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TOPIC PAPER

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Robotic extended pyelolithotomy for treatment of renal calculi: a feasibility study

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Abstract Percutaneous nephrolithotomy (PCNL) remains the treatment of choice for staghorn renal calculi. Many reports suggest that laparoscopy can be an alternative treatment for large renal stones. We wished to evaluate the role and feasibility of laparoscopic extended pyelolithotomy (REP) for treatment of staghorn calculi. Thirteen patients underwent REP for treatment of staghorn calculi over a 12-day period. Twelve patients had partial staghorn stones and one had a complete staghorn stone. All patients had pre-operative and post-operative imaging including KUB and computed tomography. All procedures were completed robotically without conversion to laparoscopy or open surgery. Mean operative time was 158 min and mean robotic console time was 108 min. Complete stone removal was accomplished in all patients except the one with a complete staghorn calculus. Estimated blood loss was 100 cc, and no patient required post-operative transfusion. REP is an effective treatment alternative to PCNL in some patients with staghorn calculi. However, patients with complete staghorn stones are not suitable candidates for this particular technique.

Keywords Robotic · Pyelolithotomy · Calculi · DaVinci · Kidney

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Introduction

The use of Robotics has allowed urologists to provide minimally invasive surgical treatment options for complex extirpative and reconstructive procedures that would otherwise be case prohibitive with standard laparoscopy. Patient and practitioner acceptance has allowed robotic surgery to dominate urologic pelvic surgery including radical prostatectomy, radical cystectomy, and many gynecologic procedures [1, 2]. Many have successfully transferred the robotic platform to kidney surgery and have had success with donor nephrectomy, partial nephrectomy, and pyeloplasty for uretero-pelvic junction (UPJ) obstruction [3–5].

Recently, authors have explored the use of laparoscopy as a useful alternative to percutaneous nephrolithotomy (PCNL) for treatment of large renal calculi; however, operative times were longer than PCNL and outcomes were similar [6, 7]. With the enhanced reconstructive capabilities of the robotic platform, we wished to investigate the role and feasibility of utilizing this technology in the treatment of staghorn renal calculi. We focused on the management of large renal calculi using a robotic extended pyelolithotomy (REP) technique of stone extraction. Since the technology of laparoscopic renal cooling is still under investigation, we limited our technique to REP and not robotic anatrophic nephrolithotomy. We wished to determine the feasibility and define the indications of robotics in renal stone surgery.

Patients and methods

The robotic surgery team from the Vattikuti Urology Institute (VUI) in Detroit, Michigan, traveled to the Institute of Urology and Nephrology, Kuala Lumpur Hospital (KLH) in Malaysia to perform a robotic renal surgery workshop over a 12-day period in March 2006.

The KLH team had recruited patients over a 6-month period for the workshop, paying special attention to those patients requiring minimally invasive treatment of staghorn renal calculi. During this time period, we performed a total of 45 robotic surgeries: 13 REP, 3 donor nephrectomies for transplantation, 5 radical nephrectomies, 1 partial nephrectomy, 3 pyeloplasties, 4 cystectomies, 1 ureterolithotomy, 2 nephroureterectomies, 1 vesico-vaginal fistula repair, 1 inguinal hernia repair, and 11 radical prostatectomies.

Among this group, 13 patients underwent REP for large renal and/or staghorn calculi. The patients' charts were prospectively reviewed as they arrived to KLH to analyze renal anatomy and stone burden including presence of hydronephrosis, degree of calyceal extension, and presence or absence of extra-renal pelvis. All patients underwent imaging including KUB, and either computed tomography and/or retrograde pyelography to further delineate anatomy. All patients underwent post-operative KUB on day one to document any residual stone burden.

Surgical technique

We placed the patients in a modified 45°–60° lateral decubitus position with minimal to no flexion of the operating table and no kidney rest elevation (Fig. 1). A few patients had pre-operatively placed ureteral stents for obstruction; otherwise no pre-procedural cystoscopy was routinely performed. Pneumoperitoneum was achieved with the Veress needle into the peritoneal space. A-12 mm camera port was placed laterally between the anterior axillary and mid-clavicular lines (Figs. 2, 3, 4). Two 8-mm robotic ports were placed under direct vision and triangulated towards the renal pelvis. Two assistant ports, 12 and 5 mm, were placed peri-umbilical midline between the two robotic arm ports. An additional 5 mm port was placed in some instances for liver retraction.

Fig. 1 Patient positioning for left side stone

Fig. 2 Port placement for left side stone

The entire procedure was performed with robotic assistance. All procedures were performed trans-peritoneal starting with medial reflection of the colon. The renal pelvis and hilum were identified along with the UPJ. The renal pedical was not clamped. Once adequate

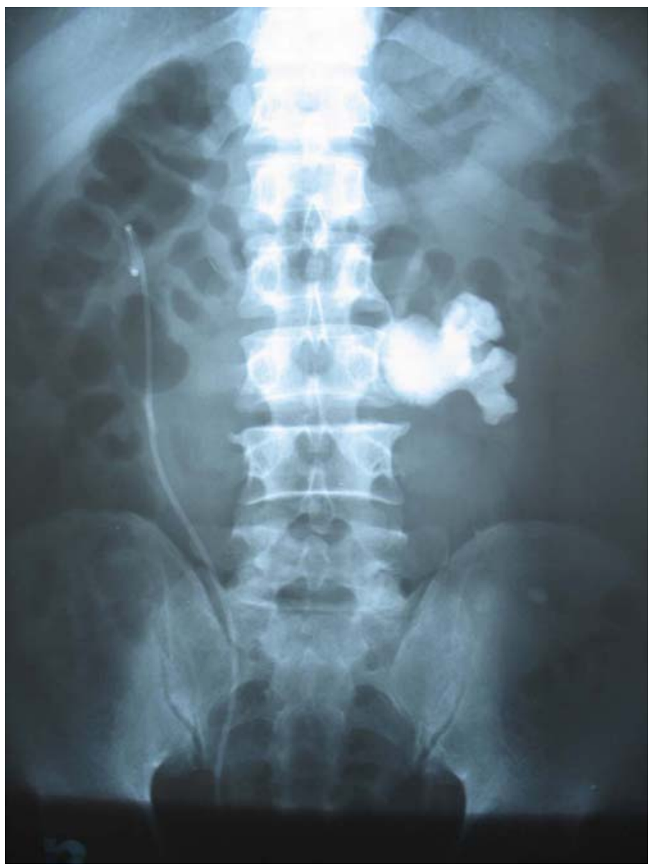

Fig. 3 Staghorn calculus (patient no. 6)

Fig. 4 Specimen after removal (patient no. 6)

exposure of the renal pelvis was achieved, a visor-shaped incision was made away from the UPJ and extending into the upper and lower pole infundibula as necessary. For larger stones adherent to the mucosa, a lower pole nephrotomy was made in addition to the pyelotomy. The collecting system was closed intracorporeally with running and interrupted suture after placement of an antegrade ureteral stent. A suction drain was also left in place through one of the port sites. Stones were placed into a bag and removed through the 12 mm periumbilical port site.

Results

All procedures were completed robotically without the need for conversion to laparoscopy or open surgery. Patient demographics and peri-operative data are shown in Table 1. The mean age (range) of the patients was 55.4 (30–72) years. Seven patients were female and five procedures were on the left side.

All patients were symptomatic prior to presentation with flank pain and/or hematuria. The average stone size was approximately 4.2 cm, with12 patients having a partial staghorn calculus, and one having a complete staghorn calculus occupying 100% of the collecting system. All stones were successfully removed prior to collecting system closure except the patient with a complete staghorn calculus. The average (range) blood loss was 100 cc (50–350).

Operative time varied depending on the complexity of the stones (Table 1). The mean (range) operative time from Veress needle placement to completion of skin closure was 158 (90–257) min. The mean (range) robotic console time was 108 (60–193) min.

There was no significant difference in suturing time for those patients with extension of pyelotomy into infundibula. All patients had complete stone removal on post-operative imaging except the patient with a complete staghorn calculus. No stones were lost in the peritoneal cavity. No patient required a post-operative transfusion or had fever. One patient developed a transient ileus lasting 48 h. No patient had persistent urine leak and suction drains were removed in all patients prior to discharge from hospital. Post-operative pain was minimal and most patients were ambulating and tolerating a diet on the same day as surgery.

Discussion

Surgical renal stone treatment has evolved from open surgery to several minimally invasive treatments including extracorporeal shockwave lithotripsy, ureteroscopy with energy ablation, and percutaneous stone removal. PCNL remains the treatment of choice for patient with large staghorn renal calculi. Many authors have studied the role laparoscopy in stone treatment with success. In 1993, Gluckman and associates performed the first successful laparoscopic excision of a calyceal diverticulum [8]. Soon to follow, Gaur et al. [9] explored the role of retroperitoneal laparoscopy and

Table 1 Patient demographics and operative times

Patient number	Age	Sex	Side	Extra-renal pelvis	Stone type	Op time (min)	Console time (min)
1	51	F	R	Yes	Partial staghorn	203	140
2	42	F	R	No	Partial staghorn	110	70
3	65	M	L	No	Partial staghorn	167	94
4	47	M	R	Yes	Partial staghorn	158	136
5	72	F	R	Yes	Partial staghorn	195	105
6	53	F	L	No	Partial staghorn	147	99
7	55	M	R	No	Partial staghorn	159	97
8	66	F	R	Yes	Partial staghorn	129	84
9	30	M	L	Yes	Full Staghorn	257	193
10	61	M	L	Yes	Partial staghorn	200	158
11	64	M	R	Yes	Partial staghorn	90	60
12	55	F	L	No	Partial staghorn	122	90
13	59	F	R	No	Partial staghorn	120	80
Average	55.4 years	54% (Female)	62% (Right)	54% (Yes)	92% (Partial staghorn)	158.2 min	108 min

pyelolithotomy. Many studies have shown good success with pyelolithotomy and concomitant UPJ repair. Ramakumar et al. [10] presented their series of pyelolithotomy and UPJ repair in 19 patients with 3 and 12-month stone free rates of 90 and 80%, respectively. Nambirajan et al. [7] presented laparoscopy as an alternative treatment modality of renal stones with or without concomitant UPJ repair. They concluded that laparoscopy is effective for renal stones and it allows adjunctive procedures. Atug et al. [11] presented their data on robotic-assisted laparoscopic pyeloplasty with 8 patients who also had renal pelvic calculi. Their mean operative time was 61.7 min longer for concomitant stone extraction, and had 100% stone free rates and no delayed complications with follow-up of 12.3 (4–22) months.

Most of the studies discussed to evaluate laparoscopy for stone surgery in patients with aberrant renal anatomy, i.e. concomitant UPJ obstruction, pelvic kidney, and those with calyceal diverticulum. Given the known advantages that the robotic system affords, including excellent visualization of tissues, magnification, three-dimensional view, and wristed movements of the arms, we felt that robotic stone surgery may extend a role to all patients with staghorn renal calculi, as a minimally invasive alternative to percutaneous techniques. The tremendous reconstructive capability using the daVinci system will allow watertight closure of the collecting system after stone removal. We found no urinary leaks post-operatively from the closed suction catheter after Foley catheter was removed in even the most extensive repairs involving upper pole infundibula and intrarenal dissection.

We performed all procedures through a trans-peritoneal approach. Traditionally, stone surgery has been performed retroperitoneal to avoid contamination of the peritoneum with infected urine. All of our patients received preoperative antibiotics, and drainage of urine was minimized with suction to avoid spillage during the procedures. We did not find any adverse sequelae as no patient had post-operative fever, prolonged ileus, or peritonitis. We therefore conclude that trans-peritoneal stone surgery is equally safe.

Approximately, half the patients had extra-renal pelvis, and the others were mostly intra-renal. The procedure is easier in patients with an extra renal pelvis. While exposing an intra-renal pelvis is more difficult, the magnification and wrested instruments allowed easier access than with open surgery. The main renal vein was our barrier to extending the incision into the upper pole calyces—this may be easier if the pelvis was approached from the posterior aspect—and in two patients with adherent stones, we performed a lower pole nephrotomy. We were able to remove all stones successfully in all but the patient who had a complete staghorn calculus. We did not clamp the renal artery, nor did we attempt anatrophic nephrolithotomy in any patient since we did not feel there was a satisfactory technique of renal cooling [12]. Therefore, at the current time, we do not recommend REP as the technique to treat full staghorn renal calculi.

We found this technique to be comparable to PCNL for treatment of complex partial staghorn calculi. During our workshop, the urologists at KLH performed a similar number of PCNL procedures. This study was not meant to be a head-to-head comparison between PCNL and REP, given the extensive experience KLH has in PCNL, and the fact that we were just developing the REP technique. We did find similar post-operative pain and operative times. We will need longer-term follow up to determine if there is infundibular stenosis or renal pelvic obstruction. Barring this outcome, we can conclude that REP is a safe and effective technique for renal stone surgery. REP and PCNL may be complementary techniques and a randomized study is necessary for a more accurate comparison of relative benefits.

Conclusion

Robotic extended pyelolithotomy appears to be a safe and effective minimally invasive treatment alternative to PCNL for some patients with staghorn calculi. In the absence of reliable techniques of laparoscopic renal cooling, patients with complete staghorn calculi are not suitable candidates for this approach.

References

1. Smith JA Jr, Herrell SD (2005) Robotic-assisted laparoscopic prostatectomy: do minimally invasive approaches offer significant advantages. J Clin Oncol 23:8170–8175
2. Menon M, Shrivastava A, Tewari A (2005) Laparoscopic radical prostatectomy: conventional and robotic. Urology 66:101–104
3. Palese MA, Munver R, Phillips CK et al (2005) Robot-assisted laparoscopic dismembered pyeloplasty. JSLS 9:252–257
4. Phillips CK, Taneja SS, Stifelman MD (2005) Robot-assisted laparoscopic partial nephrectomy: the NYU technique. J Endourol 19:441–445
5. Gettman MT, Neururer R, Bartsch G, Peschel R (2002) Anderson–Hynes dismembered pyeloplasty performed with the daVinci robotic system. Urology 60:509–513
6. Hemal AK, Goel A, Kumar M, Gupta NP (2001) Evaluation of laparoscopic retroperitoneal surgery in urinary stone disease. J Endourol 15:701–705
7. Nambirajan T, Jeschke S, Albqami N et al (2005) Role of laparoscopy in management of renal stones: single-center experience and review of literature. J Endourol 19:353
8. Gluckman GR, Stroller M, Irby P (1993) Laparoscopic pyelocaliceal diverticula ablation. J Endourol 7:315
9. Gaur DD, Agarwal DK, Purohit KC, Darshane AS (1994) Retroperitoneal laparoscopic pyelolithotomy. J Urol 151:927–929
10. Ramakumar S, Lancini V, Chan DY et al (2002) Laparoscopic pyeloplasty with concomitant pyelolithotomy. J Urol 167:1378–1380
11. Atug F, Castle EP, Burgess SV, Thomas R (2005) Concomitant management of renal calculi and pelvi-ureteric junction obstruction with robotic laparoscopic surgery. BJU Int 96:1365–1368
12. Kaouk JH, Gill IS Desai MM et al (2003) Laparoscopic anatrophic nephrolithotomy: feasibility study in chronic porcine model. J Urol 169:691–696