Original Article

A comparative study of air pyelogram and contrast pyelogram for initial puncture access and to see its efficacy during percutaneous nephrolithotomy

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Abstract

Objective: The current investigation was aimed to compare the safety, efficacy, adverse effects, and outcome of air pyelogram versus contrast pyelogram for percutaneous nephrolithotomy.

Materials and Methods: This was a cross-sectional study conducted from August 2018 to November 2020, which included 400 patients with a clinical diagnosis of renal calculus and randomly (1:1) assigned into Group I (air pyelogram) and Group II (contrast pyelogram). Air was injected in Group I and diatrizoate meglumine 76% was used in Group II for PCS identification. In the case of difficulty in visualization in either group, a mixture of contrast and air was used. The following parameters were assessed: duration of access, total duration of radiation exposure during access, total attempts needed to puncture the desired calyx, failure rate, complications, and outcomes.

Results: Both the groups were comparable including renal calculus characteristics. The mean (standard deviation) duration of access was 3.08 (1.21) and 5.23 (1.02) min ($P < 0.0001$) in Groups I and II, respectively; in 85% and 57.5% of patients ($P < 0.0001$), respectively, the caliceal puncture was done in a single attempt. The duration of radiation exposure was more in Group II ($P < 0.0001$). The failure rate (22%) was higher and statistically significant in Group II. The stone clearance rate was not statistically significant between the groups ($P = 0.380$). No patient had hypoxia, cardiopulmonary complications, and air embolism in perioperative period.

Conclusion: Air contrast is effective and safe, and it reduces the duration of caliceal puncture and radiation exposure with lower failure rate. If both air and contrast fail, a combination of both may be effective.

Keywords: Air pyelogram, contrast pyelogram, percutaneous nephrolithotomy

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INTRODUCTION

Percutaneous renal calculus removal was first described 30 years ago, and it has become one of the common surgical interventions for patients with renal calculus and was considered a safe and effective treatment for patients with large or complex renal calculus.[1,2]

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Goodwin *et al*. in 1955 performed first percutaneous nephrostomy to decompress an obstructed kidney.[3] Percutaneous access into the intrarenal collecting system has been recognized as the most critical step for access to the collecting system.[4] Ultrasonography, fluoroscopy, and computed tomography (CT) guidance are the major tools to perform percutaneous nephrolithotomy (PCNL).[5] Fluoroscopy is used as the major tool to achieve renal access in PCNL procedures due to its better acquaintance among urologists and clear visibility.[6,7]

Fluoroscopy is used for the advancement of guidewires in the pelvicalyceal system (PCS), dilation of tract, calculus removal, and nephrostomy sheath placement, providing real-time depiction of the collecting system and the stones therein. PCNL is performed with a combination of endoscopic and fluoroscopic visualization of the PCS.[4]

Delineation of PCS is the most crucial step before puncture and dilation of tract. In contrast, air or both of them can be used to delineate PCS. These agents can be gradually established in PCS by antegrade or retrograde means.[8] The use of air has few advantages over contrast, 1) better visualization of posterior calyces when the patient is in the prone position 2) significantly reduces radiation exposure,[9] 3) reduces risk of extravasations of contrast,[9] and 4 contrast allergy.

One concern when using air for retrograde pyelogram is the perceived risk of air embolism which is an extremely rare event.[10]

There is only one similar study[11] conducted to date, and this study is having the largest sample size to date on extensive search on the Internet. Keeping all these facts in view, the current investigation was aimed to compare the safety, efficacy, adverse effects, and outcome of air pyelogram versus contrast pyelogram for PCNL.

MATERIALS AND METHODS

This was a cross-sectional study which was conducted from August 2018 to November 2020. Institutional Ethical Committee clearance was taken in accordance with the Declaration of Helsinki (IEC approval no. 345). Written informed consent was obtained from all patients before the study. The sample size was calculated, based on a previous similar study[11] and considering the power of study at 80% with a 5% significance level.

A total of 400 patients who had radiopaque renal calculi and underwent PCNL were included in this study. Patients with complete staghorn, uncorrectable coagulopathy, congenital abnormalities, pregnancy, and urinary tract infection, were excluded from the study. Baseline assessment of all patients was done which included the demographic characterization, physical examination, complete blood count, renal function test, urine analysis, urine culture and sensitivity, and coagulation profile. All patients were evaluated following CT intravenous urography or contrast-enhanced CT abdomen to ascertain the size, site, number of calculi, anatomy of the upper urinary tract, and the grade of hydronephrosis. Access to the PCS was defined to gain entry to the desired calyx. All patients were randomly assigned into two groups, namely the air pyelogram group and the contrast pyelogram group designated as Group I and Group II, respectively, by using odd–even formula. Each group had 200 patients. In Group I (air pyelogram), room air was injected through the ureteric catheter for PCS identification [Figure 1]. In Group II (contrast pyelogram group), diatrizoate meglumine 76% was used and diluted with normal saline which was slowly injected through the ureteral catheter to delineate the PCS under the c-arm machine [Figure 2].

In the case of difficulty in visualization in either group, a mixture of contrast and air was used. Under aseptic condition, the patient is placed in lithotomy position and 5F open-ended ureteric catheter is placed in the renal pelvis. The patient is put into prone position and pressure points are padded appropriately. Five- to fifteen-milliliter air contrast is used for opacification of the collecting system. Now, the C-arm fluoroscopy unit is moved 30° toward the operating surgeon to locate the calyx that can provide the optimal access for performing the procedure.

Using fluroscope desired calyx was identified and caleceal puncture was attempted. Caleceal puncture was made with the help of initial puncture needle (18G) using Bull's eye technique or triangulation technique & guidewire was placed. Thereafter, the tract was dilated serially over guidewire using Alken dilators till 24–30 Fr and finally Amplatz sheath is passed over metallic dilators and all dilators are removed en mass leaving Amplatz sheath. The nephroscope is passed through Amplatz sheath. The pneumatic lithotripter was used as energy for fragmentation of calculi. Similar procedure is repeated in Group II where dye was used instead of air.

Following parameters evaluation were made between groups:

- Duration of access (time required after positioning the patient till placement of guidewire in the targeted calyx)
- Total duration of radiation exposure during access

- Total attempts needed to puncture the desired calyx
- Number of the patients requiring iodinated contrast material in failed air nephrostogram and vice versa (failure rate)
- Complications
- Outcome of each group was evaluated with X-ray KUB following the operation (to look for residual stone).

Statistical analysis

To determine the significance of differences, Student's *t*-test was applied in the present study. Quantitative data were expressed as mean (standard deviation [SD]) and qualitative data were indicated in percentage and proportion. Results were considered statistically significant when $P < 0.05$ using the Chi-square test.

RESULTS

A total of 400 patients with PCNL were included in this study. Of these, 200 cases were performed using an air retrograde pyelogram and 200 cases using a contrast retrograde pyelogram. The baseline characteristics of the two groups are presented in Table 1, and there was no statistically significant difference noted in each group. Renal calculus characteristics (site of calculus, size of calculus, number of calculi, Guy's stone score, and degree of hydronephrosis) of the two groups showed no statistically significant difference [Table 1].

The mean (SD) duration of access was 3.08 (1.21) min after prone positioning in Group I and 5.23 (1.02) min in Group II, which was statistically significant ($P < 0.0001$) [Table 2]. In 85% of patients in Group I and 57.5% of patients in Group II, caliceal puncture was done in a single attempt which was statistically significant ($P < 0.0001$) [Table 2]. The duration of radiation exposure was 0.75 (0.18) min in Group I and 1.10 (0.40) min in Group II which was statistically significant ($P < 0.0001$) [Table 2]. The failure rate (22%) was higher and statistically significant in Group II [Table 2]. The stone clearance rate was 85% using air pyelogram and 88% on contrast pyelogram and was not statistically significant ($P = 0.380$) [Table 2]. No patient had hypoxia, cardiopulmonary complications, and air embolism in perioperative period [Table 3].

DISCUSSION

The role of PNCL is very important in the management of renal calculi. Renal access is a very significant step in the PCNL and needs a detailed knowledge of renal, retroperitoneal, and thoracic anatomy to reduce the risk of complications. Fluoroscopy and the proper equipment's access are necessary for renal calculus extraction.[12] Air can be used as contrast for visualization of PCS without the

Table 1: Demographics and baseline characteristics (*n*=200)

Characteristics	Group I (air pyelogram)	Group II (contrast pyelogram)	*P*
Age, mean (SD)	43.94 (9.0)	42 (8.6)	0.2466
Gender (male)	126 (63.0)	128 (64.0)	0.8357
Pain distribution			
Right	88 (44.0)	96 (48.0)	0.4228
Left	100 (50.0)	97 (48.5)	0.7644
Bilateral	12 (6.0)	7 (3.5)	0.2405
Calculus characteristics			
Site of calculus right (%)	112 (56.0)	96 (48.0)	0.109
Size of calculus (>1 cm)	104 (52.0)	96 (48.0)	0.424
Guy's stone score, mean (SD)	1.39 (0.56)	1.34 (0.48)	0.682
Number of calculi (<1)	128 (64.0)	140 (70.0)	0.202
Degree of hydronephrosis			
No hydronephrosis	106 (53.0)	120 (60.0)	0.158
Mild hydronephrosis	40 (20.0)	40 (20.0)	1.000
Moderate hydronephrosis	40 (20.0)	30 (15.0)	0.188
Severe hydronephrosis	14 (7.0)	10 (5.0)	0.4003

Data presented as *n* (%), unless otherwise specified. SD: Standard deviation

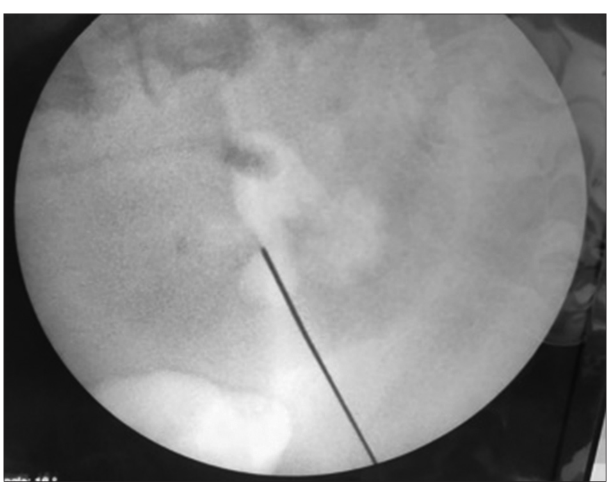

Figure 1: Air pyelogram

Figure 2: Contrast pyelogram

Table 2: Characteristics of cases using air versus contrast for retrograde pyelogram (*n*=200)

	Group I (air pyelogram)	Group II (contrast pyelogram)	*P*
Failure rate			
Both (air and contrast)	16 (8.0)	44 (22.0)	0.0001
Number of attempts required for caliceal puncture			
One attempt	170 (85.0)	115 (57.5)	0.0001
Two or more attempts	30 (15.0)	85 (42.5)	
Mean access time, mean (SD)	3.08 (1.21)	5 (21.02)	0.0001
Duration of radiation exposure, mean (SD)	0.75 (0.18)	1.1 (0.40)	0.0001
Stone clearance rate			
Complete clearance	170 (85.0)	176 (88.0)	0.380
Incomplete clearance	30 (15.0)	24 (12.0)	

Data presented as *n* (%), unless otherwise specified. SD: Standard deviation

Table 3: Complications (*n*=200)

	Group I (air pyelogram)	Group II (contrast pyelogram)
UTI	15 (7.5)	18 (9.0)
Significant blood loss requiring blood transfusion	5 (2.5)	4 (2.0)
Cardiopulmonary complications	Nil	Nil
Air embolism	Nil	Nil

Data presented as *n* (%). UTI: Urinary tract infection

risk of extravasations of contrast. The use of air contrast reduces the risk of allergic reactions to contrast, preserves visualization of the stone, and helps in differentiation between residual stone and residual contrast.[9]

Our study described the technique of initial renal access for PCNL with the use of air and contrast in a high volume endourology center, and we looked at every aspect of the procedure (time, radiation exposure, safety, efficacy, and outcome of each group).

In our study, the peak incidence of urinary calculi is from the thirties to fifties age group. We found renal calculi to be more common in males than in females. Liao and Richardson[13] had described that the low serum level of testosterone renders certain immunity in females. On an extensive search over the Internet (PubMed and Google Scholar), we found many studies on the benefits and adverse effect of air pyelogram in PCNL, but we could able to find only one comparative study between air pyelogram and contrast pyelogram which was done by Mehrabi.[11]

In a study done by Mehrabi,[11] the mean (SD) access time in Groups I and II was 4 (2) min and 6 (2) min, respectively ($P = 0.03$). The puncture time (mean) for target calyx was 3 (1) and 4 (2), respectively, and the radiation time in the two groups was similar. The stone free was similar in the two groups. In our study, the mean time required to access the calyx was 5.23 (1.02) min in Group II (contrast pyelogram) and 3.08 (1.21) min in Group I (air pyelogram). Hence, the mean access time was less with air pyelogram as compared to contrast pyelogram and was statistically significant ($P < 0.0001$). While radiation time was more in the contrast pyelogram group and it was statistically significant ($P < 0.0001$). Stone clearance rates were not statistically significant which was similar to the above study.

A study done by Lipkin *et al*.[9] showed significantly lower radiation exposure in the air pyelogram group than in the contrast pyelogram group ($P = 0.001$). In our study, the mean duration of radiation exposure was less with air pyelogram as compared to contrast pyelogram and was statistically significant ($P < 0.0001$) which was similar to the Lipkin *et al*. study.[9]

One of the demerits of contrast pyelography is that poorly opacified calculi were completely obscured by high-density contrast media. This camouflage effect was not seen when only an air nephrostogram was used for caliceal puncture.[14] When calyx identification with contrast alone is difficult, the addition of little air helps in identifying posterior calyx.[15]

In difficult cases, combining the air and nonionized contrast may help as air being light in weight fills the posterior calyx against the dark nonionized contrast of high density in the anterior calyx.

There were few studies[16,17] which showed air embolism and cardiopulmonary complication in the air pyelogram group, but in our study, no such complication occurred.

The limitations of this study are that it is a nonrandomized study and X-ray KUB was used in follow-up which is inferior to NCCT KUB.

CONCLUSION

We conclude that feasibility of air contrast is effective and safe. It reduces the time taken for the caliceal puncture as well as the radiation exposure. It has less failure rate as compared to the contrast pyelogram.

Air is ubiquitously available for the procedure, which further reduces the expense of the already costly procedure.

The punctures were precise and accurate. Even multiple punctures undertaken for clearance calculi were accurate. Air embolism is a rare possibility of air contrast, however, we did not find any such complication. If air or contrast fails, a combination of both may be effective.

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Conflicts of interest

There are no conflicts of interest.

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