

Sterile Water Versus Isotonic Saline Solution as Irrigation Fluid in Percutaneous Nephrolithotomy

Seyed Mohammad Kazem Aghamir,¹ Farshid Alizadeh,² Alipasha Meysamie,³ Shadi Assefi Rad,⁴ Ladan Edrisi⁴

Introduction: We evaluated the safety of sterile water as an irrigation solution for percutaneous nephrolithotomy (PCNL).

Materials and Methods: Forty-four patients with kidney calculi were enrolled in this study and randomly divided into two groups for PCNL. Approaches to the calculi were through a single subcostal access with an Amplatz sheath, and either sterile water or isotonic saline solution was used as the irrigation fluid. Serum hemoglobin, haptoglobin, sodium, potassium, and creatinine were measured before and 12 hours after the procedure. The patients were evaluated for signs of transurethral resection of the prostate syndrome during the operation for 24 hours afterwards.

Results: The mean calculus size, irrigation volume, irrigation time, and age were not significantly different between the two groups. Hemolysis occurred in 10 and 9 patients in sterile water and saline groups, respectively. The mean change in haptoglobin level was -1.7 ± 59 mg/dL in the sterile water and 11 ± 55 mg/dL in the saline group. Also, the mean change in plasma sodium level was -2.2 ± 4.7 and -0.4 ± 3.8 in sterile water and saline groups, respectively. None of these values were significantly different between the two groups, nor were other laboratory values. None of the patients developed transurethral resection of the prostate syndrome or needed transfusion.

Conclusion: Sterile water is an inexpensive alternative to isotonic saline for irrigation during PCNL. We did not find any difference between the two irrigation solutions regarding the safety; however, this should be confirmed further, especially for larger calculi.

Keywords: lithotripsy, kidney calculi, irrigation, water

Urol J. 2009;6:249-53.
www.uj.unrc.ir

¹Department of Urology, Tehran University of Medical Sciences, Tehran, Iran

²Department of Urology, Isfahan University of Medical Sciences, Isfahan, Iran

³Department of Community and Preventive Medicine, Tehran University of Medical Sciences, Tehran, Iran

⁴Tehran University of Medical Sciences, Tehran, Iran

Corresponding Author:
Farshid Alizadeh, MD
No 8, Farhad Alley, Daneshgah Ave,
Isfahan, Iran
Tel: +98 913 317 9509
Fax: +98 21 8855 5320
E-mail: f_alizadeh_md@yahoo.com

Received May 2009
Accepted July 2009

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is the standard treatment for most kidney calculi that are not good candidates for extracorporeal shock wave lithotripsy (SWL) or not responding to it. Its advantages over open surgery include the lower cost, less postoperative pain, shorter hospital stay, and minimal scarring.^(1,2) However, this endoscopic procedure is associated with a number of potentially serious postoperative

complications. One of them is rapid absorption of irrigating solution, which is due to direct intravascular absorption through the opened veins or peritoneal resorption after opening the peritoneal space.⁽³⁾

Postnephrolithotomy syndrome, which is more or less similar to the transurethral resection of the prostate (TURP) syndrome, has been described when glycine 1.5% has been used as the irrigation solution.⁽⁴⁾ Under general

anesthesia, the diagnosis of this syndrome is difficult and often delayed. The usual signs are unexplained rise and then fall in blood pressure and refractory bradycardia. Changes in electrocardiography, including nodal rhythm, ST-segment changes, U waves, and widening of the QRS complexes, may be observed. Recovery from general anesthesia and muscle relaxants may be delayed.⁽⁵⁾

It is well known that using water for irrigation during TURP carries a risk of hemolysis. However, water has advantages over the other irrigation solutions; the visibility is slightly better as blood in the operating field is hemolyzed (although not significant with modern optics) and, if absorbed, water molecules are rapidly distributed in the total body water, resulting in less hypervolemia and less hyponatremia than glycine and mannitol solutions. Furthermore, plain water has no potentially harmful substances usually added to avoid hemolysis. Last but not least, water is an inexpensive available irrigation solution. In most developing countries, addition of glycine, mannitol, or sorbitol cannot be afforded.⁽⁶⁾

The use of water as the irrigation solution in TURP has been investigated in several studies.⁽⁶⁻⁹⁾ However, its use in PCNL has not been widely studied. The aim of this study was to evaluate the effect of sterile water as the irrigation solution in PCNL and its effect on hemolysis and electrolyte changes.

MATERIALS AND METHODS

Between June 2006 and July 2007, a total of 107 patients with kidney calculi were referred to our clinic. The diagnosis of calculus was made by ultrasonography and plain abdominal radiography. When PCNL was planned, an intravenous urography was also performed to delineate the pyelocaliceal anatomy. The calculus size was determined by measuring the largest diameter of its shadow (opaque calculi) or filling defect (radiolucent calculi). In rare cases in which the overlapping bowel gas made accurate measurement impossible, the size measured by ultrasonography was relied on to avoid performing spiral computed tomography scan.

Among the patients, 44 were selected and randomized into 2 equal groups of 22. Adult patients between 18 and 60 years, with an American Society of Anesthesiologists class I or II, and with pelvis or caliceal calculi larger than 2 cm that could be approached through a single subcostal access or smaller than 2 cm not responsive to SWL were included. The local ethics committee approved this study for calculi that could be treated through a single subcostal access to reduce the possibility of complications that could occur due to absorption of large amounts of water into the circulation. The exclusion criteria were the presence of hepatic, renal, pulmonary or cardiovascular failure, active urinary tract infection, history of hemolytic or hemorrhagic disorders, syndromes causing electrolyte changes such as syndrome of inappropriate antidiuretic hormone secretion (SIADH) and diabetes insipidus, any electrolyte disturbances, hypertension, and any medication affecting serum electrolytes.

Laboratory studies including complete blood count, blood urea nitrogen (BUN), plasma creatinine, sodium, potassium, haptoglobin, urinalysis and urine culture were performed the day before and 12 hours after the operation. Induction of general anesthesia was achieved with the same method for all of the patients with thiopental, atracurium, and fentanyl and continued with isoflurane. A 5-F ureteral catheter was placed and anchored to a Foley catheter, and then, the patient turned to the prone position with appropriate padding. Percutaneous access to the renal collecting system was established under the guidance of monoplane fluoroscopy by the use of a 19-gauge percutaneous needle. Then, the tract was dilated with telescopic metal dilators and a 30-F Amplatz sheath was placed in the tract. Calculus fragmentation was performed with pneumatic lithotripsy (Swiss Lithoclast) using a rigid nephroscope. Irrigation was performed by either sterile water or isotonic saline solution with the reservoir being kept at a height of 80 cm from the patient. The statistician provided us with closed numbered pockets, each of which containing a piece of paper with either “saline” or “water” being written on it. For each patient, the related pocket was opened and the type of irrigation fluid was chosen accordingly.

The procedure was done in a totally tubeless manner unless pelvis perforation or severe bleeding occurred, in which cases, a 24-F nephrostomy tube was placed for tamponade. The ureteral catheter was removed upon the completion of the procedure. Intravenous isotonic saline was infused during and after the operation. The dose was calculated by the anesthesiologist according to the ongoing and insensible water loss, as well as blood pressure; hence, it was individualized for each patient and included 100 mL/kg for the first 10 kg of the weight, 50 mL/kg for the second 10 kg, and 20 mL/kg for the remainder of weight, plus 15 mL/kg/d as the insensible water loss. However, when hypotension was encountered during the operation, additional booster doses of isotonic saline were administered to keep the systolic blood pressure above 100 mm Hg. The patient was kept nil per os until the next morning, when the intravenous fluid was discontinued and oral intake started. Pulse oxymetry and noninvasive monitoring of the cardiac function and blood pressure were established during the operation and in the recovery room. The patients were continuously checked for signs of TURP syndrome during the operation, in the recovery room, and at 3-hour intervals in the ward by checking blood pressure and level of consciousness for the next 24 hours, afterwards.

Statistical analyses were performed by the SPSS software (Statistical Package for the Social Sciences, version 13.0, SPSS Inc, Chicago, Ill, USA). Comparisons between groups were done using the chi-square test, Fisher exact test, *t* test,

or Mann-Whitney U test, where appropriate. Comparison of values measured before and after the procedures were done using the paired *t* test. A *P* value less than .05 was considered significant.

RESULTS

The patients' demographic and surgical characteristics are presented in Table 1. Hemolysis, as detected by a fall in serum haptoglobin, was observed in 10 (45.5%) and 9 (40.9%) patients in the sterile water and normal saline groups, respectively (*P* = .81). There was no difference between plasma mean haptoglobin before the operation in the two groups (Table 2). The mean difference between haptoglobin before and after the operation in the saline and sterile water groups were 10.7 ± 55 mg/dL and -1.7 ± 58.7 mg/dL, respectively (*P* = .47). None of the patients developed signs of TURP syndrome during or after the operation. Also, there was no difference between sodium values before and after the procedure or the mean changes in these values after the operation in the two groups (Tables 2 and 3).

Table 1. Demographic and Surgical Characteristics of Patients Who Underwent Percutaneous Nephrolithotomy Using Sterile Water or Isotonic Saline*

Characteristic	Irrigation Fluid		<i>P</i>
	0.9% Saline	Sterile Water	
Age, y	36.8 ± 9.8	35.6 ± 11.2	.69
Male/female	15/ 7	17/ 5	.50
Calculus size, mm	31.0 ± 9.9	25.9 ± 10.9	.13
Irrigation time, min	35.0 ± 13.1	29.27 ± 10.7	.12
Irrigation volume, L	6.70 ± 3.37	6.90 ± 2.77	.85
ASA class I/ II	18/ 4	15/ 7	.11

*ASA indicates American Society of Anesthesiologists.

Table 2. Blood Laboratory Values Before and After Percutaneous Nephrolithotomy Using Sterile Water or Isotonic Saline

Parameter	Before	After	<i>P</i>
0.9% saline			
Sodium, mEq/dL	140.80 ± 3.30	140.40 ± 1.90	.87
Potassium, mEq/dL	4.16 ± 0.30	4.00 ± 0.56	.65
Creatinine, mg/dL	1.10 ± 0.22	1.20 ± 0.31	.51
Hemoglobin, g/dL	14.50 ± 1.15	13.68 ± 1.17	.61
Haptoglobin, mg/dL	84.10 ± 1.15	94.80 ± 43.10	.37
Sterile water			
Sodium, mEq/dL	140.50 ± 3.75	138.30 ± 3.31	.76
Potassium, mEq/dL	4.18 ± 0.31	3.90 ± 0.32	.39
Creatinine, mg/dL	1.17 ± 0.27	1.32 ± 0.15	.51
Hemoglobin, g/dL	14.87 ± 1.21	13.97 ± 1.00	.77
Haptoglobin, mg/dL	90.30 ± 45.70	88.60 ± 43.30	.62

Table 3. Mean Differences of Laboratory Values Before and After Percutaneous Nephrolithotomy Using Sterile Water or Isotonic Saline

Parameter	Mean Changes		P
	0.9% Saline	Sterile Water	
Sodium, mEq/dL	-0.40 ± 3.76	-2.18 ± 4.75	.18
Potassium, mEq/dL	-0.15 ± 0.60	-0.22 ± 0.37	.63
Creatinine, mg/dL	0.10 ± 0.13	0.15 ± 0.12	.22
Hemoglobin, g/dL	-0.81 ± 0.91	-0.89 ± 0.77	.75
Haptoglobin, mg/dL	10.72 ± 55.03	-1.72 ± 58.77	.47

By dividing the mean irrigation volume into mean irrigation time, the mean irrigation velocity was calculated to be 0.19 L/min and 0.23L/min for saline and sterile water groups, respectively ($P = .47$). Serum creatinine rise (> 1.5 mg/dL) occurred in 1 patient in the saline group that returned to normal after 24 hours. Laboratory values before and after the operation and their mean changes are presented in Tables 2 and 3.

Renal pelvis perforation occurred in 2 and 1 patients in the sterile water and saline groups, respectively. When perforation was diagnosed, the procedure was terminated, a nephrostomy tube was placed, and the operation deferred to a later date. Only 1 patient in the sterile water group showed a fall in haptoglobin, but hyponatremia occurred in none. None of the patients needed transfusion after the operation.

The rate of becoming calculus-free, defined as complete calculus clearance or residuals smaller than 4 mm, was 95% (21/22) and 91% (20/22) in the sterile water and saline groups, respectively. It was evaluated by plain abdominal radiography for opaque and spiral computed tomography for nonopaque calculi. A sample of Tehran tap water was analyzed chemically, in order to determine its electrolyte composition and osmolality. The results are presented in Table 4.

Table 4. Electrolyte Composition of Tehran Tap Water and Isotonic Saline

Parameter	Tap Water	0.9% Saline
Sodium, mEq/dL	30.0	2542.0
Potassium, mEq/dL	2.0	...
Chloride, mEq/dL	22.0	5390.0
Magnesium, mEq/dL	17.3	...
Calcium, mEq/dL	35.2	...
Sulphate, mEq/dL	50.0	...
Nitrate, mEq/dL	3.2	...
Osmolality	23.0	308.0

DISCUSSION

Irrigation solutions are widely used in endourological procedures for better vision. Ideally, they should be isotonic, nonhemolytic, nontoxic, transparent, easy to sterilize, and inexpensive.⁽¹⁰⁾ However, such a solution is not yet available. Solutions such as isotonic saline or Ringer Lactate are least harmful when absorbed into the circulation. Although sterile water has many qualities of an ideal irrigating fluid, its disadvantages are extreme hypotonicity, shock, and kidney failure.⁽⁵⁾

Using distilled water as the irrigation solution in TURP has been evaluated in a number of studies. Mommsen and colleagues showed that the concentration of serum sodium decreased and plasma free hemoglobin increased significantly, but without significant change in haptoglobin level, after TURP using distilled water.⁽¹¹⁾ However, in a study by Chen and associates, haptoglobin decreased immediately and 24 hours after the operation, while all other parameters (plasma hemoglobin, lactate dehydrogenase, sodium, and creatinine levels) returned to their preoperative levels 24 hours after surgery in patients with hemolysis. They found hemolysis in 43.6% of their patients after TURP using distilled water.⁽⁷⁾

Haptoglobin is an α_2 -glycoprotein which is mainly produced in the liver. Since it is an acute-phase protein, its concentration may increase by inflammation or tissue trauma during surgery or decrease as a result of hemolysis. Although its half-life is about 5 days, when bound to hemoglobin, it will be cleared from plasma within minutes.⁽¹²⁾ Warkentin and coworkers showed that decrease in serum haptoglobin levels due to hemolysis occurred much faster than its increase due to acute-phase response.⁽¹³⁾ Others have shown that

in an acute-phase reaction, hemolysis is associated with plasma depletion of haptoglobin.⁽¹²⁾ We checked haptoglobin 12 hours after the operation to minimize the effect of acute-phase increase in its plasma levels, which could probably counterbalance its decline as a result of hemolysis.

Malhorta and colleagues showed that a mean volume of 696.7 mL of irrigation solution is absorbed during PCNL.⁽¹⁴⁾ Thus, development of hemolysis or TURP syndrome is a potential risk when water is used as an irrigation solution. Using distilled water for PCNL, Feizzadeh and associates found no case of symptomatic or asymptomatic hyponatremia among their patients.⁽¹⁵⁾ We did not find any case of hyponatremia either. Moreover, the mean plasma haptoglobin, potassium, creatinine, and hemoglobin before and after the operation and the mean changes in these values were not significantly different between the two groups. In these both studies, the calculi were approached through a single tract and Amplatz sheath was also used. It seems that these two factors were important in decreasing the amount of water absorbed and the possibility of hyponatremia and hemolysis. To our knowledge, our study was the first to evaluate the effect of water as an irrigation fluid for PCNL on both hemolysis and electrolyte changes. We found sterile water to be a safe and inexpensive alternative to isotonic saline for irrigation during PCNL, but considering the small mean calculus size in this study (28.45 ± 10.67 mm), the safety of sterile water for large calculi or when multiple tracts are required has to be further evaluated.

CONCLUSION

Sterile water is an inexpensive alternative to isotonic saline for irrigation during PCNL. Although we did not find any difference between the two irrigation fluids with regard to the safety for smaller calculi, its safety has to be confirmed with larger studies, especially for large calculi.

ACKNOWLEDGEMENT

We thank Mehrnaz Hadidi, Soghra Rahimi, Simin Hajinia, and Mehdi Soori for their contribution in conducting this study.

CONFLICT OF INTEREST

None declared.

REFERENCES

- O'Keeffe NK, Mortimer AJ, Sambrook PA, Rao PN. Severe sepsis following percutaneous or endoscopic procedures for urinary tract stones. *Br J Urol.* 1993;72:277-83.
- Lang EK. Percutaneous nephrostolithotomy and lithotripsy: a multi-institutional survey of complications. *Radiology.* 1987;162:25-30.
- Gehring H, Nahm W, Zimmermann K, Fornara P, Ocklitz E, Schmucker P. Irrigating fluid absorption during percutaneous nephrolithotripsy. *Acta Anaesthesiol Scand.* 1999;43:316-21.
- Fellahi JL, Richard JP, Bellezza M, Antonini A, Thouvenot JP, Cathala B. The intravascular transfer of glycine during percutaneous kidney surgery. *Cah Anesthesiol.* 1992;40:343-7.
- Moorthy HK, Philip S. TURP syndrome - current concepts in the pathophysiology and management. *Indian J Urol.* 2001;17:97-102.
- Hultén JO, Tran VT, Pettersson G. The control of haemolysis during transurethral resection of the prostate when water is used for irrigation: monitoring absorption by the ethanol method. *BJU Int.* 2000;86:989-92.
- Chen SS, Lin AT, Chen KK, Chang LS. Hemolysis in transurethral resection of the prostate using distilled water as the irrigant. *J Chin Med Assoc.* 2006;69:270-5.
- Memon A, Buchholz NP, Salahuddin S. Water as an irrigant in transurethral resection of the prostate: a cost-effective alternative. *Arch Ital Urol Androl.* 1999;71:131-4.
- Creevy CD, Reiser MP. The importance of hemolysis in transurethral prostatic resection: severe and fatal reactions associated with the use of distilled water. *J Urol.* 1963;89:900-5;
- Madsen PO, Madsen RE. Clinical and experimental evaluation of different irrigating fluids for transurethral surgery. *Invest Urol.* 1965;3:122-9.
- Mommsen S, Genster HG, Moller J. Changes in the serum concentrations of sodium, potassium, and free haemoglobin during transurethral resection of the prostate--parts of the TUR-syndrome? *Urol Res.* 1977;5:201-5.
- Kormoczi GF, Saemann MD, Buchta C, et al. Influence of clinical factors on the haemolysis marker haptoglobin. *Eur J Clin Invest.* 2006;36:202-9.
- Warkentin DL, Marchand A, Van Lente F. Serum haptoglobin concentrations in concurrent hemolysis and acute-phase reaction. *Clin Chem.* 1987;33:1265-6.
- Malhotra SK, Khaitan A, Goswami AK, Gill KD, Dutta A. Monitoring of irrigation fluid absorption during percutaneous nephrolithotripsy: the use of 1% ethanol as a marker. *Anaesthesia.* 2001;56:1103-6.
- Feizzadeh B, Doosti H, Movarrehk M. Distilled water as an irrigation fluid in percutaneous nephrolithotomy. *Urol J.* 2006;3:208-11.