Urological Science 28 (2017) 97–100

Contents lists available at ScienceDirect

Urological Science

journal homepage: www.urol-sci.com

Original article

Outcomes of percutaneous nephrolithotomy versus open stone surgery for patients with staghorn calculi

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ARTICLE INFO

Article history:
Received 21 February 2015
Received in revised form
2 January 2017
Accepted 13 February 2017
Available online 30 March 2017

Keywords:
open stone surgery
percutaneous nephrolithotomy
staghorn calculi

ABSTRACT

Objectives: Advances in shock wave lithotripsy and endourological procedures have markedly limited the need for open surgery in the treatment of renal stones. We retrospectively compared the clinical outcomes of percutaneous nephrolithotomy (PNL)-based therapy with open stone surgery (OSS) to treat staghorn stones.

Materials and methods: Hospital and office charts, operative records, and radiographic studies of all patients undergoing OSS (Group 1, 11 patients) and PNL (Group 2, 61 patients) for the treatment of large staghorn calculi from 2007 to 2013 were reviewed. Only patients with stones $\geq$ 10 cm^2 in area were included. Patient characteristics, stone burden, indications, and surgical outcomes between the two procedures were compared. Stone-clearance was confirmed using postoperative kidney, ureter, bladder X-rays.

Results: There were no differences between the two groups in patient demographics, stone size, estimated blood loss, and mean renal function level change, however, there were statistically significant differences in mean operative time (282.1 ± 54.5 minutes vs. 156.6 ± 41.2 minutes, $p < 0.001$), mean hospital stay (10.3 ± 1.8 days vs. 6.2 ± 2.7 days, $p < 0.001$), postoperative stone-clearance rate (97.5% vs. 76.1 ± 23.9%, $p < 0.001$), and number of procedures per patient (1.6 vs. 2.8, $p < 0.001$) between the OSS and PNL group.

Conclusion: Both OSS and PNL are viable options for the management of staghorn stones. Considering the lower postoperative complication rate and need for auxiliary treatment, we suggest that OSS is more suitable for staghorn stones with large burdens. OSS should still be considered as a valid treatment for patients with complex staghorn calculi, although PNL is a less invasive treatment option in most cases.
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1. Introduction

Open surgical removal of staghorn calculi was once considered to be the "gold standard" to which all other forms of treatment were compared. However, advances in shock wave lithotripsy (SWL) and endourological techniques, percutaneous nephrolithotomy (PNL) and ureterorenoscopic lithotripsy (URSL), have reduced the use of open stone surgery (OSS) to only 1–5.4% of patients with complex stones.[1] Nevertheless, many clinicians still regard OSS to be an acceptable management option for complete staghorn stones.[2–5]

According to the American Urological Association (AUA) guidelines, PNL is recommended as the first-line therapy for most staghorn stones.[2] It has been used successfully to treat renal calculi of $\geq$ 2.5 cm^2 with a low complication rate, however, the most appropriate treatment option for complex staghorn calculi is still under debate. To reduce the need for postoperative auxiliary treatment, some authors still suggest that primary open anatrophic nephrolithotomy should be used for complex staghorn stones. In this study, we reviewed the efficacy and complications associated with PNL, and compared the results to OSS for complex staghorn stones.

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http://dx.doi.org/10.1016/j.urols.2017.02.001
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2. Patients and methods

This retrospective study was conducted at Mackay Memorial Hospital, Taiwan. Hospital charts, operative records, and radiographic studies of all patients undergoing OSS (11 patients) and PNL (61 patients) for the treatment of complex staghorn calculi from 2007 to 2013 were reviewed. We defined complex staghorn stones as those with a total area of ≥ 10 cm^2. Patient characteristics, laboratory data, stone surface area, operative data, surgical comorbidities, complications, outcomes, and auxiliary treatment were recorded. Preoperative imaging studies to clarify the size and location of the calculi and the grade of hydronephrosis included intravenous urography, ultrasonography, and computed tomography. Coexisting anatomical anomalies were assessed with imaging and intraoperative findings. All patients were routinely given first-line parenteral antibiotics perioperatively.

Stone burden was determined by the radiographic findings, and the stone surface area was calculated by tracing the stone on a kidney, ureter, bladder X-ray (KUB) in the anteroposterior view, and then applying the formula: surface area = length $\times$ width $\times$ $\pi \times 0.25$ ($\pi = 3.14159$).[6]

The length of postoperative hospital stay, complications (modified Clavien system), stone clearance rate, and the need for auxiliary treatment including (SWL, URSL, or PNL) were recorded. The results were classified as stone free, clinically insignificant residual fragments (CIRFs), and residual stones (> 4 mm). CIRFs were defined as being $\leq$ 4 mm, nonobstructive, noninfectious, and asymptomatic residual fragments found in postoperative evaluations.[7] The postoperative stone-clearance rate was defined as the elimination rate of total stone burden after calculi debulking on radiographic studies. The primary stone-free rate was defined as the absence of visible fragments (no residual stones) determined with KUB X-ray at discharge. The number of procedures per patient was defined as the mean number of primary, secondary, and adjunctive procedures that the patients received. The complication rate was defined as the frequency of complications associated with the primary and subsequent treatments.

Blood count tests were performed on the 1st postoperative day and the day of discharge to assess changes in hematocrit (Hct) level, and the overall hospital blood loss was calculated using the formula: estimated blood loss (mL) = $Hct_{initial} - Hct_{final}/Hct_{initial} \times$ body weight. All patients were regularly followed-up with urinalysis, serum creatinine, KUB, and renal ultrasound. The chi-square test and Mann–Whitney rank sum test were used for statistical analysis. A p value < 0.001 was considered to be statistically significant. Data were analyzed using SigmaStat statistical software version 4.0 (Systat Software Inc., San Jose, CA, USA).

3. Surgical techniques

3.1. Open stone surgery

Under general anesthesia, the kidney was exposed through a flank incision on the 11th intercostal space. Gerota's fascia was longitudinally incised and perinephric fat carefully dissected off the entire renal capsule. The renal artery and vein were identified and then the renal pedicle was cross clamped using Satinsky's vascular clamps. Cold ischemia was performed to maintain adequate regional hypothermia by packing the perirenal space with sterile crushed normal saline, and the renal vessels were occluded. The kidney was then opened at the convex border and the stones were exposed and removed. Hemostasis was achieved visually by partially releasing the clamp and under running bleeders with 3-0 Vicryl. A Malecot tube was left in the pelvis. Calicoplasty was performed using a 6-0 Vicryl suture, and the parenchymal suture was completed using a 3-0 Vicryl suture.

3.2. Percutaneous nephrolithotomy

A 5Fr ureteral catheter was placed initially with the patient in the lithotomy position. In the absence of hydronephrosis, saline was infused through the ureteric catheter to ensure the ballooning of the pelvicalyceal system. PNL for staghorn calculi was performed in the prone position. An 18-gauge coaxial puncture needle was introduced into the targeted calyx under ultrasound guidance.

A two-step method was used to establish the working channel. Dilatation of the percutaneous tract was serially performed over a guide-wire using a 6–24Fr Amplatz Teflon fascial dilator set (uro-Vision, Bad Aibling, Germany). A 24Fr Cook Amplatz opaque sheath (Cook Medical, Bloomington, IN, USA) was placed as the percutaneous access port, and a 20Fr rigid nephroscope (Richard Wolf, Knittlingen, Germany) was used. Stone fragmentation was then accomplished using an ultrasonic-pneumatic lithotripter and a Swiss Lithoclast system (Electro Medical Systems, Nyon, Switzerland). Fragments were removed using graspers. For complex staghorn stones occupying several calyces, a second or third tract was created using the same technique.

After removal of the working sheath, a 16Fr nephrostomy tube was placed in all patients. The operative time was defined as the time from introduction of the 18-gauge coaxial needle into the patient's skin to the placement of the nephrostomy tube. In patients who were considered to be stone-free, the nephrostomy tubes were removed 72 hours after surgery; however, the nephrostomy tube was left in place if a second PNL session was planned for residual stones.

4. Results

4.1. Patient characteristics

The patient demographics and stone characteristics of the OSS and PNL groups are summarized in Table 1. There were no significant differences in age, sex, Charlson comorbidity index score, mean stone burdens, and preoperative renal function level between the two groups. The congenital anomalies in both groups are shown in Table 1. A total of 11 patients (3 men and 8 women) underwent open surgical procedures for stone removal, including pyelolithotomy in seven and anatrophic nephrolithotomy in four. The indications for open surgery were previous failure of endourology in three patients (27.3%), anatomic obstruction (infundibular stenosis, bifid renal pelvis with ureteropelvic junction obstruction) in three patients (27.3%), complex staghorn calculi associated with massive caliceal dilation in four patients (36.4%), and struvite calculi with refractory uroseptic episodes in one patient (9.1%).

4.2. Surgical outcomes

Comparisons of intraoperative and postoperative parameters are shown in Tables 2 and 3, and complications classified according to the modified Clavien system are summarized in Table 4. The stone-free rate was 63.7% (7 of 11 patients), and four patients (36.3%) had residual stones in the OSS group, compared with eight (13.1%) stone-free patients, 36 (59.0%) patients with residual fragments, and 17 (39.9%) patients with CIRFs in the PNL group ($p < 0.001$). The postoperative stone-clearance rate was 97.5% in the OSS group and 76.1 $\pm$ 23.9% in the PNL group ($p < 0.001$). Four patients (36%) received auxiliary treatment for residual stones in the OSS group compared with 36 (59%) in the PNL group ($p < 0.001$). The auxiliary treatments required to eliminate residual stones >

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