Effect of Irrigation Solution Temperature on Complications of Percutaneous Nephrolithotomy: A Randomized Clinical Trial

Seyed Reza Hosseini[1]*, Mohammad Ghasem Mohseni[2], Seyed Mohammad Kazem Aghamir[3], Hamed Rezaei[4]

Purpose: Many factors affecthypothermia and shivering during percutaneous nephrolithotomy and in recovery. Hence this study was carried out to determine the effect of irrigation solution temperature on complications of percutaneous nephrolithotomy.

Materials and Methods: In this randomized clinical trial, 60 patients undergoing PCNL in Sina University Hospital were enrolled. The patients were randomly assigned in three groups according to simple random manner. The groups included three groups of room temperature fluid (24 degree), warm solution (37 degree), and cold fluid (20 degree) during nephroscopy.

Results: Although the initial core temperature was alike across the groups ($P > .05$); the hypothermia rate occured in all 20 patients in the cold fluid group ($P = .012$). There was significant difference between the groups in terms of final temperature and alteration amount ($P = .001$). The mean VAS scores were significantly lower in the warm fluid group compared with the others groups at recovery, and 8hrs post-operatively ($P = .03$). Assessment of shivering rates revealed that 3(15%) patients in warm solution group shivered compared to8 (40%) patients in cold fluid group ($P = .018$).

Conclusion: Warm irrigation solution during PCNL results in significantly decreased hypothermia, mean postoperative pain score and shivering. Hence use of warm irrigation fluid for this matter is recommended.

Keywords: hypothermia; irrigation fluid; percutaneous nephrolithotomy

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a routine treatment for stones larger than two centimeters, staghorn calculi, and resistant to extracorporeal shockwave lithotripsy (ESWL). It is usually done by fluoroscopy or ultrasonography via the calyceal system. Even for the most experienced urologist, major complications can still occur in up to 7% of patients undergoing PNL and minor complications may be encountered in up to 25% of patients. Hemorrhage is the most significant complication of PCNL, with transfusion rates reported to be from less than 1% to 10%. [1,17]

During nephroscopy, continuous irrigation of pyelocalyceal system with fluids is required to develop good visual field. The irrigation fluid temperature is studied in different endoscopic procedures showing controversial results. Postoperative hypothermia may result in hazardous complications such as myocardial ischemia, coagulopathy, surgical wound infection, decreased drug metabolism, and shivering[2].To our knowledge, only one study about hypothermia in PCNL has evaluated the anesthetic complications of hypothermia.[3]

The optimal temperature of irrigation solution is not clear and not evidence based. Use of warm intra-operative solution may be effective for reduction of postoperative hypothermia risk. On the other hand use of cold fluid may result in better intra-operative homeostasis due to peripheral blood vessel vasoconstriction.

Finding the appropriate temperature for irrigation fluid would result in better surgical outcomes and decreased intra-operative complications such as bleeding and would prepare better visual appearance during nephroscopy, and may result in less hypothermia and related complications. Accordingly, in this study, intra-operative and post-operative complications in PCNL were compared across three groups including those receiving solution with room temperature, warm fluid, and cold solution.

MATERIALS AND METHODS

Study population

In this randomized clinical trial, 60 patients undergoing PCNL in Sina University Hospital were enrolled. The subjects had an age range of 18 to 60 years old. In our department, PCNL is performed in patients with kidney stones more than 2 cm in diameter, stones refractory to extracorporeal shock wave lithotripsy, proximal ureteral stones larger than 1.5 cm in diameter, diverticular stones, and stones producing distal obstruction. The exclusion criteria wasmedium to high cardiovascular risk, coagulation disorder, renal failure, hepatic failure, diabetes mellitus, and hypothyroidism. The Helsinki Dec-

[1]Associate Professor, Department of Urology, Tehran University of Medical Sciences ,Tehran, Iran.
[2]Professor, Department of Urology, Tehran University of Medical Sciences ,Tehran, Iran.
[3]Associate Professor, Department of Urology, Tehran University of Medical Sciences, Tehran, Iran.
[4]Resident of Urology, Tehran University of Medical Sciences ,Tehran, Iran.
*Correspondence: Department of Urology, Sina Hospital, Imam Khomeini Ave., Tehran, Iran.
E mail: rhosseinim@yahoo.com.
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Table 1. Background data across the groups.

Variable	Room temperature fluid	Body temperature fluid	Cold fluid	*P* Value
Age	45.9 ± 11.9	44.9 ± 12.2	39.9 ± 16.6	0.345
BMI (kg/m²)	26.5 ± 3.4	25.6 ± 2.1	24.8 ± 3.6	0.241
hemoglobin decrease (g/dl)	1.6 ±1.1	1.5 ± 0.9	2.1 ± 1.0	0.132
irrigation volume (liter)	12.1 ± 2.8	12.6 ± 3.3	12.8 ± 3.2	0.768
stone size (cm)	3.1 ± 0.9	3.2 ± 1.1	3.6 ± 1.3	0.331
Operation duration (min)	85.0 ± 31.2	85.7 ± 38.7	86.5 ± 30.1	0.988
Hospital stay (day)	5.2 ± 2.5	4.8 ± 1.4	5.1 ± 2.3	0.778
Creatinine increase(mg/dl)	0.5 ± 0.2	0.4 ± 0.1	0.6 ± 0.4	0. 11

laration was respected during the study and informed consent form was signed by all patients. Also, the study was approved by the Ethical Committee of Tehran University of Medical Sciences.

Patients' enrollment algorithm is illustrated in **Figure 1.** Routine laboratory exams (FBS,CBC,BUN.Creatinine,urine culture) were perfomed before surgery.

Study design

A randomized multi-arm parallel-group clinical trial with balanced randomization (1:1:1) was conducted at the De¬partment of Urology of Tehran University of Medical Sciences in Tehran, Iran. The study group allocation was by a sequentially running computer-generated block randomization list as blocks of three unique numbers/block, ranging from 1 to 3 unsorted. Sample size was calculated considering a 5 percent expected difference between core temperature in three groups as the primary outcome of interest. We conducted a test with a significance level of 0.05 and power of 0.80 and an¬ticipated that groups of equal size were required. We concluded that at least 20 pateints were needed in each group. The groups included three groups of room temperature fluid (24°C), warm solution (37°C), and cold fluid (20°C) during nephroscopy. Demographic data, previous medical history, stone-related data, and operation data were recorded in three groups.

Surgical technique

The patients were not warmed before operation. All patients were transferred to operation room and anesthetized with general method during 20-minute period. The core temperature was assessed and recorded just before initiation of anesthesia. Esophageal temperature probes were planted to measure core temperature. The probe was connected to the monitoring system continuously, during the operations, and monitored the patients' temperature constantly. However, core temperature recorded its average every 10 minutes. Temperature of the operating room was constantly set at 23 ± 1°C, by a central thermostat. Six patients were excluded before operation due to preoperative hypothermia (core temperature less than 36°C). The operations were carried out by single practiced surgeon endourologist. The irrigation fluid volume and duration of operation (just prone PCNL time) were also recorded.

After general anesthesia, a 5F urethral catheter was placed cystoscopically and percutaneous access was obtained while the patient was placed in a prone position. Then the access to calyceal system was developed by Shiba needle under fluoroscopy guide and it was dilatated with plastic dilatator up to 30F. Then amplatz sheath was inserted and stones were removed using nephroscope 26F and pneumatic lithoclast. Distilled water was used as irrigation fluid in pressure of 60 mmHg. To ensure patient safety, core temperature was measured during the procedure; if patients suffered severe hypothermia, the surgeon stopped the irrigation and patient warming using blanket and warmer was performed.

Outcome assessment

The core temperature as the primary outcome of interest was recorded again just after operation. The rest of data were secondary outcome. Then, the patients were transferred to the recovery room and underwent routine monitoring for at least one hour. The shivering at recovery room was recorded. Post-operative pain scores were evaluated using a 10-cm self assessed visual analog scale (VAS) with 0 indicating no pain and 10 representing the worst pain experienced by the patient in the recovery room and 8 hours after PCNL.

The reader(fourth author; urology resident) was blinded to both patient groups. After operation, routine labexamination and plain abdominal radiography were performed. Also, the abdominal CT-scan was done as indicated. Stone-free was defined as stone diameter less than 4 mm. The complications were categorized to five levels by modified Clavien system.[4]

Data analysis was performed by SPSS (version 24.0) software [Statistical Procedures for Social Sciences; Chicago, Illinois, USA]. Fisher exact and Kruskal wallis tests were used and were considered statistically significant at p values less than .05.

RESULTS

Three groups of patients consisting of 20 patients in each were compared . The age, body mass index (BMI), hemoglobin decrease, irrigation volume, stone size, surgical duration, and hospital stay were similar in terms of a number of background variables (**Table 1**). Although the initial core temperature was alike across the groups ($P > .05$); there was significant difference between groups for final temperature and alteration amount (**Table 2**). Males comprised 80%, 65%, and 70% of patients in the room temperature fluid, warm solution, and cold fluid group, respectively ($P = .563$).

Seventy percent, 80%, and 80% were stone-free in

Table 2. Core temperature across the groups.

Variable	Room temperature fluid	Body temperature fluid	Cold fluid	*P* Value
Initial temperature	36.8 ± 0.4	36.7 ± 0.4	36.6 ± .4	0.259
Final temperature	35.7 ± 0.9	36.1 ± 0.6	35.0 ± 1.1	0.001
Temperature alteration	1.1 ± 0.8	0.6 ± 0.4	1.6 ± 0.9	0.001

Table 3. Complications across the groups.

Variable	Room temperature fluid	Body temperature fluid	Cold fluid	*p*-value	test
Shivering*	5 (25%)	3 (15%)	8 (40%)	0.198	
Fever	1 (5%)	3 (15%)	3 (15%)	0.68	Fisher exact
DVT	---	---	1 (5%)	1.000	Fisher exact
Angioembolization	1 (5%)	---	---	1.000	Fisher exact
Transfusion	1 (5%)	1 (5%)	1 (5%)	1.000	
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groups of room temperature fluid, warm solution, and cold fluid, respectively (*P* = .700). Assessment of shivering rates revealed that patients in the warm solution group shivered less compared with other groups although it was not statistically significant (**Table 3**) (*P* = .198). The mean VAS scores were significantly lower in warm fluid group compared with the others groups at recovery, and 8hrs post-operatively (**Table 3**) (*P* = .03). Clavein complications grading was same across the groups (**Table 4**). The hypothermia significantly occurred in cold fluid group (**Table 5**) (*P* = .021).

DISCUSSION

The main finding of the present study is that warm irrigation solution could significantly decrease hypothermia, the mean postoperative pain score and shivering.

Previous studies showed that cardiovascular, hemorrhagic and infectious complications are significantly more frequent in hypothermic than in normothermic patients[2]. Lots of studies have proved that cold stress could influence the immune responses by elevating the levels of inflammatory cytokines, including pro- and anti-inflammatory cytokines. It has been reported that many proinflammatory cytokines, such as TNF-a, IL-1, IL-6, significantly increased under cold stress. For minimally invasive procedures like PCNL, this response is concerned with regional pain.[5]

The effects of fluid temperature on core temperature in patients under endoscopic surgeries has been assessed in different studies. The effects on bleeding volume and homeostasis of cold solution are established in some investigations. The effects of experimental lowering of temperature on decreased blood flow are reported by some animal studies[6]. Also, it has been demonstrated in human studies such as prostatectomy procedures, resulting in appropriate hemostasis.[7] The bleeding time more than two times after superficial lowering of the temperature is reported in human volunteers [8].

Use of warm irrigation fluid has also been studied in some reports. In the study by Parodi et al.[9], use of warm fluid for irrigation during arthroscopy had no effect on reduction of hypothermia in shoulder joint but it had an significant effect in the hip joint. This difference in a single study may also explain variations in different studies. As in our study, Jin and colleagues[10] recommended the use of warm irrigation solution to reduce hypothermia and shivering and also intra-operative blood loss after endoscopics surgeries.Althoughin our study, hemoglobin level differences were not significant. The isothermal solution led to further fluid overload after operation due to decreased viscosity[11]. There are few studies discussing this issue in endoscopic urological procedures. Mirza et al. reported that hypothermia is common after endoscopic urological procedures which isrelated to duration of operation, weight, irrigation fluid volume, and type of procedure.[12] Rezaei et al. showed that using warm saline irrigation in ureteral endoscope results in better surgical outcomes including a lower ureteral spasm rate, greater ureteral muscle relaxation and better access to the upper ureteral zone, and a lower rate of complications, such as ureteroscope impaction, ureteral dislodge and stone retropulsion.[13] Regarding these confounding factors, we matched all of these variables across the groups of the current study. Also, warm and isothermal irrigation fluids were effective to reduce the hypothermia rate after TURP [14]. Use of isothermal fluid was also effective on hypothermia reduction in another study.[15] Similar results were also reported by Tekgul and colleagues[3] compared to the irrigation fluid with room temperature and warm solution in PCNL and reported that lower hypothermia and shivering were seen in the warm fluid group. Compared to this study, longer follow-up was made in our study during hospitalization to discharge. In line with the mentioned study,, using warm irrigation fluid resulted in lower hypothermia after procedure, but the complications that could be related to hypothermia, as surgical site infection or coagulopathy were not seen more frequently in patients suffering from hypothermia. This may be due to shortness of surgical time or limited number of patients studied in this survey. Actually, longer operation time may exaggerate the impact of irrigation fluid temperature on core body temperature and subsequently such complications. Also in the present study, the mean VAS score was significantly lower in the warm fluid group compared tothe other groups in the recovery and 8hrs post-operatively. In our recently published article, we showed that pain score after PCNL has an important role in needing analgesic drugs. [16] Therefore, warm fluid group may be received low dose analgesic drugs compare other groups. Some of limitation of our study were small sample size and limited temperature range of irrigation solutions to compare because of there was no distinct evidence that support to use extreme temperatures in practice . Fu-

Table 4. Clavein complications grading across the groups.

Grade	Room temperature fluid	Body temperature fluid	Cold fluid	p-value of kruskal wallis
1	2 (10%)	1 (5%)	1 (5%)	0.910
2	2 (10%)	3 (15%)	4 (20%)	
3	1 (5%)	----	----	
Negative	15 (75%)	16 (80%)	15 (75%)	

Table 5. Hypothermia across the groups.

Grade	Mild (34-36 degree)	Moderate (32-33.9 degree)	Negative	True *p*-value of kruskal wallis
Room temperature fluid	11 (55%)	1 (5%)	8 (40%)	0.021
Body temperature fluid	6 (30%)	---	14 (70%)	
Cold fluid	13 (65%)	3 (15%)	4 (20%)	

ther studies recommended more patients to attain more reliable results.

CONCLUSIONS

Overall, according to our study, it was concluded that use of warm irrigation solution during PCNL results in significantly less hypothermia, mean postoperative pain score and shivering. Hence, use of warm irrigation fluid for this matter is recommended. However, further studies with larger sample size and multi-center sampling are required to attain more definite results with higher reliability and potency for generalization.

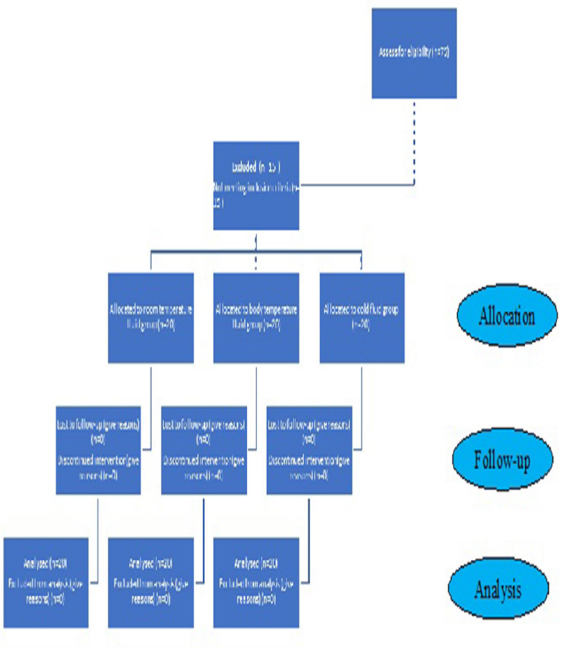

Figure 1. Patient flowchart

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