Laparoscopic heminephrectomy for duplex system: observed difference in outcomes between upper and lower pole resections

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Introduction: *Renal duplication is a relatively common congenital abnormality of the urinary tract, but symptomatic duplex kidney is a rare presentation in adults. Traditionally, the treatment of choice for poorly functioning moiety has been heminephrectomy. There is extensive literature detailing the outcomes of minimally invasive upper pole heminephrectomy, but comparatively little published regarding lower pole resection, especially in adult patients. We present a series of 13 patients who underwent minimally invasive heminephrectomy for duplex kidney.*

Materials and methods: *Over a 6 year period (2011-2017) 13 patients at a single center underwent laparoscopic heminephrectomy for symptomatic duplex kidney with a poorly functioning moiety. A retrospective review of case notes and imaging was undertaken.*

Results: *Eight and 5 patients underwent upper and lower pole heminephrectomies, respectively. Laparoscopic transperitoneal approach was utilized in all cases. Median length of stay was 2 days (range 1 to 16 days). In the upper pole cohort, one patient had a postoperative infection requiring IV antibiotics. In the lower pole cohort by contrast, there were three major complications (60%). Conversion to complete nephrectomy was necessary in one case; one patient had urinary leakage requiring selective embolization and one patient required a second operation to resect remnant calyces. Furthermore, two patients (40%) developed late recurrence of symptoms.*

Conclusions: *Symptomatic duplex kidney is a rare presentation in adults. In our experience, heminephrectomy for non-functioning renal unit is safe and reproducible in experienced hands with no major complications and resolution of symptoms in the majority of patients. We have, however, observed a higher complication rate in those undergoing resection of a lower pole moiety. Alternative management such as uretero-ureterostomy should be considered in these cases.*

Key Words: heminephrectomy, duplex collecting system, renal duplication

Introduction

Renal duplication or a duplex renal collecting system is a frequently occurring congenital abnormality of the urinary tract with an incidence of 0.8%.[1] It has been observed to affect females more commonly than males and is usually unilateral.[2] While mostly asymptomatic, ureteral duplication can be associated with clinically significant renal disease in up to 30% of patients with this condition, with symptomatic cases often a result of obstruction, vesicoureteral reflux or infection.[3] With advance in antenatal ultrasound, many cases of ureteral duplication with upper tract sequelae are now identified and managed early in life.[4] As such, symptomatic renal duplication is a relatively rare presentation in adult life, with the most frequent presenting complaints being recurrent urinary tract infection and loin pain.

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Management strategies for a symptomatic duplex system include both extirpative (i.e. hemi-nephrectomy) and reconstructive options, though heminephrectomy is often the treatment of choice in systems with a poorly functioning moiety. There has been widespread use of the minimally invasive technique since the first reported laparoscopic heminephrectomy in 1993.[5] While there is a wealth of evidence for the efficacy of this technique in the pediatric population with the publication of several large case series demonstrating good long term outcomes,[6,9] there has been comparatively little published in the adult population.

Furthermore, lower pole heminephrectomy is far less frequently performed. While a small number of case series exist in children specific to lower pole hemipherectomy,[9,10] our literature search has not identified any papers directly comparing the outcomes of upper and lower pole resections.

We present a series of 13 patients treated at a single United Kingdom tertiary referral center that underwent heminephrectomy over a 6 year period for symptomatic renal duplication presenting in adult life. We describe an observed difference in outcomes between resections of upper and lower pole moieties.

Materials and methods

Study population

A search was conducted of the operative database of a single center with retrospective review of patient case notes and imaging. A total of 13 patients were identified who underwent minimally-invasive heminephrectomy between September 2011 and May 2017 inclusive. All operations were performed by one consultant urologist. Analysis of outpatient clinic letters, operation notes, inpatient medical documentation and discharge letters was performed. Demographic information, presenting symptoms, length of stay, operative details, intraoperative and postoperative complications and outcome of long term follow up were recorded. We used only descriptive statistics, since the small number of cases does not allow meaningful statistical analysis.

All patients were evaluated preoperatively with DMSA nuclear medicine scan and cross-sectional imaging in the form of either CT urogram or MRI. One patient was further investigated with micturating cystourethrogram which confirmed the presence of Grade 4 reflux into a poorly functioning lower pole moiety.

Operative technique

The patient is placed in the lateral position, tilted 30 degrees, as for a laparoscopic nephrectomy. Transperitoneal access is gained and 3 to 5 ports are used, depending on the need for liver retraction and the risk of bleeding, which is higher for lower pole cases. The kidney and ureters are exposed. For upper pole heminephrectomy, the ureter is clipped and divided near the lower border of the kidney and dissected behind the hilum. The line of demarcation with the lower pole moiety is identified. The capsule is scored with a diathermy hook and any vessels supplying the upper pole are clipped and divided. The upper pole moiety is then resected, keeping in mind that the border with the lower pole is not straight in the axial plane but instead is more caudal on the posterior side. For lower pole heminephrectomy, the ureter is more easily dissected, but the amount of parenchyma to be resected tends to be larger. The number of vessels supplying the lower pole is greater and the collecting system is more extensive. We have adapted our technique to include injecting methylene blue through a Veress needle into the lower pole renal pelvis to help ensure that the entire collecting system is removed. In both upper and lower pole cases, the resulting defect in the kidney is closed over a bolster with V-lock sutures. In both upper and lower pole approaches, the ureteral stump is dissected down to the level of the pelvic brim. If preoperative vesicoureteral reflux has been identified, the ureter is oversewn. Otherwise, the ureter is left open after transection.

Results

Patient characteristics are summarized in Table 1. All patients were symptomatic at presentation. Complications and postoperative outcomes are shown in Table 2. There were no instances of open conversion or transfusions. Median length of stay overall was 2 days with a range of 1 to 16 days.

Upper pole results: 8 patients underwent upper pole resection. There were no major (Clavien-Dindo Grade 3+) complications. A single patient developed a febrile urinary tract infection postoperatively which was managed with IV antibiotics (Clavien-Dindo Grade 2). There was a complete resolution of symptoms in all patients.

Lower pole results: 5 patients underwent lower pole resection. There were three major complications. Complete nephrectomy was deemed necessary in one lower pole case intraoperatively due to difficult dissection and the finding of abnormally loculated perinephric fluid. This patient had a history of previous sport-related renal trauma. Further intervention was necessary in 2 patients (Clavien-Dindo Grade 3b). One patient had a persistent urine leak postoperatively and was readmitted; a retrograde of the upper pole ureter showed no leak and stenting unsurprisingly did not improve the leak. Selective embolization of a remnant lower pole calyx

TABLE 1. **Preoperative demographics of cohort, stratified by patients undergoing upper or lower pole heminephrectomy**

	Total 13	Upper 8 (61.5%)	Lower 5 (38.5%)
Patient demographics			
Male	2 (15.4%)	1 (12.5%)	1 (20%)
Female	11 (84.6%)	7 (87.5%)	4 (80%)
Mean age (range)	36.5 (16-60)	35.9 (16-59)	37.6 (16-60)
Median length of stay (range)	2 (1-16)	2 (1-7)	2 (1-16)
Presenting symptoms			
Recurrent UTI	9 (69.2%)	6 (75%)	3 (60%)
Loin pain	9 (69.2%)	5 (62.5%)	4 (80%)
Laterality			
Right	5 (38.5%)	3 (37.5%)	2 (40%)
Left	8 (61.5%)	5 (62.5%)	3 (60%)
Imaging findings			
Mean % function of affected side (range)	38.8 (24-53)	44.5 (39-53)	29.6 (24-45)
Mean % function of affected moiety (range)	5.5 (0-28)	3 (0-11)	10 (0-28)
Mean parenchymal thickness (mm) (range)	3.8 (1-14)	2.8 (1-8)	5.4 (2-14)

ultimately provided complete resolution. One patient had ongoing abdominal pain six months after lower pole resection and subsequently underwent a further surgery in the form of laparoscopic resection of a remnant lower pole calyx.

Successful, complete resolution of symptoms after one procedure occurred in none of the 4 patients who had the lower pole resected. 2 patients experienced a late recurrence of symptoms with further UTIs, which were of a lower severity than preoperatively. The patient who underwent selective embolization of remnant calyx has experienced episodes of abdominal pain postoperatively but no further cases of pyelonephritis or UTI. Imaging has shown no recurrence of a urine leak. The only patient who has ultimately become asymptomatic underwent a second operation to remove a remnant calyx.

In summary, all of the patients undergoing upper pole resection have had a successful and safe resolution of their symptoms after one procedure, while none in the lower pole group have.

Discussion

In our experience to date, when managing symptomatic renal duplication with laparoscopic heminephrectomy, we report excellent results with upper pole resection and very disappointing results in lower pole cases.

TABLE 2. **Complications, stratified by patients undergoing upper or lower pole heminephrectomy**

	Total	Upper	Lower
Intraoperative complications	1 (7.7%)	0	1 (20%)
Conversion to complete nephrectomy	1 (7.7%)	0	1 (20%)
Postoperative complications	3 (23.1%)	1 (12.5%)	2 (40%)
Remnant calyx - second operation	1 (7.7%)	0	1 (20%)
Remnant calyx - embolization	1 (7.7%)	0	1 (20%)
Urinary tract infection - antibiotics	1 (7.7%)	1 (12.5%)	0
Long term outcome			
Resolution of symptoms	10 (76.9%)	8 (100%)	2 (40%)
Abdominal pain	1 (7.7%)	0	1 (20%)
Ongoing urinary tract infections	2 (15.4%)	0	2 (40%)

TABLE 3. **Literature review – heminephrectomy for renal duplication in adult patients**

Primary author	Title	Journal	Year	Total resections	Upper pole	Lower pole
Wan[11]	Chylous leakage after retroperitoneoscopic upper pole heminephrectomy for duplex kidney	Zhong Nan Da Xue Xue Bao Yi Xue Ban	2012	39	39	0
Li[12]	Retroperitoneal laparoscopic upper pole nephroureterectomy for duplex kidney anomalies in adult patients	Urology	2011	32	32	0
Gao[13]	Transperitoneal laparoscopic heminephrectomy in duplex kidney: our initial experience	Urology	2011	18	15	3
Abedinzadeh[14]	Transperitoneal laparoscopic heminephrectomy in duplex kidneys: a one center experience	German Medical Science	2012	14	14	0
Dönmez[15]	Laparoscopic upper pole heminephrectomy in adults for treatment of duplex kidneys	Urology Journal	2015	10	10	0
Wang[16]	Laparoscopic upper pole heminephrectomy for ectopic ureter: initial experience	The Canadian Journal of Urology	2004	3	3	0

Comparison can be made between the upper and lower pole resection groups despite small numbers in each. We judge there to be little difference in patient demographic values between the groups. Length of stay was comparable. Our data is consistent with that of the published literature for minimally-invasive upper pole heminephrectomy in adults. A review of contemporary series reveals the vast majority of reported cases involve upper-pole resection, with only a handful of lower-pole heminephrectomies reported in the adult literature, see Table 3. Thus, approaches to the diseased lower-pole moiety are likely understudied in the adult population. Interestingly, within the pediatric population, upper pole heminephrectomy is associated with a higher risk of major complications, such as renal loss, as compared to lower pole hemiphrectomy.[6] However, given the delayed presentation in adults, comparisons to the pediatric literature may not be accurate and to date, no series directly compare adult and pediatric outcomes or complications with these approaches

The explanation for the discrepancy between upper and lower pole resection may lie in the relative size of the moieties, which makes lower pole resection a more extensive procedure. In two of our cases, a lower pole calyx adjacent to the line of resection was not removed at the time of the operation, leading to symptoms and the need for further intervention. Lower pole resection is technically more difficult due to the challenge of identifying and removing all lower pole tissue. Indeed, in our series, diseased lower pole moieties had higher mean percent function as

well as greater average parenchymal thickness than diseased upper pole moieties. Demarcation of upper/lower boundary, we have found, can be aided by the injection of methylene blue into the collecting system. Additional technologies have been reported utilizing intraoperative fluorescent technology instilled either intra-vascularly or via the collecting system in order to better delineate the upper and lower moeities.[17,18]

Alternatively, lower to upper pole uretero-ureterostomy could be considered as an alternative for lower pole resection. Uretero-ureterostomy relies on a healthy ipsilateral ureteral segment to which the diseased ureter can be anastomosed in an end to side fashion. For this reason, it is import to radiographically document that the recipient ureter is not compromised by obstruction or reflux. Location of the anastomosis, either proximal or distal, has been debated. While a proximal anastomosis has traditionally been utilized, in order to avoid the phenomenon of "yo-yo" reflux, recent data of more distal anastomoses have not suggested any complications with "yo-yo" reflux.[19,20] Reconstructive techniques (including both uretero-ureterostomy and more complete lower tract reconstruction with ureteral reimplantation) have classically been employed in cases where significant function still remains in the diseased renal moiety.[21] Recent data shows, however, that uretero-ureterostomy can be undertaken even in the case of poorly or non-functioning renal moieties.[22,23] While these studies are limited to children with non-functioning obstructed upper pole segments, they certainly raise a question as to the utility of removing poorly functioning remnants. Uretero-ureterostomy carries some risk of obstruction and injury to the healthy ipsilateral ureter, though has the benefit of sparing risk to the healthy ipsilateral renal unit itself.[24] As our experience shows a higher risk in lower pole heminephrectomy, the approach is especially attractive in cases where the risk of heminephrectomy is especially high.

In ureteral duplication, according to the Weigert-Meyer law, the upper pole segment is typically obstructed while the lower pole segment typically refluxes owing to a ureteral orifice positioned more cranio-laterally with a shorter intramural tunnel.[25] Thus when managing lower pole pathology from reflux, it is important to manage the distal ureteral segment accordingly. Many authors advocate oversewing the ureteral stump in order to prevent reflux into the abdomen following excision.[26,27] Concomitant ureteropelvic junction obstruction and ureteral duplication is estimated to be about 2%, with the lower pole most commonly involved.[28] In these cases, a pyeloureterostomy could be considered, anastomosing the lower pole pelvis to the upper pole ureter in order to bypass the obstruction, utilizing similar principles as the ureteroureterostomy.[29] Complications of the distal ureteral stump remnant have been reported in 5-10% of cases following upper tract management of duplicated systems.[10,26] One benefit of a laparoscopic or robotic-assisted approach, in addition to expedited convalescence, is visualization of the distal ureteral stump deep into the pelvis, allowing for a more complete resection of the stump.[24]

Limitations of this study: the significance of our observation is difficult to determine due to the small number of cases in the series. Furthermore, our results from a single surgeon, in a single center, may not be generalizable to a broader population. Symptomatic renal duplication is a rare presentation in the adult population, so even in a large regional urology center, very few heminephrectomies are performed for this indication. Additionally, postoperative outcome was determined through retrospective analysis of case notes and there was no objective measure used to determine symptoms.

Conclusion

From our series of 13 cases, we conclude that laparoscopic heminephrectomy for upper pole abnormalities is a safe and effective treatment for symptomatic renal duplication in adults. We did not encounter any major intraoperative complications and there were relatively few postoperative complications requiring further invasive management. We did, however, observe a difference in outcomes between those undergoing upper and lower pole resections. Patients undergoing lower pole resection had a comparatively higher complication rate; we attribute this to difficulty in achieving complete resection due to the larger volume of tissue. Consideration should be given to carrying out lower pole to upper pole uretero-ureterostomy as an alternative, especially in cases where there is a large lower pole moiety. □

References

1. Bauer SB, Perlmutter AD, Retik AB. Anomalies of the upper urinary tract. In: Campbell's Urology. Philadelphia: 1992 WB Saunders, pp1357–1442.
2. Decter RM. Renal duplication and fusion anomalies. *Pediatr Clin North Am* 1997;44(5):1323-1341.
3. Privett, J, Jeans W, Roylance J. The incidence and importance of renal duplication. *Clin Radiol* 1976;27(4):521-530.

4. Woodward M, Frank D. Postnatal management of antenatal hydronephrosis. *BJU* Int 2002;89(2):149-156.
5. Jordan GH, Winslow BH. Laparoendoscopic upper pole partial nephrectomy with ureterectomy. *J Urol* 1993;150(3): 940-943.
6. Jayram G, Roberts J, Hernandez A et al. Outcomes and fate of the remnant moiety following laparoscopic heminephrectomy for duplex kidney: a multicenter review. *J Pediatr Urol* 2011;7(3):272-275.
7. Esposito C, Escolino M, Castagnetti M et al. Retroperitoneal and laparoscopic heminephrectomy in duplex kidney in infants and children. *Transl Pediatr* 2016;5(4):245-250.
8. Sakellaris G, Kumara S, Cervellione RM et al. Outcome study of upper pole heminephrectomy in children. *Int Urol Nephrol* 2011;43(2):279-282.
9. Sakellaris G, Hennayake S, Cervellione RM et al. Outcome of lower pole heminephrectomy in children. *Scand J Urol Nephrol* 2009;43(6):482-485.
10. Caluwé D, Chertin B, Puri P. Long-term outcome of the retained ureteral stump after lower pole heminephrectomy in duplex kidneys. *Eur Urol* 2002;42(1):63-66.
11. Wan Y, Tang Z, Chen Z et al. Chylous leakage after retroperitoneoscopic upper-pole heminephrectomy for duplex kidney. *Zhong Nan Da Xue Xue Bao Yi Xue Ban* 2012;37(4):405-407.
12. Li HZ, Ma X, Zhang J et al. Retroperitoneal laparoscopic upper-pole nephroureterectomy for duplex kidney anomalies in adult patients. *Urology* 2011;77(5):1122-1125.
13. Goa Z, Wu J, Lin C et al. Transperitoneal laparoscopic heminephrectomy in duplex kidney: our initial experience. *Urology* 2011;77(1);231-236.
14. Abedinzadeh M, Nouralizadeh A, Radfar MH et al. Transperitoneal laparoscopic heminephrectomy in duplex kidneys: a one centre experience. *Ger Med Sci* 2012;10.
15. Donmez MI, Yazici MS, Abat D et al. Laparoscopic upper pole heminephrectomy in adults for treatment of duplex kidneys. *Urol J* 2015;29;12(2):2074-2077.
16. Wang DS, Bird VG, Cooper CS et al. Laparoscopic upper pole heminephrectomy for ectopic ureter: initial experience. *Can J Urol* 2004;11(1):2141-2145.
17. Lee Z, Packer M, Dean G et al. Paediatric robot-assisted lower pole heminephrectomy with intraureteral indocyanine green in a duplicated collecting system not following Weigert-Meyer law. *J Uro*l 2017;197(4):825.
18. Herz D, DaJusta D, Ching C et al. Segmental arterial mapping during pediatric robot-assisted laparoscopic heminephrectomy: A descriptive series. *J Pediatr Urol* 2016;12(4):266.
19. Husmann DA, Ewalt D, Glenski W, Bernier P. Ureterocele associated with ureteral duplication and a nonfunctioning upper pole segment: management by partial nephroureterectomy alone. *J Urol* 1995;154(2 Pt 2):723-726.
20. Chacko JK, Koyle MA, Mingin GC et al. Ipsilateral ureteroureterostomy in the surgical management of the severely dilated ureter in ureteral duplication. *J Urol* 2007;178 (4 Pt 2):1689-1692.
21. Lashley DB, McAleer IM, Kaplan JW. Ipsilateral ureteroureterostomy for the treatment of vesicoureteral reflux or obstruction associated with complete ureteral duplication. *J Urol* 2001;165(2):552-554.
22. Gran CD, Kropp BP, Cheng EY et al. Primary lower urinary tract reconstruction for nonfunctioning renal moieties associated with obstructing ureteroceles. *J Urol* 2005;173(1):198-201.
23. Snow GDCY, Dias E, Maizels M et al. Lower Urinary Tract Reconstruciton of Duplicated Obstructive Systems: Is Pre-operative Renal Scan Necessary? In: Society of Pediatric Urology Fall Congress. Dallas, TX, 2016.
24. Ellison JS. Robot-assisted ureteroureterostomy in pediatric patients: current perspectives. 2018. Manuscript submitted for publication.
25. Meyer R. Normal and abnormal development of the ureter in the human embryo: a mechanistic consideration. *The Anatomical Record* 1946;96(4):355-371.
26. Plaire JC, Pope JC, Kropp BP et al. Management of ectopic ureters: experience with the upper tract approach. *J Urol* 1997; 158(3 Pt 2):1245-1247.
27. Belman AB, Filmer RB, King LR. Surgical management of duplication of the collecting system. *J Urol* 1974;112(3):316-321.
28. Gonzalez F, Canning DA, Hyun G et al. Lower pole pelvi-ureteric junction obstruction in duplicated collecting systems. *BJU Int* 2006;97(1):161-165.
29. Lima M, Maffi M, Di Salvo N et al. Robot-assisted pyeloureterostomy in bifid renal pelvis with ureteropelvic junction obstruction of the lower moiety. *Urology Case Reports* 2017;10(1):23-25.