Title

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Journal

Journal of Urology, 194(3)

ISSN

0022-5347

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Publication Date

2015-09-01

DOI

10.1016/j.juro.2015.03.089

Peer reviewed

Laparoscopic Nephrectomy with Autotransplantation: Safety, Efficacy and Long-Term Durability

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Abbreviations and Acronyms

CIS = carcinoma in situ

LNA = laparoscopic nephrectomy with autotransplantation

Accepted for publication March 11, 2015.

Study received institutional review board approval.

* Equal study contribution.

† Financial interest and/or other relationship with Bard Medical and Boston Scientific.

Purpose: Laparoscopic nephrectomy with autotransplantation is a viable option when renal preservation is required or ureteral reconstruction is impossible. In this study we report on our long-term experience with laparoscopic nephrectomy with autotransplantation.

Materials and Methods: A retrospective review of data from all patients who underwent laparoscopic nephrectomy with autotransplantation since 2000 revealed data for 52 of 59 patients after study exclusions. Indications for laparoscopic nephrectomy with autotransplantation included ureteral stricture disease (41), renal malignancy (7), ptotic kidney (1), chronic flank pain (1), renal artery aneurysm (1) and renovascular hypertension (1). Followup included ultrasonography, nuclear renography and computerized tomography. Complications analyzed were Clavien-Dindo grade III or higher.

Results: A total of 52 patients (30 women, 57.6%) underwent laparoscopic nephrectomy with autotransplantation at a median age of 48 years (range 12 to 76). At a median followup of 73.5 months 47 patients (90.3%) had long-term function of the autotransplanted renal unit including 3 of 4 (75%) solitary kidneys. There were 5 patients (9.7%) who experienced renal unit failure at a median of 15 months. Of these patients 3 required nephrectomy of autotransplant unit secondary to renal vein thrombosis (1 day), pseudoaneurysm (15 months) and chronic pain (48 months). Overall 4 patients had early complications and 8 had late complications. In the tumor group 4 patients had disease progression and all are alive.

Conclusions: Laparoscopic nephrectomy with autotransplantation is an excellent long-term surgical option (greater than 90% success rate with longer than 6-year median followup) for complex ureteral and renal conditions that necessitate preservation of renal parenchyma. However, tumor progression is possible after ex vivo tumor excision. Therefore, careful patient selection and followup are mandatory. This report supports the safety, efficacy and durability of laparoscopic nephrectomy with autotransplantation in experienced hands.

Key Words: kidney transplantation; laparoscopy; transplantation, autologous

Laparoscopic nephrectomy with autotransplantation has been shown to be an effective surgical option for complex renal conditions. The surgical technique has been described previously.[1] It has been successfully used in the management of complex kidney pathology such as extensive

0022-5347/15/1943-0738/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2015.03.089
Vol. 194, 738-743, September 2015
Printed in U.S.A.

ureteral injuries, renal artery aneurysms, renovascular hypertension, difficult centrally located renal tumors and chronic flank pain.[2,3] It also serves as an alternative to immediate nephrectomy and dialysis for patients with preexisting renal failure or a solitary kidney.[4,5] For complex renal tumors and vascular anomalies, ex vivo repair offers the advantages of open surgical reconstruction.

Urinary reconstruction for complex ureteral strictures is difficult and long-term options are limited.[6,7] The use of bowel interposition, often with terminal ileum, has significantly improved, but violates the gastrointestinal tract with associated short and long-term complications. Longitudinal studies have shown that complications of bowel interposition include mucus plugs causing calculi and urinary tract infections, strictures of the anastomosis, fistulas, small bowel obstructions and metabolic acidosis.[8,9] In addition to preserving the kidney parenchyma, LNA offers an advantageous and versatile surgical option compared to bowel interposition because it does not violate the gastrointestinal tract. Until recently several groups have reported feasibility and acceptable short-term outcomes but long-term outcomes and data on complications were lacking.[10,11] In this study we describe the long-term safety, efficacy and durability of LNA at our institution.

MATERIALS AND METHODS

Institutional review board approval was obtained for this retrospective study of all patients who underwent LNA between July 2000 and October 2014. A retrospective review of medical records was performed to ascertain demographic information, indications for LNA, followup length, complications and long-term outcomes. All patients underwent LNA by the same multidisciplinary team of urological, transplant and/or vascular surgeons. Patients who had undergone open or aborted procedures were excluded from analysis. No patients were lost to followup. Followup imaging was done using diuretic nuclear renography (40 patients), ultrasonography with color Doppler (10 patients) and computerized tomography (2 patients). The renal unit was defined as operational if evidence of function was demonstrated in any/combination of imaging modality. The renal unit was considered functional if good corticomedullary differentiation was appreciated and resistive indices were 0.67 or less on followup ultrasonography.[12] The patients with renal tumors were under surveillance according to accepted guidelines.[13] Major complications were defined as Clavien-Dindo grade III or higher, and early and late complications were defined as those occurring within 30 and after 30 days, respectively.

RESULTS

A total of 59 patients underwent attempted nephrectomy and autotransplantation. Five patients were excluded from the study because they underwent open nephrectomy with autotransplantation for tumors (4) and stricture (1). The remaining 2 procedures were aborted because 1 patient had 7 renal arteries, which precluded transplantation, and the other had occult widespread peritoneal carcinomatosis discovered during surgery. After excluding open and aborted procedures, we included 52 patients who underwent successful LNA with a median followup of 73.5 months (range 1 to 170) and followup until December 2014 (table 1). Median hospital stay was 6 days (range 4 to 14). The majority of patients (47, 90%) retained long-term function of the autotransplanted renal unit at last followup. Four autotransplanted units were solitary kidneys, of which 3 (75%) had preserved function at last followup (table 2). Including autotransplant renal losses 8 patients (15%) sustained 10 major complications, with 4 (8%) and 6 (12%) occurring early and late, respectively (table 3). There were no Clavien-Dindo grade IV or V complications and no deaths were directly attributed to LNA. Five patients (10%) had autotransplanted renal losses at a median of 15 months, 4 of whom required autotransplant nephrectomy (table 2). Eight patients underwent LNA for renal tumors, of whom 4 (50%) had disease recurrence/progression, and 1 patient died of recurrent disease.

Ureteral Stricture Group

The majority of patients underwent LNA for complex ureteral strictures (tables 1 and 4). Most were due to iatrogenic injuries during the surgical management of various diseases. The majority occurred during surgery for nephrolithiasis, with others from ureteral injuries from colorectal, obstetric and gynecologic procedures. Median ureteral stricture length was 4 cm (range 1 to 7). There were 11 patients with evidence of urinary calculi necessitating perioperative management. In this group 3 patients underwent subsequent autotransplant nephrectomy (table 2). Of these patients 2 experienced chronic pain. One patient had persistent pain at the site of the autotransplantation and demanded extirpation of the normally functioning autotransplanted renal unit. Another patient had chronic pain 8 months after LNA at the site of the autotransplantation. This patient currently has preserved function of the transplanted unit without obstruction and is treated by a pain specialist team.

Renal Tumor Group

Most patients (7 of 8) underwent LNA for highly complex centrally located renal tumors, 4 in a solitary kidney. One patient had a solitary kidney, and had urothelial CIS of the renal pelvis with ex vivo excision and autotransplantation. Although

Table 1. Patient demographics

	Ureteral Stricture	Tumor (7/8 central)	Renal Artery Stenosis	Chronic Flank Pain	Ptotic Kidney	Renal Artery Aneurysm
No. pts	40	8	1	1	1	1
No. solitary kidney(s)	1	3	0	0	0	0
Median age (range)	48.6 (25e 70)	53.9 (29e 76)	12	63	35	51
No. M/F	18/22	3/5	0/1	1/0	0/1	0/1
No. lt/rt tumors	22/18	4/4	1/0	0/1	0/1	0/1
No. ASA® score:						
1	12	1	0	0	0	0
2	19	4	1	0	1	1
3	9	3	0	1	0	0
Median mg/dl baseline creatinine (range)	1.0 (0.5e 2.4)	1.9 (1.5e 3.7)	1.0	0.9	0.6	0.6
Median mos followup (range)	63 (1e 169)	101 (53e 160)	102	22	15	61

all patients had negative surgical margins at ex vivo tumor excision, 4 (50%) experienced recurrence, including the patient with CIS, and with renal function preserved in 2 of the patients with recurrence (table 5). The single death in this group was the patient with urothelial CIS, who died after tumor progression 2 years after LNA.

Single Conditions

For refractory cases of renal vascular hypertension secondary to renal artery stenosis, abnormally positioned ptotic kidney, chronic flank pain and a renal artery aneurysm, LNA and ex vivo reconstruction (when applicable) were performed successfully. At last followup all patients had resolution of presenting complaints and maintained function of autotransplanted renal units (table 1).

DISCUSSION

Autotransplantation is generally reserved for serious situations and it often remains the final option before nephrectomy. Previous reports have suggested LNA is an excellent long-term surgical option for complex ureteral pathology and severe renal disorder that necessitates preserving renal parenchyma.[2,7,10,14] To our knowledge this report represents the most robust data of the long-term safety, efficacy and durability of LNA. Our long-term (greater than 6-year median followup) experience validates the efficacy (greater than 90% preserved renal unit function) with acceptable (12%) late major complications. Although a major undertaking with significant collaborations by multidisciplinary teams, at experienced centers with appropriate expertise and proficiency LNA is safe and feasible with acceptable short and long-term morbidity. The majority of patients retained function of the autotransplanted renal unit on last followup, with a 94% success rate if only counting benign cases. Including patients who experienced loss of the autotransplanted renal unit, 8% and 12% experienced early and late major complications, respectively. Complications seen with LNA are generally limited to the urinary tract and transplantation site.[14e16] There were no acute surgical deaths associated with LNA. Although there were no grade IV or V complications, 3 of 52 patients in our cohort experienced vascular complications. One patient had a pseudoaneurysm that was repaired using endovascular techniques, another needed graft removal due to negligible residual function in the unit and 1 patient had a renal vein thrombus immediately after transplantation necessitating nephrectomy. Although uncommon, vascular complications can cause serious morbidity, thus warranting a thorough preoperative discussion with patients.

With a median followup of more than 6 years and some with more than 10 years of followup, LNA is a durable surgical option for severe renal conditions. Other investigators have reported similar outcomes of LNA in experienced hands but these involve short-term followup and low patient numbers.[10,11] Five autotransplanted renal units failed, necessitating graft nephrectomy in 4, of which 2 were due to tumor progression. Of the 5 cases that required nephrectomy due to vascular complications 1 was due to chronic pain (ureteral stricture group) and 1 in the tumor group had local recurrence after nephron sparing surgery.

Table 2. Renal loss (functional and anatomical)

Event	Group	Time to Event	Treatment	Solitary Kidney
Renal vein thrombosis	Stricture	1 Day	Autotransplant nephrectomy	No
Pseudoaneurysm	Stricture	15 Mos	Autotransplant nephrectomy	No
Chronic renal insufficiency	Tumor	1 Yr	Hemodialysis	Yes
Recurrent tumor	Tumor	2 Yrs	Autotransplant nephrectomy	No
Chronic pain	Stricture	4 Yrs	Autotransplant nephrectomy	No

Table 3. Complications (including renal loss)

Major Complication	Grade	Group	Time to Event	Treatment	Renal Loss
Renal vein thrombosis	III-b	Stricture	1 Day	Autotransplant nephrectomy	Yes
Broken drain	III-b	Stricture	5 Days	Extraction with pt under anesthesia	No
Urinoma	III-a	Stricture	13 Days	Nephrostomy tube + drain	No
Incisional hernia	III-b	Aneurysm	29 Days	Hernia repair	No
Anastomotic stricture	III-b	Stricture	6 Mos	Chronic ureteral stent	No
Pseudoaneurysm	III-b	Stricture	3 Yrs	Endovascular graft	No
Pseudoaneurysm	III-b	Stricture	15 Mos	Autotransplant nephrectomy	Yes
Chronic renal insufficiency	Not applicable	Tumor	1 Yr	Hemodialysis	Yes
Recurrent tumor	Not applicable	Tumor	2 Yrs	Autotransplant nephrectomy	Yes
Chronic pain	III-b	Stricture	4 Yrs	Autotransplant nephrectomy	Yes

Pain after renal autotransplantation or allotransplantation deserves special mention. In a study of 1,000 patients who underwent kidney transplantation 14.6% had continued opioid analgesic use at 1 year from transplantation.[17] Our practice involves a multidisciplinary approach with expertise from pain management, neurologists and anesthesiologists to effectively address chronic pain after autotransplantation. Despite this practice 1 patient demanded that the properly functioning autotransplanted unit be removed due to chronic pain. Finally, although LNA was performed successfully for pain in 1 patient, other treatment options may offer renal denervation without autotransplantation.[18]

It is generally believed that patients with renal masses treated with radical nephrectomy have a higher prevalence of chronic kidney disease than those treated with partial nephrectomy or radio frequency/cryoablation.[19] Many patients in the tumor group had preexisting chronic kidney disease (median baseline creatinine 1.9 mg/dl) or a solitary kidney, necessitating a nephron sparing approach to avoid dialysis, an option considered undesirable by many patients and practitioners. Furthermore, all tumors except the urothelial CIS were large, complex and centrally located, making them unfit for traditional nephron sparing approaches. Of patients who underwent nephron sparing surgery with ex vivo excision and repair 50% had recurrence at a median of 4 years after LNA. Although negative surgical margins were achieved in all excised tumors, recurrence rates were considerable due to the aggression of centrally located tumors, which are more likely to recur than peripheral tumors.[20,21]

Table 4. Ureteral stricture group characteristics

	No. Cases
Etiology:	
Iatrogenic injury	33
Previous repair (pyeloplasty, tumor excision)	6
Ureteropelvic junction obstruction (congenital)	1
Location:	
Proximal	20
Middle	7
Distal	1

The single patient with a large renal pelvic urothelial CIS had recurrence 2 years after LNA. Radical nephroureterectomy was strongly recommended for optimal oncologic control but LNA was performed at the patient's insistence after exhaustive discussion regarding the risk of oncologic progression and recurrence in the hope of temporarily avoiding dialysis.

Nevertheless, LNA can offer durable treatment with ex vivo nephron sparing surgery for carefully selected patients to treat traditionally inoperable masses destined for radical nephrectomy. Indeed, while ex vivo partial nephrectomy during LNA is feasible, it is important to note that extensive excision can lead to poor graft function in 14% to 21% of grafts after autotransplantation.[22] The amount of parenchyma preserved is critical to the residual function of the remaining renal unit. However, for most of the patients in the tumor group, and especially those with solitary kidneys, LNA offered a moderately durable option to delay dialysis. Nevertheless, lifelong followup is critical in these patients.

Bowel substitution with ileum has been used for the management of long ureteral strictures. Armatys et al recently reported stable or improved renal function in 74.7% in a series of 91 patients who underwent bowel substitution for long ureteral strictures,[8] matching the results of Boxer et al from 1979.[23] Other series have small numbers and short followup.[24] Although successful in most, bowel substitution can be limited by complications resulting from the violation of the gastrointestinal tract and can be catastrophic.[25]

Using ileum as a urinary conduit from the kidney to the bladder can result in mucus plugging, metabolic derangements, chronic stones, infections and, rarely, malignancy.[24] Harvesting bowel necessitates restoring bowel continuity, which exposes the patient to the risks of strictures at the bowel anastomosis, and small bowel obstructions.[25] The problems with bowel interposition are widely known. Recent work to mitigate metabolic derangements and mucus production includes a report on the use of reconfigured intestines as an onlay flap on a preserved ureter, which minimizes necessary bowel length.[26]

Table 5. Tumor group recurrences

	Pt No. 1	Pt No. 2	Pt No. 3	Pt No. 4
Final pathology	Renal cell carcinoma, clear cell, grade 2	Urothelial (CIS)	Renal cell carcinoma, clear cell, grade 2	Renal cell carcinoma, chromophobe, grade 2
Solitary kidney	Yes	Yes	No	No
Time to recurrence	6 Mos + again 6 yrs	2 Yrs	6 Yrs	11 Mos
Location of recurrence	Old renal hilum, adrenal, subsequent pulmonary, lymphatic, liver, bilat femurs	Local (renal pelvis with obstruction)	Local (kidney)	Metachronous (contralat kidney)
Management	Immunotherapy + tyrosine kinase inhibitors, metastasectomy	Chemotherapy/dialysis	Nephrectomy	Cryoablation
Renal outcome	Preserved function	Functional failure	Nephrectomy	Preserved function

Continued advancement and use of bowel interposition may become more feasible with the use of intracorporeal/robotic procedures. However, the complications stem from the core of the procedure, that is, the use of bowel and the violation of the alimentary system.[27,28] In patients with recurrent nephrolithiasis the more efficient urinary drainage provided after LNA due to shorter or absent ureteral length may prevent urinary stasis and stone formation. The shorter/absent ureteral length also facilitates retrograde renoscopy. Although bowel interposition to replace a diseased ureter may provide free passage of stones, infections and bowel obstruction can complicate such repairs. Furthermore, LNA can be used in complex renal conditions other than complex upper urinary tract strictures, making it a more versatile technique.

Strengths of our study include adequate followup in all patients who underwent LNA during the previous 15 years. No patients were lost to followup. Our study represents the largest cohort with the longest followup in the literature reporting LNA. However, our study has limitations. It is a single tertiary care center experience with vast resources and experiences in urological, transplant and vascular surgery. A multidisciplinary approach with a knowledgeable and experienced team is necessary to the success of LNA. Therefore, this may not be reproducible in community hospitals or some academic institutions.

In addition, the imaging followup was not standardized, so interobserver and intermodality variability may exist in determining renal unit function. Although nuclear renography was used in determining renal function after LNA in most patients, we used ultrasonography and computerized tomography in the remaining patients. Ultrasonography has been used in renal transplantation to follow long-term graft function,[12] and although studies have demonstrated that in native kidneys renal volume measured on computerized tomography is a reasonable surrogate for function, it has not been studied in post-transplant situations.[29] Finally, this study is a retrospective, descriptive report that has its biases. A randomized trial comparing LNA with another approach such as bowel interposition is needed to ascertain the variances in benefits and risks associated with these procedures.

LNA should be used in carefully selected patients in whom in situ urinary tract reconstruction (ureteral or vascular) is difficult or impossible, and in those for whom severe renal disease necessitates heroic measures to preserve renal parenchyma. Chronic flank pain may be managed with conservative measures before considering LNA. Tumor progression and even death are possible after ex vivo tumor excision, especially in patients requiring heroic measures to avoid or delay dialysis. Therefore, LNA should only be used in the most serious situations. Careful patient selection and vigilant followup are paramount.

CONCLUSIONS

LNA is an excellent long-term surgical option (greater than 90% success with longer than 6-year median followup and acceptable morbidity) for complex pathology. It affords treatment without violating the gastrointestinal tract and, thus, avoids associated anatomical, functional and metabolic consequences. Our collaborative multidisciplinary approach has been critical for long-term success, and this report supports the safety, efficacy and durability of LNA in experienced hands.

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