.05
Mean Serum Bicarbonate levels (mmol/l)	21.75±1.05	21.22±0.65	20.43±1.26	<0.05
Mean Serum Sodium levels (meq/l)	140.60±3.03	141.00±1.28	138.85±3.26	<0.05
Mean serum potassium levels (meq/l)	4.08±0.34	4.04±0.20	4.34±0.33	>0.05
Mean serum chloride levels (in meq/l)	104.45±5.07	106.08±4.46	106.56±1.74	<0.05
Mean Hemoglobin levels (gm/dl)	12.18±1.40	-	11.92±1.38	>0.05

Table-1: Study parameters distribution between preoperative, intraoperative, and postoperative periods

Correlation - Irrigation Duration Vs Post Operative Parameters	Irrigation Duration (mins)	pH	Bicarbonate (mmol/l)	Sodium (meq/l)	Potassium (meq/l)	Chloride (meq/l)	Haemoglobin (g/dl)
Mean	29.50	7.34	20.43	138.85	4.14	106.08	11.92
Standard Deviation	10.05	0.05	1.26	3.26	0.33	4.46	1.38
P value		0.0001	0.0039	0.0645	0.7732	0.2318	0.7332

Table-2: Correlation between Irrigation duration Vs Postoperative Parameters

Correlation - Irrigation Volume Vs Postoperative Parameters	Irrigation Volume (ml)	pH	Bicarbonate (mmol/l)	Sodium (meq/l)	Potassium (meq/l)	Chloride (meq/l)	Haemoglobin (g/dl)
Mean	11037.50	7.34	20.43	138.85	4.14	106.08	11.92
Standard Deviation	4489.86	0.05	1.26	3.26	0.33	4.46	1.38
P value		0.0001	0.0064	0.0758	0.7713	0.4083	0.6312

Table-3: Correlation between Irrigation volume Vs Postoperative Parameters

a negative correlation per Pearson's coefficient of -0.46. The relationship between irrigation duration and sodium level was not statistically significant as the p-value is >0.05 with a negative correlation as per Pearson's coefficient of -0.31. The relation between irrigation duration and potassium level was not statistically significant as the p-value is >0.05 with a positive correlation as per Pearson's coefficient of 0.04. The relationship in values between the duration of irrigation and chloride level was not statistically significant as the p-value is >0.05 with a positive correlation as per Pearson's coefficient of 0.20. Irrigation duration and haemoglobin level were not correlated significantly as the p-value was >0.05 with a positive correlation as per Pearson's coefficient of 0.07. [Table 2]. When irrigation volume was cross-matched against postoperative parameters, the mean irrigation volume was 11037 ml; the mean pH was 7.34, the mean bicarbonate level was 20.43 mmol/l, the mean sodium level was 138.35 meq/ml, the mean potassium level was 4.14 meq/ml, the mean chloride level was 106.08 meq/ml and the mean haemoglobin level was 13.92 gm/dl. The relationship in values between irrigation volume and pH was statistically significant as the p-value was 0.0001 with a negative correlation as per Pearson's coefficient of -0.58. The relationship in values between irrigation volume and bicarbonate level was again statistically significant as the p-value was 0.0039 with a negative correlation as per Pearson's coefficient of -0.41. The relationship in values between irrigation volume and sodium level was not statistically significant as the p-value is >0.05 with a negative correlation as per Pearson's coefficient of -0.27. The relationship in values between irrigation volume and potassium level was not statistically significant as the p-value was >0.05 with a positive correlation as per Pearson's coefficient of 0.05. The relationship in values between irrigation volume and chloride level was not statistically significant as the p-value was >0.05 with a positive correlation as per Pearson's coefficient of 0.13. The relationship in values between irrigation volume and haemoglobin level was also not statistically significant as the p-value was >0.05 with a positive correlation as per Pearson's coefficient of 0.07. [Table 3].

DISCUSSION

PCNL is a widely accepted method for the removal of renal stones with many advantages. However, various studies have assessed hemodynamic, electrolyte and metabolic changes during this procedure. Mechanical handling of kidney and continuous irrigation may give rise to certain homeostasis and hemodynamic balance disturbances, thus making it essential to study various parameters. Our study measures serum sodium, potassium, chloride, pH & bicarbonate values as recorded in preoperative (baseline), intra-operative (30mins after irrigation) and postoperative periods and correlates these with the duration of irrigation and volume of irrigation fluid infused. The study also compared the preoperative and postoperative Hemoglobin levels.

In our study, mean pH levels were significantly less intraoperatively compared to preoperative levels by a mean

difference of 0.03, indicating that 79% of the subjects intra-operatively had a decreased pH value compared to preoperative value with a significant statistical p-value. The mean pH distribution levels were significantly less postoperatively than intra-operative levels by a mean difference of 0.02. 79% of the subjects postoperatively will have a decreased p-value than the intra-operative stage with a significant p-value of 0.0330. The mean pH levels were significantly less postoperatively compared to preoperative levels by a mean difference of 0.05. 82% of the subjects postoperatively will have a decreased pH value compared to the preoperative stage, with statistical significance indicating the chances of acidosis. This result is similar to the study conducted by MedhaMohta et al.³ There was a tendency towards metabolic acidosis with an increase in the duration of irrigation and volume of absorbed irrigation fluid.

In our study, mean bicarbonate distribution levels were significantly less intra-operatively than preoperative levels by a mean difference of 0.53. 69% of the subjects intra-operatively had decreased bicarbonate value compared to preoperative value with statistical significance. Also, bicarbonate levels were significantly less postoperatively than intra-operative levels by a mean difference of 0.79, indicating that 88% of the subjects postoperatively will have a decreased bicarbonate value compared to intra-operative value. This difference is significant with a p-value of 0.0001. The mean bicarbonate levels were significantly less postoperatively than preoperative levels by a mean difference of 1.32, indicating that 84% of the subjects postoperatively will have decreased bicarbonate value compared to the preoperative stage significant p-value of <0.0001 . In a study conducted by Akash Gupta et al.⁴, there was a decrease in bicarbonate levels with an increase in irrigation duration, with a tendency towards metabolic acidosis. The above result is similar to a study published in Atici et al.^[2] where metabolic acidosis decreased due to decreased bicarbonate levels.

In our study, mean serum sodium distribution levels were not significantly less preoperatively than intra-operative levels with a p-value of 0.3937 as per paired t-test. The mean serum sodium distribution levels were significantly less postoperatively than intra-operative levels by a mean difference of 2.15, indicating that 96% of the subjects postoperatively had decreased serum sodium value compared to the intra-operative stage is significant. The mean serum sodium distribution levels were significantly less postoperatively compared to preoperative levels by a mean difference of 1.75, indicating that 69% of the subjects postoperatively will have decreased sodium value compared to the preoperative stage is significant with a p-value of 0.0104. In a study by MedhaMohta³ et al., serum sodium and potassium values did not change significantly during or after irrigation. Atici et al.² reported hyponatremia and hypokalemia and explained these changes by renal tubular dysfunction due to mechanical irritation of kidneys. In our study, there was no statistically significant difference in relation to serum potassium levels between the preoperative,

intra-operative and postoperative periods with a p-value of >0.05 . In the study by Gehring et al.⁵, the main aim was to compare groups with intravascular versus extravascular absorption. However, electrolyte values before irrigation and discharge from the recovery room in individual groups were not found to be different.

In our study group, mean serum chloride distribution levels were significantly more intra-operatively than preoperative levels by a mean difference of 1.63, indicating that 66% of the subjects intraoperatively will have an increased serum chloride value preoperative stage with a significant p-value of 0.0382. The mean serum chloride distribution levels were not significantly less intra-operatively than postoperative levels with a p-value of 0.5030. The mean serum chloride levels were significantly more postoperatively than preoperative levels by a mean difference of 2.11, indicating that 88% of the subjects postoperatively had an increased serum chloride value than the preoperative value with a significant p-value 0.0053. Korogluet al.⁶ monitored all the variables at 10-min intervals but compared values before, during and after irrigation. There was no significant difference in fluid-electrolyte balance and hemodynamics related to irrigation volume and irrigation duration when 0.9% normal saline was used in Percutaneous nephrolithotomy.

Our study showed no statistically significant difference in haemoglobin levels between the preoperative and postoperative periods with a p-value of >0.05 as per paired t-test.

In our study, the relationship in values between irrigation duration and pH was statistically significant as the p-value is 0.0001 with a negative correlation as per person's coefficient of -0.57. The relationship between irrigation time and bicarbonate level was also statistically significant as the p-value is 0.0039 with a negative correlation as per Pearson's coefficient of -0.46. The linear increase in irrigation duration measurement with increased pH levels is actual 57% of the times. But out of the 57%, only 33% of the variation in mean pH levels can be predicted from the relationship between irrigation duration and pH levels. When the irrigation duration increases, there is a corresponding decrease in pH levels. The linear increase in irrigation duration measurement with increased bicarbonate levels is actual 46% of the times. But out of this 46%, only 21% of the variation in mean bicarbonate levels can be predicted from the relationship between irrigation duration and bicarbonate levels. When the irrigation duration increases, there is a corresponding decrease in bicarbonate levels. In a study conducted by VahitGuzelburcet al.⁷, an increase in irrigation duration and volume of irrigation fluid used leads to a significant increase in irrigation fluid absorption in the PCNL group.

The increase in levels of irrigation volume negatively correlates with the rise in pH levels. When the irrigation volume increases, there is a corresponding decrease in pH levels. The increased irrigation volume correlates negatively with the increase in bicarbonate levels. The linear increase in irrigation volume measurement with increased bicarbonate levels is actual 41% of the times. But out of this 41%, only

17% of the variation in mean bicarbonate levels can be predicted from the relationship between irrigation volume and bicarbonate levels. When the irrigation volume increases, there is a corresponding decrease in bicarbonate levels. KukrejaRaet al.⁸ reported that reducing the nephroscopy time and the amount of irrigation fluid used and staging the procedure for large renal stones reduces fluid absorption and avoids volume overload. In our study, we included a total of 40 subjects, among whom 16 subjects had a duration of irrigation exceeded more than 30 minutes with the increasing irrigation volume infused. The maximum irrigation duration was 50 minutes, and the maximum volume of irrigation fluid infused was 22500ml. The mean duration of irrigation was 29.50 minutes, and the mean volume of irrigation was 11038 ml. We found that electrolyte and metabolic changes were frequently recorded in the subjects, increasing irrigation duration and irrigation volume. Therefore, it is advisable to monitor arterial blood gases in patients during and after PCNL if increased irrigation duration and irrigation volume, previously compromised renal functions and metabolic status.

CONCLUSION

We conclude that the use of normal saline as an irrigation solution in percutaneous nephrolithotomy is associated with decreased mean pH and serum bicarbonate levels leading to metabolic acidosis. This is linearly correlated with the increase in the duration of irrigation and volume of irrigation fluid. Also, postoperatively there was a tendency for hyponatremia and hyperchloremia. We also conclude that there was no significant change in serum potassium and haemoglobin levels using normal saline as irrigation fluid.

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