Fluid Absorption During Percutaneous Nephrolithotomy: Does It Matter?

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ABSTRACT

Background and Purpose: Large amounts of irrigating fluid are used during percutaneous nephrolithotomy (PCNL). This use may be associated with migrating calculus debris, infection, and fluid absorption. This study evaluated the presence of fluid absorption during PCNL, its clinical and biochemical significance, and maneuvers to reduce it.

Patients and Methods: Fluid absorption during PCNL was evaluated in 148 patients by estimating the expired breath ethanol concentration. Factors thought to affect the amount of fluid absorbed were studied, including the amount of irrigating fluid used, the number of nephrostomy tracts, the presence of a low-pressure system, the presence of existing tracts, and complications such as bleeding or perforation of the pelvicaliceal wall.

Results: Fluid absorption was evident in all patients, although no patient had any clinical or biochemical evidence of intraoperative or postoperative electrolyte imbalance. Creating a low-pressure system by using an Amplatz sheath, reducing the amount of irrigating fluid used, and staging the procedure significantly reduced the amount of fluid absorbed.

Conclusions: Fluid absorption does take place during PCNL. This may be clinically significant in patients with compromised cardiorespiratory or renal status and in pediatric patients, leading to fluid overload. Using a low-pressure system, reducing the nephroscopy time and the amount of irrigating fluid used, and staging the procedure for large renal stone burdens, especially in the presence of complications such as perforation of the pelvicaliceal system, reduces fluid absorption and avoids volume overload. Fluid absorption may also be associated with both infective and noninfective pyrexia, necessitating adequate preoperative control of urinary infection.

INTRODUCTION

PERCUTANEOUS NEPHROLITHOTOMY (PCNL) is now a widely accepted modality of treatment for complex renal calculi, especially staghorn calculi. Large amounts of irrigating fluid are used during PCNL and may be associated with migrating calculus debris, infection, and fluid absorption. While it is a well-established fact that there is considerable fluid absorption during transurethral resection of the prostate (TURP), there is little evidence of fluid absorption in percutaneous stone surgery.1-3 This study evaluated the extent of fluid absorption during PCNL, its clinical and biochemical significance, and maneuvers to reduce it.

PATIENTS AND METHODS

A series of 148 cases of PCNL done during the period July–December 2000 were included in this study. Of these, 95 patients were males and 53 female. The age of the patients ranged from 2 years to 71 years with an average of 43 years. All the patients had a preoperative hemogram, serum creatinine and electrolyte estimation, and urine culture and sensitivity analyses. Cardiac and respiratory status was evaluated when indicated.

Ultrasound-guided peripheral caliceal puncture was done in all the cases. The tract was sequentially dilated by serial Alken dilators. 27-F Wolf nephroscope was used in all the cases, and


\[(2140 + 3430 \times \text{Eb-Ethanol L}) \times \text{EB} + (44 + 806 \times \text{Eb-Ethanol L})\]

\[\text{EB} = \text{Change in Ethanol conc. during a 10 min period}\]

\[\text{Eb-ETHANOL L} = \text{Ethanol at beginning of 10 min period}\]

**FIG. 1.** Formula for calculation of irrigating fluid absorbed (after Hann).\(^6\)

A 28 F Amplatz sheath was placed to create a low-pressure pelvicalceal system in 124 cases. Physiologic (0.9%) saline was used as the irrigating fluid, the bag being kept at a fixed height of 45 cm above the midaxillary line. Absolute ethanol 30 mL was added to each 3-L of saline bottle, giving a net ethanol concentration of 1% in the irrigating fluid. Huhlen and colleagues in 1986\(^4\) and Hahn in 1991\(^5\) proposed measuring breath ethanol after the addition of 1% ethanol to the irrigating solution. The linear correlation between the ethanol concentration in the expired breath and the volume of absorption makes it possible to estimate with reasonable accuracy the amount of irrigating fluid that has been absorbed.

The procedure was either staged or completed in one setting, depending on the calculus burden, operative time, and presence of risk factors (renal insufficiency, compromised cardiac and pulmonary status). When the PCNL was staged, the tract was dilated at the initial sitting and a nephrostomy tube placed. Subsequently (48 hours later), stone disintegration was done through the matured dilated tract.

Fluid absorption was estimated every 10 minutes by measurement of the expired breath ethanol concentration (EBEC) with the help of the Alcosensor, a device that was directly connected to the endotracheal tube. A standard formula was used to convert the EBEC to the amount of irrigating fluid absorbed (Fig. 1).\(^5\) Routine hemogram and electrolyte examinations were done at the end of the procedure. The various factors evaluated were the amount of irrigating fluid used, the number of tracts, presence or absence of a low-pressure system, the presence of existing tracts, and the appearance of complication such as bleeding or perforation of the pelvicalceal wall. Statistical analysis was done using the chi-square test for each of these factors. The incidence of postprocedural pyrexia (fever \(>100^\circ\)) during the immediate 24 hours was also determined.

**RESULTS**

Of the 148 patients, 38 (25.6%) underwent a staged procedure. The indications for staging were a large stone burden, renal insufficiency, and the presence of infected urine or frank pus at the initial puncture. In 110 patients, 84.4%, complete clearance was achieved in a single stage in 75% of the single-stage procedures (78%). A low-pressure system was maintained with the help of an Amplatz sheath, while 34 (30%) of these patients required more than one tract.

Fluid absorption was detected in all patients and ranged from a minimum of 44 mL to a maximum of 474 mL. The volume of fluid absorbed increased with the amount of irrigating fluid used and the duration of the procedure (Fig. 2). Placement of an Amplatz sheath with subsequently reduced pressure in the pelvicalceal system reduced the amount of fluid absorption (Fig. 3A). The difference became statistically significant \((P < 0.05)\) at higher amounts of irrigating fluid \((>9 \text{ L})\). The presence of multiple tracts did not affect the amount of fluid absorbed \((P = 0.46)\) compared with cases with single tracts with identical nephroscopy time (Fig. 3B).

Staged nephrostomy with nephroscopy through the matured tract reduced the amount of fluid absorbed. Compared with cases done through a fresh tract, the difference in the amount of fluid absorbed was statistically significant \((P < 0.05)\) at higher amounts (6 L and above) of irrigating fluid (Fig. 3C).

The presence of significant perforation of the pelvicalceal wall (seven cases) and bleeding (nine cases) during the procedure was associated with increased fluid absorption, the difference becoming statistically significant \((P < 0.05)\) at nephroscopy times of 50 minutes and above (Fig. 4).

No patient had any clinical or biochemical evidence of intraoperative or postoperative electrolyte imbalance. The incidence of pyrexia was 10.8% (16 cases) in our series. In nine of these patients, urine culture showed evidence of infection, while in the others, no obvious cause could be identified. Ten of the cases were associated with longer nephroscopy times (\(>1\) hour). The average irrigating fluid absorbed in these cases was 178 mL.

**DISCUSSION**

During percutaneous stone surgery, systemic absorption of irrigant fluid may occur when there is extravasation of fluid caused by rupture of the renal pelvicalceal wall.\(^1\)\(^2\) Absorption may also occur via the vessels that open up during tract dilatation and in the kidney during stone disintegration. Another route for massive and rapid fluid absorption is leakage of fluid into the peritoneal space.\(^3\) Because diathermy is rarely used during PCNL, the irrigating fluid is always saline and never distilled water.\(^4\) This prevents any electrolyte imbalance, especially hypotension, in the presence of fluid absorption as is sometimes seen during TURP.

![FIG. 2.](attachment://image.png) **Effect of amount of irrigating fluid used on absorption in 86 patients with fresh tract and Amplatz sheath.**
Fluid absorption was evident in all the patients in our study, the maximum amount being 474 mL. None of the patients had any evidence of electrolyte imbalance or fluid overload, however. Reducing the height of the irrigating fluid bag and use of an Amplatz open drainage (low-pressure) sheath helps keep the intrapelvic pressure low and prevent fluid absorption. Cases with complex renal stones or large stone burdens should be staged to reduce the amount of fluid absorbed. Staging also leads to formation of a mature nephroscopy tract and less bleeding, significantly reducing fluid absorption. Major perforations of the pelvicicalcual wall or infundibular tears allow direct access of fluid to the perinephric space and subsequent absorption. In the presence of extravasation or excessive bleeding, the procedure should be terminated and completed later. This reduces the amount of bleeding, allows the tract to mature, and reduces fluid absorption.

Clinically significant volume overload may take place in patients with borderline cardiopulmonary or renal status, especially in the presence of complications such as excessive bleeding and large perforations. The procedure should always be staged in such patients with complex renal calculi. Administration of a diuretic (furosemide) at the end of the procedure would prevent volume overload in these cases.

Irrigating fluid absorption may be one of the factors responsible for infective and noninfective pyrexia after PCNL. Release of bacteria and infected material during stone fragmentation and its subsequent absorption would lead to infective pyrexia and occasionally septicemia, necessitating adequate preoperative control of urinary infection.

CONCLUSIONS

There has been little study in the literature of fluid absorption during PCNL. The occurrence of fluid absorption during PCNL and various factors affecting it have been evaluated in this study. Fluid absorption does take place during PCNL and may be clinically significant in patients with compromised cardiopulmonary or renal status and in pediatric patients, leading to fluid overload. Absorption of infected stone debris and bacteria released from the nidus of an infected stone may lead to bacteremia, fever, and, occasionally, septicemia. This can be prevented by adequate preoperative control of urinary infection and staging of the procedure in the presence of infection. Using a low-pressure nephroscopy system and reducing the nephroscopy time and the amount of irrigating fluid can reduce this problem. Staging the procedure for large renal calculi, especially in the presence of complications such as perforations and excessive bleeding, reduces fluid absorption and avoids volume overload and fever.
REFERENCES


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