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RESEARCH

Comparison of lateral flank approach and low anterior access for single port (SP) retroperitoneal partial nephrectomy: an analysis from the single port advanced research consortium (SPARC)

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Abstract
Single Port (SP) robotic partial nephrectomy (RPN) can be performed via retroperitoneal and transperitoneal approach. We aim to compare outcomes of two commonly described incisions for retroperitoneal SP RPN: lateral flank approach (LFA) and low anterior access (LAA). We performed a retrospective study of patients who underwent SP retroperitoneal RPN from 2018 to 2023 as part of a large multi-institute collaboration (SPARC). Baseline demographic, clinical, tumor-specific characteristics, and perioperative outcomes were compared using $\chi 2$, t test, Fisher exact test, and Mann–Whitney U test. Multivariable analyses were conducted using robust and logistic regressions. A total of 70 patients underwent SP retroperitoneal RPN, with 44 undergoing LAA. Overall, there were no significant differences in baseline characteristics between the two groups. The LAA group exhibited significantly lower median RENAL scores (8 vs. 5, $p < 0.001$) and more varied tumor locations ($p = 0.002$). In the bivariate analysis, there were no statistically significant differences in ischemia time, estimated blood loss, or complication rates between the groups. However, the LAA group had longer operative times (101 vs. 134 min, $p < 0.001$), but was more likely to undergo a same-day discharge ($p < 0.001$). When controlling for other variables, LAA was associated with shorter ischemia time ($p = 0.005$), but there was no significant difference in operative time ($p = 0.348$) and length of stay ($p = 0.122$). Both LFA and LAA are acceptable approaches for SP retroperitoneal RPN with comparable perioperative outcomes. This early data suggests the LAA is more versatile for varying tumor locations; however, larger cohort studies are needed to ascertain whether there is an overall difference in patient recovery.

Keywords Single port · Robotics · Partial nephrectomy · Surgical access · Patient positioning

Introduction

Partial nephrectomy is the preferred treatment option for stage I and stage II renal cell carcinoma (RCC) [1]. The use of robotics (RPN) has shown durable perioperative, functional, and oncological outcomes, and remains a safe treatment modality for patients with localized kidney tumors [2]. Traditionally, RPN was performed using the daVinci Si and Xi models, allowing for multiport (MP) access to both the retroperitoneum and peritoneal cavity. Recently, the advent of the da Vinci single port (SP) platform (Intuitive Surgical, Sunnyvale, CA) has ushered in fervent activity in the space of minimally invasive oncologic surgery, with numerous studies comparing outcomes to established MP surgeries [3, 4].

The SP platform has revolutionized the ability to approach kidney tumors using novel and customizable access. Both transperitoneal and retroperitoneal SP RPN have been described [5, 6]. The benefits of retroperitoneal approach to kidney masses include direct access to the renal hilum without manipulation of bowel[7]. In the MP literature, retroperitoneal approach also has allowed for faster operative

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times and warm ischemia times (WIT) [8]. A recent systematic review also showed that retroperitoneal approach to kidney tumors could potentially allow for shorter length of hospital stay, thereby decreasing aggregate surgical costs[9].

There are two commonly described incisions for retroperitoneal SP RPN: lateral flank approach (LFA) and low anterior access (LAA). The LFA involves making a 2.5 cm transverse skin incision, anterior and inferior to the tip of the 12th rib with the patient in the flank position. Division of the flank musculature and subsequent exposure and incision of the thoracolumbar fascia allows for access to the retroperitoneum [10]. More recently, an LAA has been described (analogous to a mini-Gibson incision), wherein the retroperitoneum is accessed through a 2.5 cm incision at approximately the McBurney point, 3 cm medial, and 3 cm cephalad to the anterior superior iliac spine with the patient in the supine position [11].

While the LAA has seen greater uptake in recent surgical series due to ease of patient positioning, there is very little comparative data assessing superiority of one incision to another. We aim to compare outcomes LFA and LAA for SP retroperitoneal RPN.

Materials and methods

Data source/patient selection

This study utilized the Single Port Advanced Research Consortium (SPARC) database, which comprises prospectively maintained data from 427 patients who underwent robotic-assisted nephrectomy using the da Vinci SP robot in the United States. The database encompasses information on patient baseline demographics, clinical profiles, and tumor-specific characteristics, as well as perioperative and follow-up data spanning from 2018 to 2023. Institutional ethics review board approval specific to each center and data sharing agreements were secured prior to patient identification, data collection, or the transfer of de-identified data. De-identified data are securely stored at one of the participating sites. Patients were included if they underwent partial nephrectomy using the retroperitoneal approach ($n = 137$), and surgical access was either LFA or LAA ($n = 83$). Patients with missing data on baseline characteristics were excluded from the study ($n = 13$).

Study variables

The primary exposure variable in this study is the incision type, categorized as either LFA or LAA. Baseline demographic, clinical, and tumor-specific characteristics considered in our analysis include age, gender, body mass index (BMI), tumor laterality, hypertension status, diabetes mellitus status, Charlson comorbidity index (CCI), baseline estimated glomerular filtration rate (eGFR), tumor size, RENAL nephrometry score, and tumor location. Tumor location was categorized as anterior, posterior, or neither. The eGFR was estimated using the Chronic Kidney Disease Epidemiology Collaboration creatinine equations for glomerular filtration rate.

Outcome variables

The study focused on perioperative and postoperative outcomes, including operative time, ischemia time, estimated blood loss (EBL), length of hospital stay (LOS), positive surgical margin (PSM) rate, and the 90-day postoperative complication rate (both overall and major complications [Clavien ≥ 3]). LOS was further classified as either < 1 day or ≥ 1 day.

Statistical analysis

Categorical variables are presented as frequencies and percentages, whereas continuous variables are described with means and standard deviation (SD) or medians and interquartile ranges, depending on the distribution of the variable. The bivariate relationships between incision type and baseline characteristics, as well as outcomes, were assessed using $\chi 2$ and Fisher's exact test for categorical variables, and the student t test and Mann–Whitney U test for continuous variables.

Multivariable analyses were conducted utilizing robust and logistic regressions. The association between operative times, ischemia time, and EBL with incision type was examined through robust regression, controlling for all baseline characteristics. Logistic regression was employed to evaluate the relationship between length of stay and incision type, with control for renal score and tumor laterality.

All statistical analyses were performed using R, version 4.3.2. All p values were two-sided, and statistical significance was considered at a threshold of $p < 0.05$.

Results

A total of 70 patients who underwent SP retroperitoneal RPN were included in the study, with 44 (63%) having LAA. The mean age was 60 ± 11 years, and 61% were males. Other baseline patient demographics, clinical, and tumor characteristics are detailed in Table 1. In the bivariate analysis, there were no significant differences in patient demographics and clinical features between the two groups. In addition, there was no statistically significant difference in the mean tumor size between the groups (2.74 cm vs. 2.68 cm, LFA; $p = 0.9$). However, the LAA group had significantly lower

Table 1 Baseline demographics, clinical, and tumor characteristics among patients who had LFA and LAA

Characteristic	Overall	Lateral flank	Low anterior	*p* value
n	70	26 (37%)	44 (63%)	
Age, years, Mean (SD)	60 (11)	60 (10)	61 (11)	0.8
Gender, *n* (%)				> 0.9
Female	27 (39%)	10 (38%)	17 (39%)	
Male	43 (61%)	16 (62%)	27 (61%)	
BMI, kg/m^2, Mean (SD)	30 (6)	29 (6)	30 (7)	0.9
Hypertension, n (%)				0.8
Yes	42 (60%)	16 (62%)	26 (59%)	
No	28 (40%)	10 (38%)	18 (41%)	
Diabetes Mellitus, *n* (%)				0.5
Yes	9 (13%)	2 (7.7%)	7 (16%)	
No	61 (87%)	24 (92%)	37 (84%)	
Charlson comorbidity index, Median (IQR)	3 (2, 4)	3 (2, 4)	3 (1, 3)	0.11
Tumor laterality, *n* (%)				0.13
Left	27 (39%)	13 (50%)	14 (32%)	
Right	43 (61%)	13 (50%)	30 (68%)	
Baseline eGFR, Mean (SD)	80 (23)	86 (19)	76 (25)	0.13
Tumor size, cm, Mean (SD)	2.72 (1.34)	2.68 (1.43)	2.74 (1.30)	0.9
R.E.N.A.L score, Median (IQR)	6 (4, 8)	8 (6, 10)	5 (4, 7)	< 0.001
Tumor location, *n* (%)				0.002
Anterior	14 (20%)	4 (15%)	10 (23%)	
Posterior	33 (47%)	19 (73%)	14 (32%)	
Neither	23 (33%)	3 (12%)	20 (45%)	

Welch two sample *t* test; Pearson's Chi-squared test; Fisher's exact test; Wilcoxon rank sum test

median RENAL scores (5 vs. 8, LFA; $p < 0.001$) and was less likely to have a posterior tumor (32% vs. 78%, LFA; $p = 0.002$) (Table 1).

Table 2 presents a comparison of perioperative and postoperative outcomes between LFA and LAA. Overall, there were no instances of conversion to open or radical surgery, intra-operative complications, or blood transfusions. There was no significant difference between approaches regarding WIT, EBL, or complication rates. Although the LAA group had longer median operative times (101 vs. 134 min, $p < 0.001$), they were more likely to undergo same-day discharge (41% vs. 96%, $p < 0.001$). No statistically significant difference was observed in PSM status. Controlling for other covariates, LAA was associated with a shorter WIT ($\beta = -6.38$, 95% Confidence Interval [CI]: −10.74, −2.02; $p = 0.005$). However, there were no significant differences in operative time ($p = 0.348$), EBL ($p = 0.151$), and LOS ($p = 0.122$).

Discussion

The da Vinci SP platform, given its compact nature, has allowed for customization of access for multiple different urologic surgeries. For robotic partial nephrectomy, different incisions for both transperitoneal and retroperitoneal approaches have been described. Bang et al. in their series comparing SP transperitoneal partial nephrectomy (TPN) and retroperitoneal RPN utilized a periumbilical incision for transperitoneal approach and the incision described by Maurice et al. for retroperitoneal [5, 10]. The authors found no significant differences in baseline characteristics between patient groups, apart from BMI, with patients undergoing TPN having higher BMIs. Clinical factors were not statistically significant between groups [5].

Our group previously published our outcomes comparing SP TPN and retroperitoneal RPN. We found that patients undergoing SP retroperitoneal RPN were significantly more likely to have posterior tumors. Other intraoperative and perioperative outcomes, including WIT, total operative time, EBL, length of hospital stay, major and overall complications, PSM status, and change in eGFR, were not different [6]. In this study from SPARC, the described SP TPN incision was periumbilical, with the patient in modified flank position. For SP retroperitoneal RPN, the patient was positioned in full flank with a 3 cm incision made inferomedial to the tip of the 12th rib.

The aforementioned studies solidified the safety of SP surgery for renal masses using both transperitoneal and retroperitoneal approaches with two incisions well known to

Table 2 Comparison of perioperative and postoperative outcomes between LFA and LAA SP incisions in patients who underwent RPN

Characteristics	Lateral flank	Low anterior	*p* value	Lateral flank vs. Low anterior ***β***/aOR (95% CI)	*p* value
Ischemia time, min, Mean (SD)	24 (8)	21 (7)	0.3	$\beta = -6.38$ (− 10.74, -2.02)*	0.005
Operative time, min, Mean (SD)	101 (33)	134 (40)	< 0.001	$\beta = 9.62$ (−10.76, 30.02)*	0.348
Estimated blood loss, ml, Mean (SD)	109 (139)	88 (114)	0.5	$\beta = -20.28$ (−48.11, 7.55)*	0.151
Blood transfusion, n (%)					
No	26 (100%)	44 (100%)			
Conversion to open, n (%)					
No	26 (100%)	44 (100%)			
Conversion to radical, *n* (%)					
No	26 (100%)	44 (100%)			
Intraoperative complications, *n* (%)					
No	26 (100%)	44 (100%)			
Length of stay, days, *n* (%)			< 0.001		
< 1 day	1 (3.8%)	18 (41%)		Ref	
≥ 1 day	25 (96%)	26 (59%)		OR = 0.33 (0.04, 1.14)#	0.122
Positive margins, n (%)			0.4		
Negative	25 (96%)	44 (100%)			
Positive	1 (3.8%)	0 (0%)			
Postoperative complications, n (%)	2 (7.7%)	0 (0%)	0.13		
Major complication, n (%)	1 (3.8%)	0 (0%)	0.4		

Welch two sample *t* test; Pearson's Chi-squared test; Fisher's exact test. *Robust regression—controlled for all baseline covariate. #logistic regression—controlled for incision type, renal score and tumor laterality

robotic surgeons due to overlap with positioning from MP surgery. However, with time and surgical experience, there has been a drive to innovate novel urinary tract access, particularly with the motive to simplify patient positioning. It is well-known that there are inherent challenges and risks to flank positioning. The anesthesiology literature shows us that total flank position causes decreases in pulmonary compliance, tidal volume, and vital capacity that can result in a modest ventilation–perfusion mismatch, reducing oxygen delivery to tissues and increasing the risk of hypoxemia [12]. In addition, the flank position can lead to difficult to treat patient neuropathies, including peroneal nerve injury and brachial plexus injury [13, 14]. What is more, for complex retroperitoneal surgery, prolonged operative time in flank positioning can also lead to pressure related injuries, with rare reports of rhabdomyolysis [15, 16].

Taken together, the drive to perform retroperitoneal renal surgery in the supine position has attractive patient-specific and anesthetic benefits. The extensively described LAA provides optimal access to the retroperitoneum, while simplifying positioning. This study showed equivalent operative metrics, including WIT, EBL, conversion rates, and complication rates. On univariate analysis, LAA showed longer overall operative times, although this difference was lost on multivariate analysis. We hypothesize that the shorter operative times with LFA are due to familiarity of flank access to the retroperitoneum for most robotic surgeons accustomed to MP RPN.

In our analysis, LAA also showed shorter hospital LOS on univariate analysis. LAA involves splitting of the muscles of the anterior abdominal wall, with puncture through transversalis fascia, whereas LFA entails similar splitting of muscle with incision through the thoracolumbar fascia. Differences in nerve distribution between these musculofascial layers may contribute to differences in perceived pain by patients. While we did not explicitly study comparative pain medication requirements, we hypothesize that patients with LAA had less pain thereby allowing for same day discharge. Multivariate analysis showed shorter WIT with LAA. Long-term studies are still required to determine if this yields meaningful improvement in postoperative eGFR.

Limitations of this study include small patient population size ($n = 70$) and lack of long-term oncological and functional outcomes. While we were unable to show superiority of one incision to another in the perioperative period, the general attendant benefits of avoiding full flank positioning lends LAA to become the preferred approach for RPN, while also allowing for full access to the peritoneal cavity, if required. Another limitation is the retrospective design, with surgeons preferentially choosing an approach mindful of patient and tumor clinical factors, as shown by the LFA group having higher complexity and posterior tumors.

Strengths of this study include robust multi-institution collaborative allowing for varied surgical techniques, although all participating institutes are tertiary care academic referral hospitals. Outcomes should be viewed in the lens of higher volume MP and SP experience by the performing surgeons.

Conclusion

Both LFA and LAA are acceptable approaches for SP retroperitoneal RPN with comparable perioperative outcomes. This early data suggests the LAA is more versatile for varying tumor locations; however, larger cohort studies are needed to ascertain whether there is an overall difference in patient recovery.

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Declarations

Competing interests The authors declare no competing interests.

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