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ORIGINAL ARTICLE

Elimination of surgical drains following robotic-assisted partial nephrectomy

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Abstract

To prospectively evaluate outcomes of robotic-assisted partial nephrectomy (RAPN) following elimination of surgical drains. 100 consecutive drainless RAPN performed by a single surgeon were analyzed following a previously published quantitative assessment of drain creatinine/serum creatinine ratios. This cohort was compared to 100 preceding RAPN with drains. Variables analyzed included pre-operative patient/tumor characteristics and post-operative outcomes including post-operative estimated glomerular filtration rate (eGFR), length of hospital stay (LOS), and complications. There was no significant difference in median patient age, sex, body mass index, ASA score, or pre-operative eGFR between the two groups. The preceding 100 patients with drains did have larger median renal size (3.5 vs 2.6 cm, $p < 0.001$), higher median RENAL scores (9 vs 8, $p < 0.001$), and longer warm ischemia time (21 vs 18 min, $p = 0.004$). Patients without drains had shorter median LOS (2.0 days vs 3.0 days, $p < 0.001$), fewer Grade III or higher post-operative complications (4% vs 10%, $p = 0.007$), and no difference in 1 month percent change in eGFR (−13% vs −11%, $p = 0.84$). After adjusting for confounding variables there was no difference in LOS (OR 1.50, $p = 0.31$), Grade III–V complications (OR 1.49, $p = 0.63$), or 1 month percent change in eGFR (OR 2.3, $p = 0.41$) between the two groups. One patient in the drainless group required a post-operative drain for a urine leak diagnosed 10 days following RAPN. Omission of drains is safe in RAPN and does not appear to offer a clinical advantage.

Keywords Robotic surgery · Partial nephrectomy · Renal lesion · Drain · Renal cell carcinoma

Introduction

Minimally invasive and nephron-sparing surgical techniques have become the gold standard for the treatment of small renal masses [1]. Historically, routine intraoperative placement of a surgical drain at the time of partial nephrectomy has been used as both a diagnostic and therapeutic tool in the event of a urine leak. However, recent data suggests the occurrence of urine leak after robotic-assisted partial nephrectomy (RAPN) occurs in less than 1% of patients [2], and the complication typically resolves itself without further treatment [3].

It has been previously proposed that routine surgical drain placement may not be required for most RAPN. We previously published a quantitative analysis of post-operative drain creatinine to serum creatinine (D/S) ratios to determine the efficacy of drains in 124 consecutive patients following RAPN and concluded that most RAPN can safely forego intraoperative drain placement, especially in renal masses smaller than 4 cm [4]. Due to this finding we elected to discontinue placing drains during RAPN in our subsequent patients. We analyzed two comparable groups of patients (drains vs drainless) following RAPN by a single surgeon to examine post-operative outcomes.

Materials and methods

Patient selection

Following IRB approval, 360 consecutive RAPNs performed by a single surgeon were analyzed. Routine placement of drains was stopped at patient 260. We analyzed the subsequent 100 patients without drains and preceding 100 cases with drains for a total cohort of 200 patients.

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Analysis

Data were collected regarding patient characteristics (age, sex, body mass index [BMI], American Society of Anesthesiologists [ASA] score, Mayo Adhesive Probability [MAP] score, pre-operative creatinine and estimated glomerular filtration rate [eGFR], and pre-operative hemoglobin) and comorbidities including a history of hypertension, diabetes mellitus, and smoking. eGFR was calculated with the MDRD 2006 equation as described by Levey et al. [5]. Tumor characteristics including renal mass size and R.E.N.A.L. score were also collected. Operative variables including warm ischemia time (WIT), estimated blood loss (EBL), and collecting system (CS) entry were collected for both cohorts. We also collected post-operative variables including length of hospital stay (LOS), post-operative complications as graded by the Clavien-Dindo classification system, and percent change eGFR at 1 day and 1 month post-operatively [6]. RAPN was performed using the robotic Da Vinci Si Surgical System with sliding-clip renorrhaphy and single-layer CS repair by one experienced surgeon as previously described [7, 8]. All drains were removed prior to discharge.

Statistical analysis

Data were descriptively summarized by number and percentage for categorical variables and median and interquartile range for numeric variables. For our initial analysis, we compared patient pre-operative characteristics, pathology findings, intraoperative characteristics, and post-operative outcomes (any complication, complication of Grade III or higher, and LOS) between those who had a drain placed and those who did not have a drain placed using the Wilcoxon rank sum test for numeric and ordered variables and the Fisher's exact test for categorical variables. We additionally used logistic regression models to evaluate the impact of drain placement on binary post-operative outcomes (any complication, complications of Grade III–V, and LOS of 3 days or longer) and linear regression models for numeric outcomes (percent change in eGFR from pre-operative to post-operative day 1 and percent change in eGFR from pre-operative to 1 month following RAPN) while adjusting the models for potentially confounding variables. All statistical tests were two sided at the 5% significance level. Statistical analyses and graphics were performed using SAS statistical software (version 9.4M5, SAS Institute Inc., Cary, NC).

Results

Table 1 summarizes patient demographics of the drain and drainless groups. Age, sex, BMI, comorbidities of hypertension, diabetes, and a smoking history were comparable between the drains and drainless groups. The drains group had a larger median renal mass size (3.5 vs 2.6, $p < 0.001$), a higher median R.E.NA.L. score (9 vs 8, $p < 0.001$) and significantly more patients who had a high R.E.N.A.L. score of 10–12 (33 vs 12, $p < 0.001$).

WIT, EBL, and CS entry were evaluated for both groups. During surgery, drain patients had a median WIT of 21 (IQR, 17–24) min, median EBL of 400 (IQR 300–500) mL, and 89% had CS entry. Drainless patients had a median WIT of 18 (IQR, 13–23) min, median EBL of 300 (IQR, 300–450) mL, and 54% had CS entry. CS entry was significantly more frequent in the drain group (89 vs 52, $p < 0.001$).

Table 2 displays associations of post-operative outcomes in regards to drain placement. There was no difference in percent change in eGFR between patients with drains (− 11.4%) and patients without drains (− 12.7%) ($p = 0.8412$). Drain patients had a longer LOS compared to drainless patients (3 vs 2 days, respectively, $p < 0.001$). Patients with a drain had higher percentage of overall complications compared to drainless patients (29 vs 13%, respectively) as well as Grade III or higher complications (10 vs 4%, respectively) ($p = 0.007$). In the drainless group, four complications Grade III or higher occurred. The Grade III complications included two pseudoaneurysms and one patient who developed a urine leak 10 days following RAPN. The single Grade IV complication in the drainless cohort was a pseudoaneurysm with pulmonary failure secondary to amyloidosis.

After adjusting for possible confounding pre-operative variables (Table 1) there was no difference in LOS (OR 1.7, $p = 0.15$), complications Grade III or higher (OR 1.9, $p = 0.39$), or percent change in eGFR at 1 month post-operatively (OR 2.3, $p = 0.51$). After further adjustment for pre-operative variables and WIT, EBL, CS entry, we found no difference in LOS (OR 1.50, $p = 0.31$), complications of Grade III or higher (OR 1.49, $p = 0.63$), or percent change in GFR (OR 2.3, $p = 0.41$) between the drains and drainless groups.

Discussion

Routine intraoperative placement of surgical drains at the time of partial nephrectomy has been proposed to be diagnostic and therapeutic for post-operative urine leakage.

Table 1 Pre-operative characteristics

Characteristic	Drain ($n=100$)	Drainless ($n=100$)	p value
Median age (IQR), (years)	63 (54, 72)	64 (56, 70)	0.64
Female sex, *n* (%)	41 (41%)	41 (41%)	1.00
Median body mass index (IQR), (kg/m^2)	29.1 (24.9, 33.4)	29.7 (26.4, 35.0)	0.17
Hypertension, *n* (%)	56 (56%)	66 (66%)	0.19
Diabetes, *n* (%)	22 (22%)	19 (19%)	0.73
Smoking history, *n* (%)	29 (29%)	36 (36%)	0.37
ASA score			0.63
1	1 (1%)	0 (0%)	
2	35 (35%)	28 (33%)	
3	63 (63%)	56 (66%)	
4	1 (1%)	1 (1%)	
Median eGFR (IQR)	72.9 (64.1, 82.4)	71.7 (61.8, 85.0)	0.79
CKD stage			0.17
I	17 (17%)	14 (14%)	
II	71 (71%)	66 (66%)	
III	11 (11%)	19 (19%)	
IV	1 (1%)	0 (0%)	
V	0 (0%)	1 (1%)	
Median hgb (IQR)	13.8 (12.7, 14.5)	14.1 (12.8, 14.9)	0.17
Solitary kidney, *n* (%)	4 (4%)	0 (0%)	0.12
Median tumor size (IQR), (cm)	3.5 (3.0, 4.4)	2.6 (2.0, 3.8)	< 0.001
R.E.N.A.L score distribution, *n* (%)			< 0.001
4–6	10 (10%)	32 (32%)	
7–9	57 (57%)	56 (56%)	
10–12	33 (33%)	12 (12%)	
MAP score (low vs high), *n* (%)			0.98
Low (0–3)	68 (68%)	69 (69%)	
High (4–5)	32 (32%)	30 (30%)	

ASA score was not available for 15 patients who did not have a drain placed. MAP score was missing for one patient who did not have a drain placed

IQR interquartile range

Table 2 Post-operative outcomes following RAPN

Characteristic	Drain ($n=100$)	Drainless ($n=100$)	P value
Post-operative complications grade, *n* (%)			0.007
No complications	71 (71%)	87 (87%)	
I	11 (11%)	4 (4%)	
II	8 (8%)	5 (5%)	
III	9 (9%)	3 (3%)	
IV	0 (0%)	1 (1%)	
V	1 (1%)	0 (0%)	
Median length of stay (IQR), (days)	3 (2, 4)	2 (2, 3)	< 0.001
Median % change in eGFR from baseline			
POD1	− 21 (− 32, − 10)	− 14 (− 25, 0)	0.011
1 month post-operative	− 11 (− 20, 0)	− 13 (− 23, 0)	0.84

1 month post-operative eGFR was not available for seven patients who had a drain placed and 30 patients who did not have a drain placed

IQR interquartile range

The post-operative complications that ensue from the placement of drains following RAPN can include infection, retained drain fragment, urinary complications, patient discomfort, prolonged hospital stay, and small bowel obstruction [4, 9]. Additionally, the elimination of drain placement may prove cost-effective by shortening hospital stay and saving the cost of drain placement and removal. We previously published a quantitative drain analysis on 124 patients by examining drain creatinine/serum creatinine ratios and determined that most RAPN do not require a surgical drain post-operatively [4]. Motivated by this finding, we eliminated surgical drains from all patients undergoing RAPN.

A multicenter analysis of 1791 patients suggests the occurrence of urine leak after robotic-assisted partial nephrectomy (RAPN) occurs in less than 1% of patients [2]. Furthermore, it has been proposed that urinary fistulae that occur following partial nephrectomy typically resolve without further treatment [3]. There is limited peer-reviewed data on the outcomes of elimination of drains following RAPN. Abaza et al. [10] describes a retrospective study of 160 tumors in 150 patients to evaluate the elimination of drains following RAPN and found urine leaks to develop in 1.3% of instances where a drain was not placed. This group concluded the omission of drains following RAPN as safe and possibly even beneficial for the patient [10].

Godoy et al. [9] argued that placement of drains can lead to complications and concluded omitting drainage as a feasible and safe practice in patients with small renal masses and without CS entry but suggested selectively placing drains in patients with large endophytic masses or severe CS disruption during surgery. We propose omitting drains in patients despite CS entry is safe as well, as there is evidence to suggest urine leaks are uncommon after standard sliding-clip renorrhaphy, which is part of our standard technique. Williams et al. [11] examined the utilization of the sliding-clip renorrhaphy without formal CS closure in a cohort of 26 patients with CS entry which resulted in no urine leaks. The authors claim that single-layer renorrhaphy (SLR) can replace standard two-layer CS closure due to the efficacy of the sliding-clip technique. Our drainless cohort contained 52 patients who had CS entry. The one patient in the drainless cohort who developed a urine leak 10 days post-operatively and required a drain be placed had a 2 cm renal mass less than 4 cm away from the CS, a R.E.N.A.L. score of 7, and did have CS entry intraoperatively. Due to the delayed presentation of the urine leak, it is unlikely that post-operative drain placement would have prevented this complication. Given that the other Grade III–V complications in the drainless cohort were two pseudoanureysms and one pseudoaneurysm with pulmonary failure secondary to amyloidosis, it is unlikely that placement of a surgical drain would have been preventative.

This study was not without limitations. The two groups analyzed in this study were not precisely matched and differed in median renal mass size (3.2 vs 2.8 cm) and median R.E.N.A.L. score (9 vs 8). The number of complex (R.E.N.A.L. 10–12) tumors in the drainless group was much lower compared to the preceding 100 drain patients (33 vs 12, respectively). This may have factored into the longer WIT and higher complication rate in the drain patients compared to drainless patients. Every drain patient's RAPN was performed before any drainless patient's RAPN, therefore, creating the possibility that surgeon experience could have an effect on post-operative outcomes. Additionally, our results have been generated by a high volume surgeon and performed at a tertiary surgical center resulting in the possibility of ungeneralizable results for other institutions performing RAPN [12].

Conclusion

Post-operative surgical drains may safely be omitted following RAPN and may not provide any clinical value with regards to hospital LOS, complications, and renal function preservation.

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Compliance with ethical standards

Conflict of interest Authors Amanda E. Kahn, Ashley M. Shumate, Colleen T. Ball, and David D. They declare that they have no conflict of interest.

Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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