Identifying unrecognized collecting system entry and the integrity of repair during open partial nephrectomy: comparison of two techniques

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ABSTRACT

Purpose: To compare retrograde dye injection through an externalized ureteral catheter with direct needle injection of dye into proximal ureter for identification of unrecognized collecting system disruption and integrity of subsequent repair during open partial nephrectomy.

Materials and Methods: We retrospectively reviewed the records of 259 consecutive patients who underwent open partial nephrectomy. Externalized ureteral catheters were placed preoperatively in 110 patients (Group 1); needle injection of methylene blue directly into proximal ureter was used in 120 patients (Group 2). No assessment of the collecting system was performed in 29 patients (Group 3). We compared intraoperative parameters, tumor characteristics, collecting system entry and incidence of urine leaks among the three groups.

Results: The mean tumor diameter was 3.1cm in Group 1, 3.6cm in Group 2, and 3.8 cm in Group 3 (p = 0.04); mean EBL 320cc, 351 cc and 376cc (p = 0.5); mean operative time 193.5 minutes, 221 minutes and 290 minutes (p < 0.001). Collecting system entry was recognized in 63%, 76% and 38% of cases in Groups 1, 2 and 3 respectively. (p = 0.07). Postoperative urine leaks requiring some form of management occurred in 11 patients from group 1 and 6 from group 2. (p = 0.2). No patient in Group 3 developed a urinary leak.

Conclusions: Identification of unrecognized collecting system disruption as well as postoperative urine leak rate in patients undergoing partial nephrectomy were not influenced by the intraoperative technique of identifying unrecognized collecting system entry. Postoperative urine leaks are uncommon despite recognized collecting system disruption in the majority of patients.

INTRODUCTION

Nephron sparing surgery has become the standard of care for most small enhancing renal masses. Increasing experience has led to more patients with complex tumors being offered partial nephrectomy at most centers. The resection of large or centrally located tumors often entails entry into the collecting system in order to ensure an adequate surgical margin. It is important to recognize collecting system entry and to ensure precise closure to prevent the development of a postoperative urinary fistula.

A urinary leak is a reported complication following partial nephrectomy (1). In most cases, collecting system entry is recognized during tumor resection. However, there are different techniques used to identify unrecognized collecting system disruption. Some surgeons advocate placement of an externalized ureteral catheter with retrograde diluted methylene blue injection to confirm collecting system entry and/or to test the integrity of the subsequent repair whereas others use needle injection of methylene blue or another agent directly into the proximal ureter (2,3). Sometimes collecting system disruption is recognized and repair undertaken without retrograde assessment.

The aim of this study was to compare the two techniques with regard to detecting unrecognized collecting system entry and the integrity of subsequent repair, and to determine whether there was any difference in the development of urinary leak based on the technique used.

MATERIALS AND METHODS

This was a retrospective study involving 259 consecutive patients who underwent open partial nephrectomy from 2005 to 2010. Patients undergoing laparoscopic or robotic assisted partial nephrectomy were excluded. With approval from our Institutional Review Board, we reviewed the medical records of these 259 patients. Individual patient informed consent was not required for the study given the retrospective design and the review of existing patient data and clinical records.

Patients were divided into three groups according to the method of assessing the collecting system. Group 1 consisted of 110 patients with externalized ureteral catheters placed preoperatively and Group 2 included 120 patients in whom diluted methylene blue was directly injected into the proximal ureter through a 25-gauge needle. No assessment of collecting system integrity was performed in 29 patients (Group 3). All surgeries in Group 1 were performed by a single surgeon and all surgeries in Group 2 by another individual surgeon. The surgeries in Group 3 were performed by either one of these two surgeons.

Preoperative data elements included demographic information, tumor diameter and ne-phrometry scores (4). Intraoperative data elements included EBL, warm and cold ischemia times, clamp time, operative time and recognized entry into the collecting system. Postoperative variables included hospital stay, histology, and incidence of urinary leaks. A leak was defined as persistent drain output with chemical analysis of drain fluid creatinine consistent with urinary leak more than 2 days following partial nephrectomy.

Operative Technique

An extraperitoneal flank approach or very rarely a transperitoneal approach was used depending on the location of the tumor. The operative steps included exposure of the kidney, intraoperative sonography to better characterize tumor location or tumor margins (if required), vascular control either en bloc or individually and tumor excision. The renal vasculature was clamped in the majority of patients in each group. Intravenous mannitol was administered prior to renal artery occlusion to promote diuresis. Regional hypothermia with ice-slush was utilized in selected cases where prolonged duration (greater than 30 minutes) of vascular clamping was anticipated due to complexity of the tumor.

Technique of identifying unrecognized collecting system entry and integrity of repair

For Group 1 patients, a 5 French open-ended ureteral catheter was cystoscopically inserted into the renal pelvis preoperatively. A syringe filled with diluted methylene blue was attached to the ureteral catheter in preparation for retrograde injection. Following tumor resection, the methylene blue was injected to aid in detecting collecting system entry (if not identified during tumor resection) and the integrity of repair. In Group 2, the ureter was identified, dissected and encircled with a vessel loop. Immediately prior to tumor resection, the ureter was temporarily occluded by encircling it twice with the loop. Following tumor resection, if collecting system entry was not already identified, diluted methylene blue was injected into the ureter with 25 Gauge needle to detect entry if there was suspicion or risk for collecting system breach and/or to assess subsequent repair. If collecting system entry was recognized, methylene blue was injected only to test integrity of

repair. Collecting system repair in all groups was accomplished using 3-0 or 4-0 absorbable sutures. Approximation of renal parenchyma was performed using absorbable sutures and combined with Gelfoam-Surgicel bolsters for additional parenchymal compression. FloSeal® was used routinely in all groups for hemostasis. Sealant use was carefully documented. A perinephric drain was placed routinely in all patients except for three patients in Group 2 and three patients in Group 3.

Statistical analysis

Descriptive and analytical statistics were applied for summarizing the study results. Data were analyzed using chi-squared test for categorical data, Student's t-test for parametric variables and the Kruskal-Wallis test of ANOVA for non-pa-

rametric continuous variables. A p value < 0.05 was considered to be significant.

RESULTS

Baseline characteristics of the patients and operative outcomes are shown in Tables 1 and 2. The mean age was similar among the three groups. The mean tumor diameter was 3.1cm in Group 1, 3.6cm in Group 2 and 3.8cm in Group 3 (p = 0.04, significant between Groups 1 and 2). There was no significant difference between the mean preoperative serum creatinine (1.06, 1.15 and 1.13mg/dl respectively, p = 0.6). The majority of the lesions in all three groups (85%, 79%, and 75% respectively) were malignant histological subtypes. The mean nephrometry

Table 1 - Patient characteristics.

	Group 1	Group 2	Group 3	p value
Mean age, yrs, (range)	61 (31-84)	62.5 (28-85)	65.5 (45-85)	
Mean tumor size, cm, (range)	3.1 (0.8-8)	3.6 (1-10.5)	3.8 (0.7-11)	0.04[†]
Sex				
Male	69 (63%)	80 (67%)	18 (62%)	
Female	41 (27%)	40 (33%)	11 (28%)	
Histology				
Clear cell RCC	72 (65%)	73 (61%)	16 (55%)	
Papillary RCC	13 (12%)	18 (15%)	5 (17%)	
Chromophobe RCC	9 (8%)	4 (3%)	1 (3%)	
Oncocytoma	9 (8%)	11 (9%)	1 (3%)	
AML	3 (3%)	2 (2%)	3 (11%)	
Other	4 (4%)	12 (10%)	3 (11%)	
Sealant Use	98 (89%)	59 (49%)	16 (55%)	< 0.001[†,§]
Mean S.Creatinine, mg/dL (range)				
Preoperative	1.06 (0.6-3.30)	1.15 (0.6-5.2)	1.13 (0.6-3.5)	0.6
Postoperative	1.27 (0.6-5.4)	1.34 (0.6-5.4)	1.29 (0.7-4.8)	0.8
Nephrometry score, mean, (range)	7.1 (4-10)	7.9 (4-12)	6.5 (4-9)	< 0.001[†,‡]
Low complex (< 7)	35%	17%	56%	
Medium complex(7-9)	56%	67%	44%	
High complex (≥ 10-12)	9%	16%	0%	

[†] = p significant between Groups 1 and 2; [‡] = p significant between Groups 2 and 3; [§] = p significant between Groups 1 and 3.
Group 1 = assessment via externalized ureteral stent; **Group 2 =** assessment via direct needle injection into proximal ureter; **Group 3 =** no assessment of collecting system integrity. **RCC =** renal cell carcinoma. **AML =** angiomyolipoma.

Table 2 - Operative outcomes.

	Group 1	Group 2	Group 3	p value
Mean EBL, (mL) (range)	320 (25-1400)	351 (50-1700)	376 (20-1200)	0.5
Mean OR Time, minutes, (range)	193.5 (103-398)	221 (91-585)	290 (107-495)	< 0.001[†,‡,§]
Median Hospital Stay, days, (range)	5 (3-10)	5 (5-17)	5 (1-9)	
Mean WIT, minutes	n = 96	n=93	n = 17	
(range)	19.6 (5-45)	27 (10-45)	22.5 (12-44)	0.001[‡,§]
Mean CIT, minutes	n = 2	n = 21	n=7	0.2
(range)	40 (25-45)	66 (31-114)	56(38-90)	

[†] **=** p significant between Groups 1 and 2; [‡] **=** p significant between Groups 2 and 3; [§] **=** p significant between Groups 1 and 3. **Group 1 =** assessment via externalized ureteral stent; **Group 2 =** assessment via direct needle injection into proximal ureter; **Group 3 =** no assessment of collecting system integrity. **EBL =** estimated blood loss. **WIT =** warm ischemic time. **CIT =** cold ischemic time.

scores for Groups 1, 2 and 3 were 7.1 (range 4-10), 7.9 (range 4-12) and 6.5 (range 4-9) respectively (p < 0.05, significant between Groups 1 and 2 and between Groups 2 and 3). 56% of patients in Group 1 had moderately complex lesions (nephrometry scores 7-9) compared to 68% from Group 2 and 44% from Group 3. Only 9% of patients in Group 1 had highly complex lesions (nephrometry scores ≥ 10-12) compared to 16% in Group 2 and none in Group 3. Five (3.6%) patients in Group 1, 20 (17%) patients in Group 2 and 5 (17%) patients in Group 3 underwent partial nephrectomy for tumors in a solitary kidney.

Mean EBL was 320cc (range 25-1400), 351cc (range 50-1700) and 376cc (range 20-1200) for Groups 1, 2 and 3 respectively (p = 0.5). Mean operative time was 193.5 minutes (range 103-398), 221 minutes (range 91-585) and 290 minutes (107-495) for the three groups respectively (p < 0.001, significant between Groups 1 and 2, Groups 2 and 3 and Groups 1 and 3). There were no differences in mean hospital stay. Mean postoperative serum creatinine at 1 month was 1.27mg/dl (range 0.6-8.2), 1.34mg/dl (range 0.6-5.4) and 1.29mg/dl (0.7-4.8), respectively (p = 0.8).

Hilar vessels were clamped in 98 (89%) patients in Group 1, 114 (95%) patients in Group 2 and 24 (83%) patients in Group 3. No regional hypother-mia was used in 96, 93 and 17 patients from Groups 1, 2, and 3 respectively. Mean warm ischemia time in these patients was 19.6 minutes (range 5-45), 27 minutes (range 10-45) and 22.5 minutes (range 12-44) (p < 0.001, significant between Groups 1 and 2 and Groups 2 and 3).

Collecting system entry was recognized in 69 cases (63%) in Group 1 compared to 91 (76%) in Group 2 and 11 (38%) in Group 3 (p = 0.07). Sealants were used in 98 patients in Group 1, 59 patients in Group 2 and 16 patients in Group 3 (p < 0.001, significant between Groups 1 and 2 and between Groups 2 and 3). Postoperative urine leak requiring some form of management occurred in 11 patients from group 1 and 6 from group 2 (p = 0.2). None of the patients in group 3 developed a urinary leak (Table-3).

The mean tumor diameter of patients with leak in Group 1 was 3.8cm (range 2.1-7.2cm) and in Group 2 was 3.9cm (range 3-5.6cm). The mean nephrometry score of patients with leak in Group 1 was 8 (range 6-10) and in Group 2 was 9 (range 7-12). Eight of 11(73%) patients in Group 1 had moderately complex lesions (nephrometry scores 7-9) as compared to 5 of 7 (71%) patients in Group 2. Two (19%) patients in Group 1 and two (29%) patients in Group 2 had highly complex lesions (nephrometry scores 10-12).

Of the 11 patients with a urinary leak in Group 1, 5 were managed with a ureteral stent, 2

Table 3 - Leak rates and entry into collecting system.

	Group 1	Group 2	Group 3	p value
Recognized entry into collecting system	69(63%)	91(76%)	11(38%)	0.07
Postoperative Leak Rate requiring any management	11(10%)	6(5%)	0	0.2

Group 1 = assessment via externalized ureteral stent; **Group 2 =** assessment via direct needle injection into proximal ureter; **Group 3 =** no assessment of collecting system integrity.

with prolonged urethral Foley catheterization, 3 with both ureteral stenting and a urethral catheter and one patient had the postoperative drain left in place for a prolonged period. In Group 2, two patients were managed with ureteral stenting, three with prolonged urethral foley catheterization and one with postoperative drain. No patient in either group required percutaneous procedures or re-exploration.

DISCUSSION

Partial nephrectomy has traditionally been reserved for patients with tumor in a solitary kidney, bilateral tumors or renal insufficiency (5). In recent years there has been an increase in the use of partial nephrectomy for small renal masses due to evidence showing better preservation of renal function and overall survival as compared to radical nephrectomy (6). Increasing experience has also led to an increase in the size and complexity of renal masses being surgically managed. The most common complication following open partial nephrectomy, especially for complex masses, is urinary leakage with an incidence ranging from 1.4% to 17.4% (7). Larger tumors, centrally located lesions and major reconstruction of the collecting system are associated with an increased risk of urinary leak (1).

Intraoperative recognition and repair of collecting system defects is important to help prevent urine leak after partial nephrectomy. Some investigators have described preoperative placement of a ureteral catheter connected to methylene blue solution for intraoperative retrograde irrigation to identify the collecting system and test the integrity of collecting system repair (2,8). Others have described injecting the collecting system with diluted methylene blue after temporarily occluding the ureter (3,9). There have been no studies comparing whether one technique is superior to the other in detecting calyceal entry and preventing urinary fistulae.

In the current series, patients in group 2 had tumors with higher mean nephrometry scores and more highly complex tumors as compared to patients from Group 1. There was recognized entry into the collecting system in 76% of patients in Group 2 compared to 63% in Group 1. However, there were fewer urine leaks in Group 2 as compared to Group 1 though this difference was not statistically significant. The perioperative leak rate did not appear to be influenced by the intraoperative technique used to identify unrecognized collecting system entry as well as the integrity of subsequent collecting system reconstruction.

The overall leak rate in this entire series was low (6.6%) despite strict criteria for defining a urinary leak and the identification of collecting system entry in the significant majority of patients. All patients were managed conservatively without the need for percutaneous drainage, nephrostomy or re-exploration. The majority of urine leaks following open partial nephrectomy resolve spontaneously with drain manipulation and prolonged urethral catheterization (2,10). If this fails, ureteral stenting is usually successful in managing a persistent leak. Recent literature suggests that drain placement may be omitted after partial nephrectomy in a select group of patients (11). Seventy-five of 512 (14.5%) patients undergoing partial nephrectomy by a single surgeon at a high volume tertiary care center did not have a drain placed at the time of partial nephrectomy. Four of these patients developed complications related to the absence of a drain. While the data suggests that careful patient selection may obviate the need for a drain, the

morbidity of a drain is low, it helps in early identification of leaks, and manipulation of the drain along with prolonged catheterization results in the resolution of most leaks. In this study, the majority of patients in all groups had routine placement of a perinephric drain. Clinically, there were no signs or symptoms of a postoperative urine fistula in six patients who did not have a drain placed.

Interestingly no leaks developed in the third group of patients in whom the integrity of the collecting system was not assessed. These patients had mean nephrometry scores lower than either of the other two groups as well as less complex lesions (Table-1). Recognizing the limitations associated with selection bias, it is nevertheless possible that collecting system integrity does not need to be assessed in the majority of cases. The use of diluted methylene blue retrograde injection of dye may be reserved for larger, more endophytic tumors. Polascik et al. compared the incidence of urinary leaks in their series with and without intraoperative needle injection of methylene blue (3). They reported that all leaks in their series (6 of 28 procedures) occurred before they began routine use of diluted methylene blue via needle injection to detect collecting system defects intraoperatively. However, the mean diameter of the tumors associated with the leaks was 10cm. Similarly, while some experienced urologists who routinely perform minimally invasive partial nephrectomies do not routinely place a ureteral catheter to identify collecting system entry in tumors less than 4.5cm, intraoperative retrograde dye injection continues to be used for intraparenchymal tumors (8,12). Cost is another important factor in determining surgical approach and technique. Based on an evaluation of costs at our center, intraoperative cystoscopy and placement of an externalized ureteral stent adds an additional $625 to the total procedural cost rendering this technique more expensive than direct needle injection. However, proponents of ureteral stent placement argue that this technique more likely assures retrograde flow of dye into the renal pelvis and calyces whereas direct injection of dye through a 25-gauge needle is subject to inaccurate access into the ureteral lumen. Furthermore, direct needle injection might be more time consuming and difficult due to suboptimal simultaneous exposure of the ureter and the

region of parenchymal transection while injecting. Increased time to assess integrity of the collecting system has important implications when considering warm ischemia. This might have contributed to the increased clamp time in Group 2 patients assessed with direct needle injection in addition to other factors such as complexity of the lesion. Finally, some surgeons might ask anesthesia colleagues to administer intravenous indigo-carmine prior to clamping the renal vessels. This technique might aid in recognition of collecting system entry with extravasation of blue colored urine during tumor excision. However, particularly for larger tumors or complex cases where significant reconstruction is required, the surgeon would not be able to assess the integrity of the collecting system repair without retrograde instillation of dye-colored fluid under gentle pressure.

This study has several limitations. It is retrospective and non-randomized. Many factors such as surgeon bias and experience, the use of sealants and technique of closure may have influenced the leak rate in addition to the method of identifying collecting system disruption. Furthermore, it is possible the study was underpowered to detect a significant difference in the event of interest (urine leak) according to the method of assessing the collecting system. Regardless, this study confirms the low urinary leak rate following partial nephrectomy. It would seem that consistent access to the collecting system via an externalized ureteral stent to assess collecting system integrity would be advantageous over direct injection. However, the results of this study do not definitively support one technique over the other. Finally, given the low overall leak rate, in many patients the integrity of the collecting system might not need to be assessed at all.

CONCLUSIONS

Collecting system entry was present in the majority of patients undergoing open partial nephrectomy in this series. Despite this, postoperative urinary leak was an uncommon complication. Perioperative leak rate in patients undergoing partial nephrectomy was not influenced by the intraoperative technique of identifying unrecog-

nized collecting system entry and the integrity of subsequent collecting system repair.

CONFLICT OF INTEREST

None declared.

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