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Original Article

Anaesthesia Section

Effect of Saline Irrigation for Transurethral Resection of Prostate on Acid Base and Electrolyte Status- A Prospective Cohort Study

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ABSTRACT

Introduction: Transurethral Resection of Prostate (TURP), using bipolar resectoscope, is performed using 0.9% Normal Saline (NS) as irrigating fluid. The NS is absorbed at about 10-30 mL per minute of resection time. The TURP averages 45 to 90 minutes of resection time. Thus, 450-2700 mL of NS is expected to be absorbed in this short time. Rapid administration of higher quantities of NS can cause hyperchloraemic acidosis, hyperkalaemia and negative protein balance.

Aim: To detect changes in pH, serum electrolytes (serum bicarbonate, serum chloride, serum sodium, and serum potassium) and to record complications, if any, in patients undergoing bipolar TURP with 0.9% NS irrigation.

Materials and Methods: This prospective cohort study was conducted at Lokmanya Tilak Municipal General Hospital, Mumbai, Maharashtra, India, from May 2017 to May 2018. Thirty patients undergoing saline bipolar TURP under subarachnoid block were studied. Preoperative and postoperative venous blood pH and serum electrolyte samples were collected. The quantity of NS used, duration of resection, and occurrence of complications were recorded and statistically analysed.

Results: The mean age, mean gland size, resection time and volume of irrigation fluid used were 65.17±7.2 years, 64.9±30.85 cc, 60.67±14.17 minutes and 23.73±4.78 Litres, respectively. The mean preoperative pH of 7.33±0.047 fell by 0.03 postresection (p-value=0.02) and mean serum sodium increased from 139±3.65 meq/L to 142.2±3.60 meq/L, which was statistically significant (p-value=0.01). Serum bicarbonate, serum potassium, and serum chloride did not show any significant change. On relating the various intraoperative parameters with biochemical changes, a statistically significant but clinically insignificant association was found between the amount of irrigation fluid used and changes in serum sodium levels.

Conclusion: The use of approximately 23.73 L NS in 60.67 mins of resection time and gland sizes up to 64.91 cc appear to produce no clinically significant changes in pH, serum electrolytes or complications with Bipolar TURP. However, further studies are needed to determine the acid base changes and safety with higher gland sizes requiring prolonged resection times and subsequently higher NS absorption.

Keywords: Bicarbonate, Bipolar, Chloride, pH, Serum sodium

INTRODUCTION

The Transurethral Resection of Prostate (TURP) is routinely used to treat symptomatic benign prostatic hypertrophy. The ideal irrigant for such endoscopic resection would be a user-friendly, non conducting medium that does not interfere with diathermy, has a high degree of translucency, has similar osmolarity to the serum and causes only minimal side-effects when absorbed [1]. The NS is near ideal irrigation fluid for TURP; however, its electrical conducting properties prohibit its use with conventional monopolar TURP system [2]. The TURP with bipolar resectoscope using NS as irrigating fluid is being increasingly performed. Irrigating fluid is absorbed at the rate of about 10-30 mL/minute of resection time [3]. Though the usual duration of conventional TURP is limited to 45-90 minutes, resection time during bipolar TURP can be extended due to the relatively safer profile of NS irrigation. An average quantity of 450-2700 mL saline can thus be absorbed in this short time. Li H et al., reviewed the use of NS and concluded that despite its implied normalcy and physiological property, large volume (>2 L) saline infusion is associated with metabolic acidosis, hyperkalaemia, negative protein balance, increased occurrence of kidney dysfunction with possible reduced survival [4].

Multiple other studies in literature also state that administration of approximately 1-2 Liter intravenous NS in 60-90 minutes is associated with hyperchloraemic acidosis, an increased incidence of Acute Kidney Injury (AKI) and need for renal replacement therapy, as well as higher postoperative in-hospital mortality [5-15]. This can be explained on the basis of the changes of Strong Ion Difference (SID) and the reduction in weak non volatile acids resulting in hyperchloraemic acidosis. In normal serum, the predominant cation is sodium (140 mmol/L) and predominant anion is chloride (100 mmol/L). The SID is approximately 40 mmol/L when pH is 7.4. 0.9% saline infusion causes elevations in both sodium and chloride levels, but the increase in chloride levels is much larger, resulting in a net SID reduction and acidosis.

A higher chloride level in the renal tubules is speculated to trigger tubule-glomerular feedback, causing afferent arteriolar vasoconstriction, leading to a fall in the glomerular filtration rate [5]. Micro-perfusion experiments and real-time imaging studies reported a reduction in renal perfusion and an expansion in kidney volume; which in turn leads to reduced oxygen delivery to the renal parenchyma following saline infusion [4]. Clinically, NS administration after abdominal and cardiovascular surgery is associated with increased requirement of blood products, bicarbonate therapy, reduced gastric blood flow, delayed recovery of gut function, and impaired cardiac contractility in response to ionotropes, prolonged hospital stay, and possibly increased mortality [4]. The AKI occurs more frequently with use of saline infusion as compared to balanced fluid infusions in critically ill patients [4].

It was postulated that the absorption of NS at 15-20 mL per minute in an average TURP is equivalent to administration of intravenous NS 1 to 1.8 Litres in 60-90 minutes. Therefore, similar changes of hyperchloraemic acidosis may be seen with saline TURP. Hence, the study aimed to prospectively detect changes in pH, serum bicarbonate, serum chloride, serum sodium, serum potassium and record complications, if any, in patients undergoing bipolar TURP with 0.9% NS irrigation.

MATERIALS AND METHODS

This prospective cohort study was conducted at Lokmanya Tilak Municipal General Hospital, Mumbai, Maharashtra, India, from May 2017 to May 2018. The approval was obtained from the Institutional Ethics Committee (IEC/40/17).

Sample size calculation: Based on the pilot study of 10 cases, a sample size of 18 was required to detect 0.03 fall in pH. A sample size of 24 was required to detect 6 meq/L rise in chlorides based on a previous study [16]. Considering a dropout rate of 10%, 30 patients were recruited.

Inclusion criteria: Patients undergoing TURP with bipolar cautery using NS as irrigation fluid under regional anaesthesia were included in the study.

Exclusion criteria: Non consenting patients, patients with pre-existing acidosis or alkalosis (pH <7.3 or >7.5), patients with pre-existing hyperchloremia (S.chlorides >107 meq/L), patients on sodium bicarbonate treatment, patients on diuretic treatment and patients with gastrointestinal diversions, diarrhoea were excluded from the study.

Study Procedure

A written informed consent was obtained and patient was taken on table. Standard monitoring in the form of pulse oximetry, electrocardiography, and non invasive blood pressure monitoring was initiated. Intravenous access was secured, preoperative venous blood pH and serum electrolytes sample was collected and 0.9% NS was started at 2 mL/kg/hr. Procedure was conducted under standard central neuraxial blockade. Subarachnoid block was given using 1.5 to 2 cc of 0.5% heavy bupivacaine injected in the sitting position at L3-L4 or L4-L5 interspinous space and T10 level obtained. Postoperative venous blood pH and serum electrolytes sample was collected at end of procedure. Quantity of irrigating fluid, duration of resection, preoperative and postoperative venous blood pH and serum electrolyte values and complications, if any were recorded in the proforma.

STATISTICAL ANALYSIS

The data thus obtained was statistically analysed using Statistical Package for the Social Sciences (SPSS) software version 21. The changes in pH and serum electrolytes were compared using paired student's t-test. Association between pH, serum electrolyte levels with various intraoperative factors was done by applying one-way ANOVA test. A p-value of <0.05 was considered significant while a p-value <0.001 was considered very highly significant.

RESULTS

The age of the patients ranged from 49 to 82 years, with mean of 65.17 (±7.2) years [Table/Fig-1]. Mean gland size, resection time and volume of irrigation fluid used were 64.91 (±30.853) cc, 60.67 (±14.167) minutes, 23.73 (±4.770) L, respectively [Table/Fig-2]. Most of the patients had gland sizes between 31 to 50 cc [Table/Fig-3].

Age group (years)	Number of cases N (%)
41-50	1 (3.33%)
51-60	9 (30%)
61-70	16 (53.33%)
>71	4 (13.33%)
Total	30 (100%)

[Table/Fig-1]: Distribution of study subjects according to their age groups.

Parameter	Range	Mean±SD
Gland size (cc)	30-140	64.91±30.853
Resection time (mins)	40-90	60.67±14.167
Irrigation fluid (L)	14-32	23.73±4.770

[Table/Fig-2]: Distribution of study subjects according to gland size, resection time and irrigation fluid volume.

Grades	Gland size in cc	Cases	Mean resection time (in Minutes)	Mean irrigation fluid (L)
Grade I	21-30	2	62.50	25.00
Grade II	31-50	11	63.64	22.36
Grade III	51-80	9	57.78	24.89
Grade IV	>80	8	59.38	24.00

[Table/Fig-3]: Distribution of study subjects according to gland size.

A postresection fall in mean preoperative pH of 7.33±0.047 by 0.03 (p-value=0.02), and the increase in serum sodium from 139±3.65 meq/L to 142.2±3.60 meq/L (p-value=0.01) were seen. Serum bicarbonate, serum potassium, and serum chloride levels did not show significant change [Table/Fig-4]. Though a statistically significant association between amount of irrigation fluid used and changes in serum sodium levels was found (p-value=0.047), no association between changes in chloride, potassium, and pH levels with gland size, resection time or irrigation fluid was found [Table/Fig-5]. None of the study patients had complications like capsular perforation, bladder perforation and excessive bleeding.

Variables	Preoperative Mean±SD	Postoperative Mean±SD	p-value (Paired Student t-test)
pH	7.33±0.047	7.30±0.049	0.02
Serum bicarbonate (meq/L)	24.53±2.621	24.64±2.838	0.82
Serum sodium (meq/L)	139.90±3.652	142.23±3.607	0.01
Serum potassium (meq/L)	3.47±0.507	3.67±0.547	0.08
Serum chloride (meq/L)	101.65±4.311	101.80±3.589	0.81

[Table/Fig-4]: Comparison of preoperative and postoperative study parameters.
p-value <0.05 was considered as statistically significant

Variables	Gland size	Resection time	Irrigation fluid
pH	0.462	0.564	0.741
Serum bicarbonate (meq/L)	0.693	0.908	0.061
Serum sodium (meq/L)	0.267	0.289	0.047
Serum potassium (meq/L)	0.113	0.597	0.38
Serum chloride (meq/L)	0.543	0.609	0.841
Resection time	0.041	--	0.967

[Table/Fig-5]: Comparison of pH, serum electrolyte levels with various intraoperative factors.
p-values compared after applying one-way ANOVA, p-value <0.05 was considered as statistically significant

DISCUSSION

Bipolar TURP with NS has many advantages, such as decreased incidence of TURP syndrome, increased time available for resection, improved haemostasis, decreased bleeding, better surgeon comfort, better surgical exposure with less collateral and penetrative tissue damage, shorter catheter indwelling times, earlier hospital discharge and better patient satisfaction [17]. Infusion of 0.9% saline solution, however, temporarily causes dilution hyperchloraemic acidosis in a dose-dependent manner [6,7]. Previous studies have examined changes in serum electrolytes during TURP; however, acid base balance has been neglected.

Hence, this prospective study was carried out in cohort of 30 patients undergoing bipolar TURP using saline as an irrigation fluid under regional anaesthesia, to detect changes in pH and serum electrolytes. A mean fall in pH by 0.03 (p-value=0.02), an increase in serum sodium from 139±3.65 meq/L to 142.2±3.60 meq/L (p-value=0.01), an association between amount of irrigation fluid used and changes in serum sodium levels (p-value=0.047) was found.

Scheingraber S et al., correlated the acid base changes to the amount of absorbed irrigation fluid in 20 TURP patients who received 2% ethanol, 0.54% mannitol or 2.7% sorbitol solution as irrigating fluid [18]. The pH and bicarbonate dropped from 7.41 to 7.37 and 24.3 to 21.9 mmol/L, respectively and lactates increased from 1.2 to 2.3 mmol/L in the group with major fluid absorption. The pH fell from 7.44 to 7.42 with minimal decrease in bicarbonate, and lactates increased from 1.1 to 1.6 mmol/L in the minor or no absorption group. Strong ion difference showed a significant decrease in both groups; however, this was larger in the major absorption group. They concluded that larger irrigant absorption might lead to a clinically relevant metabolic acidosis and acid base balance monitoring was recommended. Hermanns T et al., in a study of 55 patients undergoing bipolar prostate vaporisation with green-light laser technique found significant decrease in pH by 0.09 in the nine patients with systemic fluid absorption (138-2166 mL). There were no significant changes in serum chloride, potassium, haemoglobin and haematocrit in their patients [19]. Hafez MHES et al., studied 50 cases to compare the haemodynamic and biochemical changes between monopolar and bipolar TURP. They found no significant change in pH post procedure in both the groups but found significant decrease in serum sodium level by 9.53±2.26 in the monopolar group and by 3.53±2.50 in the bipolar group [20].

Saline has zero SID i.e., equal concentrations of sodium and chloride and zero total concentration of non volatile weak acid. The existing circulating albumin and phosphate is diluted with intravenous infusion of saline, thus reducing total concentration of non volatile weak acid causing metabolic alkalosis while simultaneously reducing SID leading to metabolic acidosis. The effect of SID reduction, however, overpowers that of non volatile weak acid reduction. This causes a net metabolic acidosis, in absence of a pre-existing acid-base disturbance. Thus, saline infusion causes hyperchloraemic metabolic acidosis.

Thus, the statistically significant fall in pH in the study could be attributed to the use of normal saline as irrigating fluid. However, authors found no association between pH with the amount of fluid used, gland size or resection time. Authors expected the fall in pH to be accompanied by corresponding changes in serum chlorides and bicarbonates. However, the serum chloride and bicarbonate levels showed a marginal, insignificant increase from 101.6 to 101.8 meq/L and from 24.53 to 24.64 meq/L, respectively.

Changes in serum electrolytes have been extensively studied with use of various irrigation fluids for TURP. Yousef AA et al., in their randomized control trial on 360 patients undergoing TURP with 5% glucose, 1.5% Glycine or 0.9% saline as irrigation fluid found an insignificant increase in serum sodium (142.6±12.6 mmol/L) and reduction in serum potassium in the saline group as compared to the other groups [2]. TURP syndrome was seen in 17 patients in the glycine group but none in either glucose or saline groups.

However, most of the other studies have found a milder decrease in serum sodium levels with the use of NS as irrigating fluid as compared to other irrigants. Chen Q et al., found that the decline in serum sodium postoperatively was smaller in the saline group (6.9±0.7 vs 14.8±1.8 mM, p-value=0.001) compared with monopolar in resection of large volume prostate [21]. Ho HSS et al., also found that declines in the mean postoperative serum sodium for TURIS and monopolar TURP groups were 3.2 and 10.7 mmol/L, respectively (p-value<0.01) [22]. Many other studies like Michielsen DP et al., (1.3 mmol/L), Singh H et al., (1.2 meq/L), Mamoulakis C et al., (0.8 mmol/L), Huang X et al., (2.02±0.53 mmol/L), Singhania P et al., (1.25 meq/L) showed similar drop in sodium levels [23-27]. Watanabe Y et al., also found an increase in the serum chloride concentration from 99.4±2.8 meq/L to 104.2 ±5.1 meq/L in the preoperative and postoperative period respectively [16]. Yousef AA et al., Scheingraber S et al., Hermanns T et al., Singhania P et al., did not find any changes in serum potassium values in any of their study groups [2,18,19,27].

Dilutional hyponatremia secondary to fluid absorption is expected with use of all irrigating solutions. The variations in changes of serum sodium levels seen in the above studies may be due to many factors. These include choice and quantity of preoperative and intraoperative fluid, amount and nature of irrigating fluid used and administration of drugs like furosemide which alter sodium levels. Hyperchloremia and hyperkalaemia may occur with use of normal saline. Potassium and chloride concentrations may remain unaltered with the use of other irrigating fluids.

Complications like capsular perforation, bladder perforation and excessive bleeding can increase fluid absorption and/or resection time and affect the postoperative acid base and electrolyte status. None of the study patients had these complications. Hermanns T et al., in their study of 55 patients, recorded capsular perforation, injury to larger sinuses and deep bladder neck incision in three, one and 11 patients, respectively [19].

Limitation(s)

A limitation of the study was that it was an observational study. Better results may be obtained with prospective randomised clinical trials where, variables such as choice and quantity of preoperative and intraoperative fluid used, amount and nature of irrigating fluid used, administration of drugs altering sodium levels, duration of surgery, etc., can be controlled.

CONCLUSION(S)

The use of normal saline of around 23.73 L, resection time of around 60.67 mins and gland sizes up to 64.91 cc appears to produce no clinically significant changes in pH, serum electrolytes or complications with Bipolar TURP. Hence, this technique can be safely used within the given parameters. However, further studies need to be performed to determine the acid base changes and safety with higher gland sizes requiring prolonged resection times and subsequently higher NS absorption. It may be found that changes in pH can be a determinant of fluid absorption in these cases. Accurate estimation of absorbed fluid can also be done using techniques like ethanol tagging.

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