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Percutaneous Nephrolithotomy Versus Open Surgery for Patients with Renal Staghorn Stones

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ABSTRACT

INTRODUCTION: In 2005, the American Urological Association Nephrolithiasis Clinical Guidelines Panel recommended percutaneous stone removal as first-line treatment for the management of staghorn calculi. New endourological techniques have led to treating staghorn calculi with more effective and less invasive methods. The aim of the present study was to compare the results of percutaneous nephrolithotomy (PCNL) with open surgery for staghorn stones.

METHODS: There were 120 participants with staghorn stones; 72 patients (60%) had PCNL and 48 patients (40%) had open surgery. Variables of age, sex, group, intraoperative and postoperative complications, operation time, and duration of hospitalization were examined. Complications were compared and the probability of group differences reported.

RESULTS: Intraoperative complications occurred in 9 patients (18.8%) during PCNL and 10 patients (13.9%) during open surgery, but the group difference was not statistically significant (P = .611). The most common intraoperative complication for both groups was bleeding that required blood transfusion. Patients treated with PCNL had a significantly shorter mean hospital stay of 3.93 days when compared with a hospital stay of 5.08 days following open surgery (P = .003). Postoperative complications occurred in 2 patients (4.2%) following PCNL and 9 patients (12.5%) following open surgery, but the group difference was not statistically significant (P = .05). The stone-free rate was 81.9% after PCNL and 91.6% after open surgery, a difference that was not statistically significant (P = .84).

CONCLUSION: PCNL is a valuable treatment option for staghorn stones, with complication and stone-free rates comparable to open surgery. Moreover, PCNL resulted in a significantly shorter hospital stay. Therefore, the results of the present study concur with prior literature stating that PCNL should be considered the first stage in treatment for most patients with staghorn stones.

KEYWORDS: Percutaneous nephrolithotomy; Open surgery; Staghorn; PCNL; Stone Free Rate

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INTRODUCTION

The management of complete staghorn stones remains a difficult task for urologists [1]. Based on American Urological Association (AUA) guidelines, the term *partial staghorn calculus* designates a branched stone that occupies part but not all of the collecting system, while a *complete staghorn calculus* refers to a stone that occupies virtually the entire collecting system [2].

Over time, an untreated staghorn calculus is likely to destroy the kidney and/or cause life-threatening sepsis. Complete removal of the stone is an important goal in order to eradicate any causative organisms, relieve obstruction, prevent further stone growth and any associated infection, and preserve kidney function [2-4].

Four acceptable modalities for management of staghorn calculi are: (1) percutaneous nephrolithotomy (PCNL); (2) PCNL and shock wave lithotripsy (SWL); (3) SWL monotherapy; (4) open surgery. If it left untreated, staghorn calculi can lead to deterioration of kidney function and end-stage renal disease [2]. Therefore, nephrectomy may be needed if the stones are not effectively managed.

Most partial staghorn stones are treated with PCNL alone or combined with SWL. There is no universal consensus regarding treatment of complete staghorn stones [5]. Open surgical removal of staghorn calculi was at one time considered the gold standard to which all other forms of stone removal were compared [2]. New endourological techniques led to treating staghorn calculi with more effective and less invasive methods. In 2005, the American Urological Association Nephrolithiasis Clinical Guidelines Panel recommended percutaneous stone removal as first-line treatment for the management of staghorn calculi [2]. This is recommendation is now leading to some controversy about what should be the gold standard in treatment of staghorn calculi. Therefore, the purpose of the present prospective study was to examine the role of open surgery versus PCNL in the treatment of complete staghorn stones.

METHODS

Participants

Participants were 120 patients with staghorn stones, seen by the authors between September 2005 and September 2006. Sixty patients were referred to a surgeon with expertise in open surgery; 60 patients were referred to a surgeon with expertise in PCNL. However, all patients were informed of the 2 surgical options, and 12 patients in the open surgery group chose PCNL. Therefore, the patient groups were not equal or randomized.

There were 72 patients in the PCNL group; 9 patients had complete staghorn stones and 63 patients had partial staghorn stones. There were 48 patients in the open surgery group; 12 patients had complete staghorn stones and 36 patients had partial staghorn stones. Exclusion criteria included patients with uncorrectable coagulopathies, previous PCNL, end-stage renal diseases, or immunosuppressive disorders.

The mean age of the patients in the PCNL group was 46.5 years (SD = 13.47; range, 9-72 years); the mean age of the patients in the open surgery group was 46.25 (SD = 14.04; range, 14-79).

Procedures

All patients received a clinical examination, routine laboratory investigations, and radiological evaluation which included a plain abdominal radiograph (KUB) and ultrasound (US) of the kidneys. A radioisotope scan and retrograde ureteropyelography were performed if serum creatinine was ≥ 1.5 mg/dL to determined glomerular filtration rate (GFR). In patients with lower serum creatinine values, intravenous urography (IVU) was performed. Preoperative characteristics of both groups are shown in Table 1.

Stone burden diameter was assessed by KUB and US. Significant stone residues (> 4 mm) were treated with SWL for patients in both groups.

Patients with positive mid stream urine cultures were treated with appropriate antibiotics before surgery. All patients receiving antibiotics were treated for a total of 1 week, and the specific antibiotic given was based on results of the patient's urine culture. All patients received prophylactic antibiotics prior to surgery which were continued for 1 week after surgery.

PCNL was performed by one expert surgeon; open surgery was done by another expert surgeon. Both surgeons used an intraoperative fluoroscope to make sure that all stones were cleared.

PCNL Surgical Procedure. A standard PCNL was performed under general anesthesia. Patients were placed in the lithotomy position and a ureteral catheter was placed with the aid of a cystoscope. After turning the patient to a prone position, the renal collecting system was accessed via an 18 gauge needle under fluoroscopic guidance. A 0.035 inch J-tip guide wire was then inserted. Access to the kidney was dilated by one shot dilation. Dilatation was performed using a 9 Fr dilator. A single 28 F Amplatz dilator (Biorad Medisys Pvt Ltd; Bangalore,

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Table 1. Preoperative Characteristics of Patients (N = 120).
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Characteristic	PCNL Group (n = 72)		Open Surgery Group (n = 48)	
	Mean	SD	Mean	SD
Age (years)	46.5	13.4	46.04	13.6
Creatinine (mg/dL)	0.95	0.46	1.2	1.1
	n	% n	n	% n
Sex				
Male	35	48.6	19	39.6
Female	37	51.4	29	60.4
Stone				
Complete	9	12.5	12	25
Partial	63	87.5	36	75
Hydronephrosis				
Mild	20	27.8	12	25
Moderate	39	54.2	24	50
Severe	13	18.1	12	25
Urine Culture				
Positive	5	6.9	5	10.4
Negative	67	93.1	43	89.6

India) was pulled in the alken guide. This single passage allowed insertion of the 30 F Amplatz working sheath. Access to the kidney was achieved through 1 puncture in 61 patients, 2 punctures in 8 patients, and 3 punctures in 3 patients. A pneumatic lithotripsy was used for stone fragmentation in all patients. At the end of the procedure, an 18 Fr nephrostomy tube was left in place. This nephrostomy tube was removed 1 day after the procedure; the foley catheter and ureteral stent remained for 18–36 hours after removal of the nephrostomy tube. *Operation time* was defined as the time from entrance of the needle to the end of the procedure.

Open Surgical Procedure. Open surgery was performed under general anesthesia through a standard flank incision. The kidney was fully mobilized. Stones were retrieved via extended pyelolithotomy in 34 kidneys, combined pyelolithotomy and nephrolithotomy in 12 kidneys, and anatrophic nephrolithotomy in 2 kidneys.

A 4.8 to 6 Fr JJ stent was left in all patients. Ischemic time was defined as the time during which the arterial kidney was clamped. In patients who underwent nephrolithotomy instead of an arterial clamp, a parenchymal clamp with santenski clamp was used. *Operation time* was defined as the time from skin incision to the end of the procedure.

Post-Surgical Evaluation

Stone-free rate was defined as stone fragments < 4 mm in diameter. Stone residue was evaluated by US or KUB 2 weeks after surgery. In both groups, significant stone residue was treated with SWL. The machine used for SWL had an electromagnet generator with US for localization of the stones.

In the open surgery group, *urinary leakage* was defined as drainage > 30 cc from the surgical site 1 week after surgery. In the PCNL group, urinary leakage was defined as persistent leakage 5 days after removal of the nephrostomy tube. *Massive hematuria* was defined as the patient being discharged with clear urine but returning with gross hematuria.

Data Analysis

Variables of age, sex, group, complications during and after surgery, operation time, and duration of hospitalization were collected. Data were analyzed by SPSS-10 software (SPSS, Inc, Chicago, IL) using the chi-square test for categorical variables, and *t* test for continuous variables. Differences resulting in $P < .05$ were considered statistically significant.

RESULTS

Mean PCNL operation time was 101.67 minutes (SD = 35.13; range, 30-180 minutes); mean open surgery time was 120 minutes (SD = 20.15; range, 60-210 minutes). There was no statistically significant difference in mean surgery time between the two patient groups ($P = .456$).

Table 2 contains the length of hospital stay, intraoperative and postoperative complications, and probability of significant differences between the patient groups.

Bleeding requiring blood transfusion was the only intraoperative complication observed in 10 patients (13.9%) during PCNL and in 9 patients (18.8%) during open surgery, with no statistically significant difference ($P = .47$). In the group treated with open surgery, 5 patients receiving extended pyelolithotomy, 3 patients receiving combined pyelolithotomy and nephrolithotomy, and 1 patient receiving anatrophic nephrolithotomy had bleeding that required blood transfusion.

Patients treated with PCNL had a significantly shorter duration of hospitalization (mean = 3.93 days; SD = 1.76) than patients

Table 2. Length of Hospital Stay, Intraoperative and Postoperative Complications, and Probability of Significant Differences Between Two Patient Groups (N = 120). doi: 10.3834/uij.1944-5784.2009.10.09t2

Variable	PCNL Group (n = 72)		Open Surgery Group (n = 48)		*P*
	Mean	SD	Mean	SD	
Hospital stay (days)	3.93	1.76	5.08	2.42	.003
	n	% n	n	% n	
Intraoperative complications	10	13.9	9	18.8	.611
Postoperative complications	9	12.5	2	4.2	.05
Obstructive uropathy	1	1.4			
Massive hematuria	1	1.4			
Wound infection	1	1.4	1	2.1	
Urinary leakage	6	8.3	1	2.1	

treated with open surgery (mean = 5.08 days; SD = 2.42) (*P* = .003).

Major postoperative complications including obstructive uropathy, massive hematuria, wound infection, and urinary leakage were observed in 2 patients (4.2%) following PCNL and in 9 patients (12.5%) following open surgery. There was no significant difference between groups in the number of postoperative complications (*P* = .05).

Table 3 shows the comparison of stone-free rate and stone location for the 2 patient groups, with the probability of significant group differences. In this study, 103 patients, including 59 patients (81.9%) in the group receiving PCNL and 44 patients (91.6%) in the group receiving open surgery, had no residue of stone when they were discharged from the hospital. There was no statistically significant difference between the kind of treatment and stone-free values (*P* = .135).

DISCUSSION

Untreated staghorn stones are associated with significant morbidity, recurrent infection, stone growth, and progressive loss of renal function. The mortality rate in an untreated patient is reported to be in the range of 3-28%. The tendency for staghorn stones to recur and the complications they create have caused some authors to refer to them as *stone cancer* [6-9].

Open surgical procedures were the cornerstone of treatment until the early 1980s. These procedures were associated with improvement in renal function. However, with the introduction of PCNL by Fernstrom and Johansson in 1976 [10], the indications for open surgery to remove these stones were dramatically reduced. Open surgical procedures are only recommended in patients with complete staghorn stones associated with infundibular stenosis or distortion of intrarenal anatomy [9-13].

PCNL is currently the preferred first-line treatment for renal stones not amenable to extracorporeal shock wave lithotripsy (ESWL). The morbidity of PCNL with a single tract is less than that of open surgery, with better stone clearance rates. With increasing stone size and complexity, an inherent fear exists of greater bleeding and complication rates [14].

Some surgeons believe that the issue of how to treat patients with staghorn stones still remains unanswered [1]. Studies comparing open surgery with endourological procedures for the treatment of complete staghorn stones are not prevalent in the literature [5,15,16].

Intraoperative Complications

Although intraoperative complications during open surgery were higher than complications during PCNL (18.8% versus 13.9%), the differences were not statistically significant (*P* > .05). However, a recent report [5] showed that there were significantly more intraoperative complications during open surgery than during PCNL (*P* < .05). Both this previous report and the present investigation found that the most frequent

Table 3. Comparison of Stone-Free Rate and Stone Location for 2 Patient Groups, With Probability of Significant Group Differences (N = 120).
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Variable	PCNL Group (n = 72)		Open Surgery Group (n = 48)		*P*
	n	% n	n	% n	
Stone-free rate	58	81.9	44	91.6	.135
Complete staghorn	9	12.5	12	25	.086
Stone-free rate	7	77.7	12	100	
Partial staghorn	63	87.5	36	75	.397
Stone-free rate	52	82.5	32	88.8	

complication in both groups was bleeding requiring blood transfusion. In a review article, the blood transfusion rate was reported to be significantly higher after open surgery. The authors stated that 37%, 9%, and 17% of the total patients required transfusion during open surgery, PCNL, and PCNL combined with SWL, respectively [17].

In the present study, there were 2 anatrophic cases that had less bleeding. In the other open surgery cases, stones were retrieved via extended pyelolithotomy, combined pyelolithotomy, and nephrolithotomy. Twenty five percent of the patients having open surgery had complete staghorn calculi; 12.5% of the patients having PCNL had complete staghorn calculi. The higher percentage of patients with complete staghorn calculi in the open surgery group may explain the higher blood transfusion rate associated with this procedure in the present study. However, the difference between groups was not statistically significant.

The intraoperative complications reported in the literature emphasize the point that open surgical removal of Staghorn stones is a major surgical procedure and PCNL is much less invasive than open surgery. Some authors have reported that the results of PCNL can be improved by using a supracostal approach, because this approach is more suitable to reaching most of the stone bulk and has an acceptable rate of chest complications. Others believe that the lower caliceal approach is the most appropriate, but supracostal puncture is valuable when stones branch into the upper calyx [5,17-19].

The site of skin puncture in all of the PCNL cases in the present study was subcostal due to the surgeon's preference and his concern about supracostal access complications. In cases that needed access in the upper part of kidney, such as the upper or middle pole, the surgeons drew the kidney down by initial access and created a subcostal second access to the upper pole [20]. In this way, the surgeons did not have complications from the supracostal approach such as access through pleural space, respiratory-correlated pain, and hydrothorax.

Mean operative times for PCNL and open surgery were previously reported as 127 minutes and 204 minutes, respectively [5]. The mean operative times for PCNL and open surgery in the present study were 102 minutes and 120 minutes, respectively. The group difference was not statistically significant ($P = .456$).

Postoperative Complications

In the present study, the mean hospital stay was 3.93 days following PCNL and 5.08 days following open surgery. The difference was statistically significant ($P < .05$). Similar results were reported in a previous study, where the mean hospital stay was 4.6 days and 10 days following PCNL and open surgery, respectively [5]. Another report showed that the mean hospital stay was 12.9 and 17.7 days following PCNL and open surgery, respectively [9]. This difference was attributed to the decreased invasiveness of the PCNL method.

In a study by Al-Kohlany et al [5], postoperative complications including septicemia and massive hematuria, urinary leakage, and wound infection were higher following open surgery than following PCNL (31.1% versus 18.6%, respectively). However, the difference between groups was not statistically significant. The authors reported that the most common complications following PCNL were septicemia (7%) and massive hematuria (7%), whereas urinary leakage (13.3%) was the most common complication following open surgery.

In another study, major postoperative bleeding was the most severe complication following PCNL. Other observed complications included urosepsis, urinoma, wound infection, PCN tract discharge, prolonged drainage after removal of PCN, and flank herniation [9].

Although the results of the present study showed that the overall rate of postoperative complications following PCNL was higher than the complication rate following open surgery, the difference was not statistically significant ($P > .05$). The most common postoperative complication was urinary leaking (8.3%) after PCNL, and wound infection (2.1%) and urinary leaking (2.1%) after open surgery. Urinary leakage was treated with insertion of a JJ stent after PCNL. Although leakage could be due to stone fragments in the ureter, TUL was not needed in this group. Wound infections after open surgery were superficial

and successfully treated with appropriate antibiotics.

Stone-Free Rate

One prospective study randomly assigned patients with complete staghorn stones to treatment with open surgery or treatment with PCNL. The results showed that the stone-free rate at the time of hospital discharge was 66.7% and 48.8% following open surgery and PCNL, respectively. However, the difference in the stone-free rates between treatment groups was not statistically significant [5]. A similar study also showed that there was no significant difference in stone-free rate following open surgery and PCNL (79.41% and 85.52%, respectively) [9]. Based on AUA guidelines, the overall estimated stone-free rate is 78% following PCNL and 71% following open surgery [2].

In the present study, KUB and/or US was used 2 weeks postoperatively to assess the stone-free rate (defined as stone residue < 4 mm). The authors did not use CT scan in patient evaluations, which could be considered a weakness of the study. Results showed that the stone-free rate following PCNL was 81.9% and the rate following open surgery was 91.6%. Similar to results of other studies, the present authors did not find any significant difference in the stone-free rates following open surgery and PCNL (P = .135).

CONCLUSION

Although there are different methods to manage staghorn stones, PCNL is less invasive than open surgery and now favored by most surgeons. In the present study, open surgery was compared with PCNL and the results showed that the 2 methods had similar outcomes. Moreover, PCNL had the advantage of a significantly shorter hospital stay. In conclusion, the preferred choice of PCNL is a very effective modality for the management of staghorn stones.

Conflict of Interest: None declared

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