Medial versus lateral camera port placement for robotic nephron-sparing surgery: evaluating surgical complications and outcomes

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Abstract
As the growing popularity of robotic-assisted laparoscopic procedures for the treatment of renal cancer increases, there exists a variation in surgical technique among institutions and surgeons alike. One variation that exists in robotics is the anatomical placement of the camera port (medial versus lateral camera port placement). The purpose of this study is to evaluate surgical complications and outcomes in comparison to site of camera port placement during nephron-sparing surgery in an academic setting. Over a three-year period, outcomes for all robotic surgeries for renal cancer were examined. A total of 229 cases were discovered. Patient demographics and comorbidities were analyzed along with perioperative surgical data including location of camera port, surgery length, warm ischemia time, blood loss, pathological tumor margins, tumor size, length of stay and laboratory data. 134 patients had surgery performed with lateral camera port placement versus 95 patients with medial camera port placement. Operative time was significantly lower with an average operative time of 165.8 min for the lateral group versus 209.1 min in the medial group (p < 0.0001). Warm ischemia time was also less in the lateral group with an average of 11 min versus 15.5 min for the medial group (p < 0.0001). Blood loss was less in the lateral camera port group with an average of 158.2 mL (± 196.5 mL) versus 248.6 mL in the medial group (± 252.6) (p = 0.0040). Drain use, positive surgical margin rate, transfusion rate, conversion to radical nephrectomy, change in pre-operative versus postoperative creatinine and glomerular filtration rate and length of hospital stay did not statistically differ. Lateral camera port placement is associated with decreased operative time and warm ischemia time in this series. There may be certain laparoscopic advantages through a better visualization of surgical anatomy, thus allowing for faster extirpation of renal lesions and decrease in surgical time. These advantages may result in better long-term renal function and decreased clinical sequela from chronic kidney disease.

Keywords Camera port placement · Robotic surgery · Urology · Nephron-sparing surgery

Introduction

The incidence of small renal cancer has increased over the last several years, and this is largely due to increased analytical imaging. Surgical treatments of these renal lesions may include radical nephrectomy versus nephron-sparing surgery. While open partial nephrectomy has been the gold standard for nephron-sparing surgery, there is increasing utilization of robotic partial nephrectomy in the urologic community.

There exists a variation in surgical technique among institutions and surgeons alike. A variation that exists in robotics is the anatomical placement of the camera port: medial versus lateral camera port placement. One study suggests that lateral camera port placement leads to greater flexibility of arm movement with less collisions [1]. In our institution we...
have utilized both medial and lateral camera port placement with success in both techniques. The decision to perform medial or lateral camera port placement is largely based on surgeon preference. It is believed that the lateral camera port placement location provides a better angle of viewing the hilar anatomy with superior visibility during dissection. In addition, it is also hypothesized that there is better arm ergonomics and mobility with the lateral camera placement as well. The purpose of this study is to evaluate surgical complications and outcomes in comparison to site of camera port placement during nephron-sparing surgery in an academic setting.

Methods

We retrospectively reviewed the charts of all robotic surgery for renal lesions from 2013 to 2016 at our institution. A total of 229 cases were identified as meeting inclusion criteria, which primarily consisted of all robotic partial nephrectomies performed at our institution. Patient demographics and comorbidities were analyzed along with perioperative surgical data including location of camera port, surgery length, warm ischemia time, blood loss, pathological tumor margins, tumor size, length of stay and laboratory data. T-test and regression analysis was utilized to evaluate the differences between medial camera port placement versus lateral camera port placement for renal surgery.

Results

All patients with surgery for a small renal mass were included. Of these, 134 patients had surgery performed with lateral camera port placement versus 95 patients with medial camera port placement. Operative time was significantly better in the lateral camera port placement with average operative time of 165.8 min versus 209.1 min for the medial camera port placement. Additionally, warm ischemia time was less in the lateral group with an average of 11 min versus 15.5 min in the medial group. Blood loss was also less in the lateral camera port group with an average of 158.2 mL versus 248.6 mL (see Table 1). Drain use, positive surgical margin rate, transfusion rate, conversion to radical nephrectomy, change in pre-operative versus postoperative creatinine and glomerular filtration rate and length of hospital stay did not statistically differ.

Due to the inclusion of all robotic surgeries for renal masses, further evaluation was performed with regression analysis to evaluate if any alternative variables had a significant effect on the results of this study. Once again it was confirmed that length of surgery, warm ischemia time and blood loss had better surgical outcomes in the regression analysis with lateral camera port placement as the determining variable for this causation (see Tables 2, 3, 4 for length of surgery, warm ischemia time and blood loss respectively).

Table 1 Descriptive statistics

|                     | Lateral N=134 | Medial N=95 | P Value |
|---------------------|---------------|-------------|---------|
| **Age**             |               |             |         |
| Age (± SD)          | 62.4 (± 11.3) | 62.3 (± 11.9)| 0.9536  |
| **BMI**             |               |             |         |
| BMI (± SD)          | 31.7 (± 6.7)  | 31.3 (± 7.1) | 0.6138  |
| **Tobacco user**    |               |             |         |
| Tobacco user (%)    | 45 (33.5%)    | 31 (32.6%)  | 0.8804  |
| **Prescribed pre-operative blood thinner** | | | |
| Prescribed (%)      | 60 (44.8%)    | 32 (33.7%)  | 0.0916  |
| **Surgical analysis** |             |             |         |
| Surgery laterality  |               |             |         |
| Bilateral           | 0             | 4 (4.2%)    | 0.0043* |
| Left                | 55 (41.3%)    | 51 (53.7%)  |         |
| Right               | 78 (58.6%)    | 40 (42.1%)  |         |
| Length of surgery (in minutes) | 169.9 (± 60.7) | 213.3 (± 58.5) | <0.0001 |
| Warm ischemia time (in minutes) | 11.2 (± 4.1)  | 16.1 (± 5.5)  | <0.0001 |
| Converted to radical nephrectomy | 7 (± 6/9)     | 11 (± 14.3)  | 0.1021  |
| Drain used (in %)   | 40 (29.8%)    | 59 (62.1%)  | <0.0001 |
| Blood loss (in ml)  | 158.2 (± 196.5) | 248.6 (± 252.6) | 0.0040  |
| Needed blood transfusion | 13 (9.7%)    | 15 (16.1%)  | 0.1475  |
| **Outcome analysis** |             |             |         |
| Length of stay (in days) | 2.3 (± 2.5) | 2.8 (± 3.0) | 0.1693  |
| Positive surgical margins | 11 (9.5%) | 12 (15.2%) | 0.2251  |
| Tumor size (in cm)  | 3.9 (± 2.1)  | 3.7 (± 2.4)  | 0.3913  |
Discussion

Over the last several years there has been an increased incidences of small renal cancer, and this is largely due to increased analytical imaging. One study showed that 80 (61%) of 131 patients were diagnosed with renal cell tumors in the absence of flank pain, flank mass, or hematuria [2]. With this rise in smaller and less aggressive renal masses, there has been a shift towards performing nephron-sparing surgery for such lesions. It was reported that partial nephrectomy increased from 8.6% in 2000 to 27% in 2011, open radical nephrectomy decreased by 33%, and robot-assisted laparoscopic partial nephrectomy increased during the period from 2008 to 2011, attaining a 14% rate at university and 10% at non-university hospitals [3].

Nephron-sparing surgery has been shown to be more beneficial when compared to radical nephrectomy in terms of improved morbidity and mortality, maintaining renal function, and similar oncological results. For postoperative complications, patients that underwent radical nephrectomy had 1.4 times greater number of cardiovascular events when compared to partial nephrectomy [4]. Comparing the two also showed that the 3-year probability of freedom from new onset of GFR lower than 60 mL/min per 1.73 m² was 80% after partial nephrectomy and 35% after radical nephrectomy; corresponding values for GFRs lower than 45 mL/min per 1.73 m² were 95% and 64%, respectively [5]. The 10 year overall survival rates were reported to be 81.1% for radical nephrectomy and 75.7% for nephron-sparing surgery. With a hazard ratio of 1.50 (95% confidence interval [CI] 1.03–2.16), the test for non-inferiority is not significant (p = 0.77) [6]. According to the AUA guidelines, partial nephrectomy is now the recommendation for most clinical T1 masses, even if the patient has a normal functioning contralateral kidney [7]. In another study, 10 year follow up for partial nephrectomy in tumors < 4 cm revealed no local relapse, disease specific survival of 93% and overall survival of 86% [8].

Open partial nephrectomy (OPN) has been considered the gold standard, but recently there has been an increase in the use of laparoscopic and robotic partial nephrectomies [3]. Robot assisted laparoscopic surgery’s popularity has continued to increase, and has a lower risk for conversion, transfusion and overall complications when compared to open partial nephrectomy. Mean warm ischemia time was shorter with OPN than with RALPN (mean of 15.4 min vs

| Table 2 Regression Analysis for Length of Surgery |
|-----------------------------------------------|
| Regression analysis for length of surgery | Univariate odds ratio | P value | Multivariate | P value |
| Port placement | 0.188 | <0.0001 | 0.251 | <0.0001 |
| Surgery laterality | 0.666 | 0.1633 |
| BMI | 1.025 | 0.1390 |
| Pre-operative blood thinners | 0.918 | 0.7138 |
| Tobacco user | 0.952 | 0.8403 |

| Table 3 Regression analysis for warm ischemia time |
|-----------------------------------------------|
| Regression analysis for warm ischemia time | Univariate odds ratio | P value | Multivariate | P value |
| Port placement | 0.161 | <0.0001 | 0.151 | <0.0001 |
| Surgery laterality | 1.492 | 0.2860 |
| BMI | 1.009 | 0.6957 |
| Pre-operative blood thinners | 0.912 | 0.7602 |
| Tobacco user | 0.776 | 0.4290 |

| Table 4 Regression analysis for drain use |
|-----------------------------------------------|
| Regression analysis for drain use | Univariate odds ratio | P value | Multivariate | P value |
| Port placement | 0.257 | <0.001 | 0.267 | 0.0002 |
| Surgery laterality | 0.632 | 0.1835 |
| BMI | 0.980 | 0.2931 |
| Pre-operative blood thinners | 0.880 | 0.6383 |
| Tobacco user | 0.840 | 0.5396 |
19.2 min). This same study showed that median estimated blood loss was 150 (100–300) mL in the OPN group and 100 (50–150) mL in the RALPN group [9]. RALPN also has equivalent perioperative, early oncological and functional outcomes as OPN. Continuing in the same article, postoperative complications were recorded in 43 (21.5%) patients who underwent OPN and in 28 (14%) who received RALPN ($P = 0.02$). Major complications (grade 3–4) were reported in nine (4.5%) patients after OPN and in nine (4.5%) after RALPN. Positive margins were detected in nine (5.5%) patients after OPN and in nine (5.7%) after RALPN ($P = 0.98$) [9].

Recommended port placement for RALPN according to the Atlas of Robotic Urological Surgery consists of a 3 or 4 robotic-arm variation. The 3 arm option involves two 8 mm robotic trocars (8), a 12 mm camera trocar (C), a 12 mm assistant trocar (A), and an additional 12 mm trocar is placed for the Satinsky clamp (12-S) (image a). The 4 arm option includes one additional lateral 8 mm trocar, just medial to ASIS, and is used for the fourth arm for retraction (image b). The image below is shown for a left kidney, and can be mirrored to the ipsilateral side if a right RALPN is to be performed [10]. Both of these recommendations exhibit a medial camera port placement.

Our institution utilized a medial 3 arm variation as outlined below, consistent with the 3 arm option outlined in the Atlas of Robotic Urological Surgery (image c). The medial camera port placement projects from the tip of the 11th/12th rib along the edge of the rectus muscle, with the arm ports being placed along the anterior axillary line, approximately 8 cm from the camera port. The lateral camera port placement also consists of the port being placed medial to the tip of the 11th/12th rib depending on anatomical variation and mass location. This trocar however is placed just lateral to the border of the psoas and along the mid-axillary line with the patient flexed. The arm ports are then placed approximately 8 cm from the camera port but more medially, closer to the edge of the rectus muscle. (image d). All of these camera port locations are subject to change based on patient’s anatomy.

As discussed in our results section, lateral camera port placement had statistically significant superiority to medial camera port placement: namely lateral camera port placement is associated with decreased operative time and
decreased warm ischemia time. Our postulation is that the lateral placement results in improved visualization of the vascular structures as well as hilar anatomy. Additionally, the triangulation of trocars in this approach also provides more mobility to the robotic arms with suspected less collision. Both concepts allow the surgeon at the console to be more efficient and provide better patient outcomes. The shorter warm ischemia time helps strengthen the core principle of nephron-sparing surgery. In our review and experience, the lateral camera port demonstrates superiority and given surgeon comfort, would recommend this approach to RALPN.

This data does come with some limitations. The study is a retrospective data set with limited number of patients. It was not randomized, and selection of port placement was mainly based on surgeon preference. Further investigation into port placement with randomized controlled trials would help delineate and define the role of camera port placement in surgical outcomes. We suspect that surgeon preference and comfort do play a role in the outcomes of these cases. This study at least suggests the lateral camera port placement provides better outcomes, but further studies could confirm and elaborate on this more.

**Conclusion**

Lateral camera port placement is associated with decreased operative time, blood loss and warm ischemia time. Larger BMI is associated with increase in complications and body habitus should be considered when selecting robotic laparoscopic approach. There may be certain laparoscopic advantages to obtain a better visualization of surgical anatomy with lateral camera port placement, thus allowing for faster extirpation of renal lesions and decrease in surgical time. These advantages may result in better long-term renal function and decreased clinical sequela from chronic kidney disease.

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**Data Availability** The data that support the finding of this study are available from the corresponding author, SD, upon reasonable request.

**Declarations**

**Conflict of interest** The authors declare no competing interests.

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