The Association of Stone Opacity in Plain Radiography with Percutaneous Nephrolithotomy Outcomes and Complications

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Purpose: To investigate the influence of stone opacity in plain radiography on stone free rate and complications of percutaneous nephrolithotomy (PCNL).

Materials and Methods: A number of 101 patients who underwent PCNL between July-September 2015 were prospectively included. Stone opacity was judged on preoperative plain Kidney-Ureter-Bladder X-ray. Stone free rate was evaluated two weeks after the operation by ultrasonography and KUB.

Results: There were 61 patients with opaque stones and 40 patients with non-opaque stones. The age, body mass index, preoperative creatinine, history of stone surgery, and stone size was not statistically different between patients with opaque and non-opaque stones. Neither operation duration nor access numbers were statistically significant between opaque and non-opaque stones. The frequency of stone free patients in opaque stones and non-opaque stones were 55/61 (90%) and 30/40 (75%) respectively ($P = .04$) The magnitude of hemoglobin drop in opaque stones and non-opaque stones were 1.9 ± 1.2 mg/dL versus 2.9 ± 1.7 mg/dL ($P = .005$).

Conclusion: The stone free rate is lower and the magnitude of bleeding is higher in PCNL of non-opaque stones when compared to opaque stones if rigid instruments are used for nephroscopy.

Keywords: nephrolithiasis; opacity; percutaneous nephrolithotomy; stone free rate.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is the treatment of choice for large or otherwise complex renal or proximal ureteral stones[1]. Since first described by Fernstrom and Johannson[2], several modifications have been described to improve the outcome of surgery or reduce its potential complications by optimizing its surgical steps, including patient position, puncture of the collecting system, dilation, guidance equipment, fragmentation modality, and exit strategy. Currently, fluoroscopic imaging is the most commonly used technique in PCNL for entry to the renal collecting system, checking for the proper placement of surgical tools, and locating residual stones.[3] The success in PCNL is recognized as stone-free rate (SFR) which is under influence of factors such as stone burden and location.[4] With the advent of retrograde intrarenal surgery (RIRS), alternative options are available for patients less likely to benefit from PCNL. After completion of lithotripsy in PCNL, residuals are checked by nephroscopic inspection and by fluoroscopic imaging. Observing residual stones through fluoroscopy is largely dependent on the visibility of stones on plain radiography (namely opacity). Stone opacity can also affect the outcome of ancillary procedures like shockwave lithotripsy which are employed to treat PCNL residuals.[5,6] Previous reports have evaluated the association of computed tomography (CT) Hounsefield units (HU) with PCNL success and complications. Few studies have evaluated the association of stone opacity on KUB with PCNL success. This is important because routine preoperative evaluations before PCNL in many centers include intravenous pyelography without routine use of CT scan. Furthermore, a preoperative KUB is obtained in many centers on the morning of operation. Therefore, opacity on KUB is more readily available for PCNL candidates than CT Hounsefield units. Furthermore, the association of CT HUs with stone opacity on KUB is not perfect and wide apart cut off points have been suggested in the literature.[7,8] The present study aimed to determine whether stone opacity determined in plain KUB influenced the outcomes and complications of the PCNL procedure to help make better treatment decisions before operation.

PATIENTS AND METHODS

Between July 2015 and September 2015, 101 patients underwent PCNL at our institution by two endourology fellows. PCNL is typically done in our center for renal stones ≥ 2 cm, smaller stones refractory to ESWL, and large upper ureteral stones. All data were gathered prospectively. Preoperative data, operative characteristics and postoperative data were collected. According to our department protocol, every patient was evaluated before the procedure by urine analysis, complete blood count, serum creatinine level and coagulation assays. Preoperative imaging studies included intravenous pyelography and/or abdominal CT scan. Stone burden was calculated based on stone surface area. Stones were categorized to opaque stones (visible on plain radiography) and non-opaque stones (non-visible on plain radiography). Our protocol for PCNL was the standard prone

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Table 1. Patients' and operations' data compared between patients with and without opaque stones.

	Opaque stones; N=61	Non-opaque stones; N=40	*P* value
Age,years; mean±SD	45.0±13.5	44.8±14.3	0.94
Body mass index; mean±SD	26.9±4.4	26.8±3.8	0.93
Preop creatinine, mg/dL; mean±SD	1.3±0.2	1.3±0.2	0.67
History of PCNL or ESWL; N(%)	15 (25)	14 (35)	0.26
History of open stone surgery; N(%)	10 (16)	7 (17)	0.88
Stone surface area, cm2; mean±SD	4.7±4.2	4.8±4.2	0.95
Stone location, N(%)			0.44
Single calyx	7 (11)	5 (12)	
Pelvis	12 (20)	8 (20)	
Pelvis + single calyx	24 (39)	10 (25)	
Pelvis + ≥ 2 calices	18 (30)	17 (43)	
Operation duration, minutes; mean±SD	54±24	55±17	0.73
Pelvicaliceal system injury; N(%)	9 (15)	7 (17)	0.71
Access numbers, 1/2/3	53/5/2	35/5/0	0.57
Preop hemoglobin, mg/dL; mean±SD	13.5±1.4	13.4±1.6	0.76
Postop hemoglobin, mg/dL; mean±SD	11.5±1.6	10.5±1.4	0.001
Stone free patients, N(%)	55 (90.2)	30 (75.0)	0.04

PCNL under fluoroscopic guidance as previously reported[9] and is summarized below. Renal access was achieved under fluoroscopic guidance, preferably through the lower calyx, after injection of contrast medium through a 5F open-ended ureteral catheter placed by cystoscope. Tract dilation was performed using the one-shot method, and a 30 F Amplatz sheath was inserted. Nephroscopy was performed by 24F Wolf nephroscope. Pneumatic lithotripter (Swiss Master Lithoclast, EMS, Bern, Switzerland) was used for fragmentation of the calculi. Particles were extracted by suction or grasper. Two or three access tracts were created as needed in case of large and complex stones. Residual stones were evaluated by fluoroscopic imaging and rigid nephroscopy intraoperatively. At the end of operation, PCNL was typically terminated without insertion of nephrostomy tube (tubeless). A 4.8-F ureteral double-J stent was inserted for patients with a single kidney, pyonephrosis, pelvicaliceal system injury or significant residual calculi. The Foley and ureteral catheters were removed 24 to 48 hours after the procedure. Double-J stent was removed 2 to 4 weeks after the operation. All patients were evaluated 2 weeks after surgery by ultrasonography (US),and/or unenhanced CT scan. In accordance with previous reports, stone free patient was defined as the absence of residual fragments or observing residual fragment of < 4 mm.[10-12] Patients with residual fragments were treated with oral medications after receiving their stone analysis data. Data were entered into SPSS ver. 22.0 software (Chicago, IL). Comparison of numerical data between the two study groups was performed by independent samples t-test or Mann-Whitney as appropriate. Chi-square or fisher exact tests were used for comparison of categorical data across study groups. Statistical significance was considered at two sided *P*-value <.05.

RESULTS

The mean ± SD of patients' age was 44.9 ± 13.7 years. 33 patients were female. History of diabetes and hypertension was positive in 8 and 27 patients respectively. 58 operations were performed on the left side. Transfusion was needed in 11 operations (6 operations in the opaque group and 5 operations in the non-opaque group). Postoperative fever defined by oral T > 38°C for > 24 hours was observed in 5 patients (3 patients in the opaque group and 2 patients in the non-opaque group). No case of pleural or bowel injury was observed. Patients' and operations' characteristics between patients with opaque and non-opaque stones have been compared in **Table 1.**

Table 1 illustrates that the relative frequency of stone free patients is higher in the group of patients with opaque stones compared to patients with non-opaque stones. Also, the amount of hemoglobin drop (preoperative hemoglobin – postoperative hemoglobin) in patients with non-opaque stones was higher than patients with opaque stones. (2.9 ± 1.7 mg/dL versus 1.9 ± 1.2 mg/dL, *P* = .005)

DISCUSSION

Our study data simply reveals the inferior stone free rate of PCNL in case of non-opaque stones together with higher hemoglobin loss in these patients. Achieving a high stone free rate together with minimizing complications are the main efficacy targets for PCNL. Recently, the use of RIRS for renal stones has been reported with a high success rate sometimes equal to PCNL.[13-15] Therefore, it is advisable to explore factors that hamper the success of PCNL as alternative procedures are available in the tray of many centers. One study evaluated the association of CT HUs with SFR in PCNL.[16] They reported higher SFRs when CT HU exceeded 1000. SFR was lower in stones with HU < 1000 which includes both opaque and non-opaque stones in KUB. Flexible Nephroscopy was suggested to improve SFR in PCNL of renal stones with HU > 677 by Gucuk et al.[17] The HU suggested by Gucuk et al. is very near to the cut off point for opacity of renal stones in KUB that was proposed by Chua et al.[8] Many patients with renal stones undergo intravenous pyelography for preoperative evaluation as CT is not readily available in many countries or is expensive. Furthermore, a preoperative KUB is taken before the operation in many centers. We think that as fluoroscopy is the most commonly employed imaging modality for PCNL for detection of residual fragments[3], the visibility of renal stones on fluoroscopy images can be more simply predicted on the preoperative KUB than CT images. The association of CT HUs with opacity on KUB has been previously investigated and reported by Chau et al.[7,8] In their first report, the authors suggested HU> 498 as the best cut off point for determination of opacity on plain KUB. In their second study, HU > 630 was reported as the best cut off point. These cut off points were associated with a false negative or positive rate of up to 20%[7,8] simply implying the inaccuracy of CH HUs for determination of opacity on KUB images. Huang and colleagues studied ureteral stone visibility on plain radiography according to their characteristics in unenhanced CT. When the density of the stones exceeded 800 in HU standards, all ureteral stones could be seen, whereas only 17% of the stones could be seen on plain radiography when the HU level was less than 200. These studies point to the fact that there is no strict cut point according to which visibility of plain radiography can be estimated by CT HUs but that there is a gray zone in which some stones with a certain CT HU are visible while some are invisible on pain radiography. As previously indicated stone visibility under C-arm fluoroscopy in PCNL operating room is under the same physics of visibility in KUB. Therefore; visibility of residual stones can be predicted more accurately by their visibility in KUB than their CT HUs. Prior studies on success in PCNL studies evaluated the association of success with CT HUs. Limited publications evaluated the success of PCNL with respect to stone visibility on plain KUB.[10] The reported SFR in PCNL of non-opaque stones are widely different in the published series. SFRs of 95% (for miniperc of radiolucent 1-2 cm lower caliceal stones)[11], 87% (pediatric radiolucent stones)[18], 91% (for PCNL of radiolucent 1-2 cm renal stones) (12), and 44% (for PCNL of radiolucent stones with average stone surface area of 693 mm^2)[10] have been reported in the literature. Our study data also reveals the inferiority of SFR in patients with non-opaque renal stones. Part of this difference relates to stone size and PCNL technique (miniperc versus standard PCNL) and the use of rigid versus flexible instruments. Non-opaque stones on KUB are hard to trace in fluoroscopic imaging and instillation of contrast agent into the collecting system is employed during access phase of PCNL to determine the size and location of radiolucent stones. The contrast agent is usually washed away during nephroscopy by irrigation fluid. Therefore it is practically improbable to detect non-opaque residuals by fluoroscopy at the end of operation although some alternative options exist like intraoperative ultrasonography. Ultrasonography has long ago been used as a guide for access phase of PCNL operation or as the only method of imaging guidance in PCNL. Use of ultrasonography at the end of operation in case of radiolucent stones could probably increase stone free rate, however the overall sensitivity of US for detection of renal stones is in the range of 24-81% in the reported series[19] and lower in non-opaque stones compared with opaque stones.[10] The success of intraoperative ultrasonography to detect stone residuals is also influenced by operative factors like the shadow of access sheath, hematoma around kidney and clots in the collecting system. For these reasons, to minimize the residue rates in patients with non-opaque renal stones, the routine use of flexible nephroscopy has been advocated by Gucek et al. in a randomized clinical trial.[17] However, flexible nephroscopy is not available in some PCNL centers especially in the developing world. Another important finding of our study was the positive correlation between stone opacity and hematocrit drop. We could not find previous reports on the association of bleeding in PCNL and stone opacity. More blood loss in non-opaque stones can be possibly explained by more manipulation and trauma to renal collecting system or renal parenchyma on entry site while looking for residual fragments with a rigid nephroscope. Gucuk and colleagues reported more bleeding in case of stones with lower HUs but they used flexible instruments for detection of residual fragments. Recent clinical trials disclosed the efficiency of RIRS for treatment of renal stones even when stone size is larger than 2 cm or the stone is in the lower pole of kidney with success rates close to standard PCNL.[13-15] Few publications reported equal SFR for RIRS with respect to opacity.[20] Until further confirmatory data will be available, we think that RIRS can be suggested as an alternative method for treatment of small-medium sized non-opaque renal stones or for larger stones flexible nephroscopy should be at hand or the patients should be consulted about a higher probability of residual stones when standard PCNL is employed with only rigid nephroscopes. The study limitations include failure to use flexible instruments as commented on in the discussion section which compromises generalization of results to centers with availability of these instruments. Furthermore, stone composition data was not part of the study protocol, therefore it was not possible to comment on the role of stone composition with opacity and PCNL outcomes.

CONCLUSIONS

The PCNL stone free rate in cases of radiolucent stones is lower and the magnitude of bleeding is higher if rigid instruments are used for nephroscopy.

CONFLICT OF INTEREST

The authors reported no conflict of interest.

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