Percutaneous Nephrolithotomy: Is Distilled Water as Safe as Saline for Irrigation?

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Received July 2012
Accepted April 2014

Purpose: To compare dilutional effect of distilled water with saline solution as an irrigation fluid in percutaneous nephrolithotomy (PCNL).

Materials and Methods: Three hundred twenty eight adult patients (191 men, 137 women) who were candidates for PCNL were randomly assigned into two groups (distilled water, n = 158, group 1; saline solution, n = 162, group 2). Stone size, operation time, irrigation fluid volume, blood hemoglobin level, urea nitrogen, creatinine, sodium and potassium levels were checked before and at 6 and 12 hours after operation.

Results: The mean age of the patients was 37.8 years, and the mean stone diameter was 31.5 mm. There was no clinical case of transurethral resection (TUR) syndrome. Serum sodium depletion was significantly more in group 1 than group 2 ($P < .0001$). Group 1 had significant decreased post-operative serum sodium levels ($P < .0003$). Similarly in group 2, postoperative serum sodium levels were significantly lower than the preoperative concentration ($P < .01$), but it was not the same 6 hours after the operation ($P = .23$). Serum sodium concentrations remained within normal limits in all cases, without causing clinical signs and symptoms of hyponatremia.

Conclusion: We found that distilled water is safe irrigation fluid for PCNL in adults. In addition, it is more available and cost effective.

Keywords: nephrostomy; percutaneous; postoperative complications; intraoperative care; therapeutic irrigation.

INTRODUCTION

Nowadays, percutaneous nephrolithotomy (PCNL) is a technique to remove large and complex renal stones which cannot be treated with extracorporeal shock wave lithotripsy (SWL). Irrigation fluid is used in endoscopic urological surgeries to dilate the target organ and also for a better vision.

Physiologic saline is the most commonly used fluid because it is isotonic and also compatible with interventions, unless electro-cautery is needed. By the use of hypotonic solutions such as distilled water (DW), the visibility would be improved; however, it can result in dangerous complications especially in younger age groups.[1]

In transurethral resection of the prostate (TURP), this manifestation is called TUR syndrome which includes cardiovascular and neurologic derangements. Absorption of irrigation fluid during PCNL has also been reported, and a variety of significant complications have been reported.[2-5] Some studies have evaluated the absorbed fluid by breath-alcohol test.[6]

In our center, two cases with hyponatremia were occurred in children using DW as an irrigation fluid for PCNL, which is routine in urology practice; because it is cheaper than saline solution and is more available in large amounts at some health centers. In this study, we compared DW and saline solution (SS) as irrigation fluid during PCNL in adult patients (≥ 19 years old).

MATERIALS AND METHODS

In this study, we considered more than 2 meq/L of depletion in serum sodium level as a significant change. Considering $\alpha = 0.05$ and 90% power, the sample size was calculated as 38. Since we work in a center with a high rate of PCNL operation, 328 patients including 191 men and 137 women were included in this study. Exclusion criteria were patients with solitary kidney and abnormal renal function (serum creatinine level > 2.3 mg/dL). Thus, 8 patients were excluded from the study and as a results 320 patients were randomly divided into two groups. Group 1 included 158 patients and group 2 consisted of 162 patients. Patients with stone above the ureteropelvic junction level, and more than 2 cm in diameter were included. The minimum age for inclusion into this study was 18 years. No upper limit for stone size or age was considered. Informed consent was signed by all patients prior to the operation, and the study was conducted based on the approval of ethical committee of Shiraz University of Medical Sciences.

In group 1 DW and in group 2 SS was used as the irrigation fluid during the operation. All patients were evaluated by intravenous urography (IVU), and complete blood count (CBC), coagulation profile, blood urea nitrogen (BUN), creatinine (Cr), sodium (Na+) and potassium (K+) levels were determined; urine analysis and urine culture before operation were also performed. The patients were admitted 6 hours before the operation and received intravenous antibiotic (cephalotin 1 g) and 125 mL/h of intravenous fluid (33.3% dextrose 5% + 66.6% saline 0.9%) and oral diet was started about 12 hours after the operation. Blood sample was taken just before, at the end, 6 and 12 hours after operation for determining the serum hemoglobin (Hb), BUN, Na+, K+ and Cr levels.

PCNL was performed in the prone position, under general anesthesia after insertion of a 6 French (F) ureteral catheter. Fluoroscopy guidance was applied for nephrostomy tract creation, and metal telescopic dilator system was used for tract dilation and pneumatic lithotripsy was used for stone fragmentation. When multiple calyceal stones or a staghorn stone was present, two tracts were created. Since fluid irrigation was the main variant of the study, operation time was considered from when nephroscopy was started and it lasted until the removal of nephroscope.

The patients were visited for clinical signs of hyponatremia such as lethargy, restlessness, headache, nausea, vomiting, confusion and seizure. The diet was started 12 hours after the operation. Stone-free state was defined as no residual stone in postoperative kidney urinary bladder (KUB) X-rays. It is the most common definition for stone-free state in the literature.[7] Urinary tract ultrasonography was requested if the stone was nonopaque in X-ray images.

Ureteral stent and urethral catheter were removed 12 to 24 hours after the operation depending on the patients' condition, and the patients were usually discharged from hospital two days post-operatively. No nephrostomy tube was inserted for patients. The data were analyzed using Chi-square test, student *t* test or paired *t* test, and the *P* value less than .05 was considered as significant.

Table 1. Demographic and clinical characteristics of study population.

Variables	Group 1 (n = 158)	Group 2 (n = 162)	*P*
Gender no. (%)			
Gender			
Male	94 (58)	97 (58)	NA
Women	67 (42)	70 (42)	NA
Mean age (years)	134 (70-170)	36.8 ± 6.8	.004
Mean stone size (mm)	29 ± 12	30 ± 14	.021
Site of Kidney			
Right kidney	86	66	NA
Left kidney	72	96	.018
Mean serum parameters			
Hemoglobin (mg/dL)	14.3 ± 2.3	14.6 ± 2.5	.25
BUN (mg/dL)	17.3 ± 3.5	16.9 ± 2.5	.23
Creatinine (mg/dL)	1.2 ± 0.8	1.2 ± 0.9	.75
Sodium (meq/L)	138 ± 75	136 ± 8.3	.02
Potassium (meq/L)	4.4 ± 1.9	4.5 ± 2.1	.65

Key: BUN, blood urea nitrogen.

RESULTS

No significant preoperative difference was seen between the groups considering the stone size, serum Hb, BUN, K+ and Cr levels, but significant differences in age and serum sodium level were noted (Table 1). Before the operation, eight patients were excluded from the study because they had one or more exclusion criteria. Fourteen patients were excluded after the operation due to perforation of collecting system, prolonged operation time (> 90 minutes), or high irrigation volume (> 15 liters) used. The stone-free rates were 92.76% and 94.15%; the mean operation times were 57 and 65 minutes, and the mean irrigation volume were 10.4 and 10.6 liters in groups 1 and 2, respectively.

Complications included fever (5 vs. 3), perforation of pelvicalyceal system (1 vs. 2), bleeding (3 and 5), and transfusion (2 and 2) in groups 1 and 2, respectively (Table 2).

Table 2. Data in study groups.

Variables	Group 1 (n = 152)	Group 2 (n = 154)	*P*
Stone-free rate, %	92.76	94.15	.651
Mean operation time (min)	57 ± 34	65 ± 41	.064
Mean irrigant volume (liters)	10.4 ± 5.8	10.6 ± 6.9	.784
Mean hospital stay (days)	2.2 ± 1.1	2.5 ± 1.3	.030
Fever (T ≥ 38°C), no. (%)	5 (3.28)	3 (1.94)	.499
Bleeding, no. (%)	3 (1.97)	5 (3.24)	.722
Transfusion, no. (%)	2 (1.3.1)	2 (1.29)	1.0
Pelvicalyceal system perforation, no. (%)	1 (0.65)	2 (1.29)	1.0
Operation time > 90 min, no. (%)	3 (1.97)	4 (2.59)	1.0
Irrigant > 15 liters, no. (%)	2 (1.31)	2 (1.29)	1.0

Table 3. Perioperative laboratory data in study groups.*

Variables	Group 1				Group 2			
	Hb	BUN	Cr	K	Hb	BUN	Cr	K
Before operation	14.4	17.1	1.14	4.4	14.8	16.2	1.18	4.3
At the end of operation	13.2	22.4	1.3	4.4	13.3	21.8	1.24	4.3
Six hours after operation	13.5	22.6	1.34	4.3	13.4	22.1	1.28	4.3
Twelve hours after operation	13.6	22.1	1.32	4.5	13.7	22.7	1.28	4.6

Keys: Hb, hemoglobin (g/dL); BUN, blood urea nitrogen (mg/dL); Cr, creatinine (mg/dL); K, potassium (meq/L).
* Data are presented as means.

The mean serum Na+ level in group 1 significantly decreased 6 and 12 hours after the operation. Also, it significantly decreased in group 2 just after the operation, and 12 hours later; however, serum Na+ level in group 2 showed no significant changes 6 hours after the operation. Changes in the serum level of Na+ were significantly greater in group 1 compared to group 2, in all postoperative measurements (Tables 4 and 5). Fortunately, no case of TUR syndrome was seen.

The mean blood Hb level decreased at the end of operation in both groups, but it remained in normal range without any significant difference in both groups. The mean serum BUN and Cr levels increased in both groups postoperatively. The mean serum K+ level also showed minimal changes without any statistical significance (Table 3).

DISCUSSION

PCNL is a commonly used technique for treatment of kidney stones, and has significant advantages in comparison to open stone surgery. These advantages include lower morbidity rate, decreased amount of postoperative pain, minimal surgical scars, and faster postoperative recovery. Complications include hemorrhage, fever, infection, pneumothorax, colon perforation, extravasation and etc. The absorption of irrigation fluid during this operation causes TUR syndrome in some cases. This dangerous complication occurred when a hypoosmolar fluid is used.[8-14]

Most authors have suggested SS as the best fluid for irrigation due to its isoosmolar properties. When electro-surgery is used, ion-free fluids such as glycine or DW are preferred.[1,3,15] Hahn found that hyponatremia is depended on both volume of fluid absorption and the time of TURP.[16]

Amr Hawary and colleagues reported that the rate of TUR syndrome is related to the type of irrigating fluid, operation time, patient position, prostate size, fluid bag height, surgeon experience, intraprostatic vasopressin injection,

Table 4. Comparison of serum sodium levels (meq/l) at different times in study groups.*

Study Groups	Group 1	*P*	Group 2	*P*
Before Operation	138 ± 7.5		136 ± 8.3	NS
At the end of operation	132 ± 6.5	< .0001	132 ± 7.1	< .0001
6-hour Postoperatively	132 ± 7.0	.23	135 ± 6.9	< .0001
12-hour Postoperatively	135 ± 7.3	< .0003	134 ± 6.7	4.5

Key: NS, not significant.
* All reported P values are compared to baseline.

Table 5. Comparison of serum sodium (meq/L) changes between the study groups compared to baseline.

Study Groups	At the end of Operation	6-hour Post-operatively	12-hour Post-operatively*
Group A	-6 ± 2.3	-6 ± 2.3	-3 ± 2.1
Group B	-4 ± 1.4	-1 ± 1.3	-2 ± 1.6
P	< .0001	< .0001	< .0001

low pressure irrigation and etc. They have mentioned that "an ideal irrigating fluid should be isotonic, nonhemolytic, electrically inert, nontoxic, transparent, easy to sterilize and inexpensive". Glycine, crystal and physiological saline have been recommended to be used as irrigation fluid in TURP.[17] In the present study, distilled water has been compared to physiological saline in respect of TUR syndrome clinical signs and subclinical hyponatremia.

Aghamir and colleagues compared sterile water and isotonic saline solution as irrigation fluid in PCNL. They looked for blood Hb level drop, haptoglobin level, electrolyte level and any sign of TUR syndrome. They found no significant difference between DW and saline for their safety. They introduced DW as a safe and inexpensive irrigation fluid during PCNL operation.[18]

Gariou and colleagues investigated the amount of glycine absorption during PCNL. They indicated that glycine can cause a significant hemo-dilution in PCNL compared to TURP. They suggested that SS is a proper irrigation fluid for PCNL.[19] In another study, 1.5% glycine induced post-nephrolithotomy syndrome in 2% of the patients. This study was conducted by Fellahi and his colleagues, and they have reported that physiologic saline is a better choice for PCNL.[20]

In contrast, some studies showed no significant derangement with hypotonic solution such as water. They have suggested that these solutions are as safe as physiological saline solution during PCNL.[21-23]

In the present study, the effect of physiological saline solution and DW was compared on blood Hb, BUN, Cr, and especially Na+ levels. Na+ is the main effective ion in TUR syndrome. As we demonstrated, a significant decrease in serum Na+ level was found in group 1 (distilled water) in comparison to group 2 (saline solution). This difference was in the normal range of serum sodium level. Because no clinical case of TUR syndrome was observed, this change was considered clinically insignificant.

CONCLUSION

Distilled water can be used for PCNL in adult patients, while postoperative serum Na is monitored. Its usage needs some precautions. The authors do not recommend DW as an irrigation fluid for pediatric patients.

ACKNOWLEDGEMENT

The authors would like to thank Mr. Abdolhossein Hanaee for his assistance, and Mrs. Salami for her cooperation and typing the draft.

CONFLICT OF INTEREST

None declared.

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