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Robotic Assisted Vs Traditional Laparoscopic Partial Nephrectomy Peri-Operative Outcomes: A Comparative Single Operator Study

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Abstract

The European Association of Urology currently recommends partial nephrectomy as the preferred management for localised cT1 renal tumours, irrespective of surgical approach. With the advent of robotic assisted partial nephrectomy, there is growing evidence that warm ischaemia time may be reduced compared to the traditional laparoscopic approach. There are still no clear differences between the two approaches with regards to other peri-operative, post-operative and oncological outcomes. Current limitations in the field denote the lack of single surgeon series to compare the two approaches as other studies often include multiple operators of different experience levels. The current study aims to reduce inter-operator bias while maintaining an adequate sample size to assess the differences in outcomes between the two approaches.

We retrospectively compared patient demographics, peri-operative outcomes and renal function derangements of all partial nephrectomies undertaken by a single surgeon with experience in both laparoscopic and robotic surgery. Warm ischaemia time, length of stay and acute renal function deterioration were all significantly reduced with robotic partial nephrectomy, compared to laparoscopic nephrectomy. This study highlights the benefits of robotic partial nephrectomy. Further prospective studies with larger sample sizes would be valuable additions to the current literature.

Introduction

The first Partial nephrectomy (PN) reported was in 1887 as an accidental procedure carried out for a renal cell carcinoma. At this time, the procedure was rejected in favour of the radical nephrectomy as the gold standard for renal cancer. It has only been in recent history that partial nephrectomy has been the widely accepted procedure for small renal masses likely due to advances in radiological imaging, surgical technology and knowledge of tumour biology [1].

Based on the current oncological and quality of life evidence, the European Association of Urology (EAU) currently recommends partial nephrectomy as the preferred management for localised cT1 renal tumours, irrespective of surgical approach. The goals of partial nephrectomy are minimal renal function decrease, negative margins and avoidance of peri-operative complications. Since these recommendations, open PN was generally the approach utilised due to operator comfort however with the advancements in laparoscopic technology and operator skills, the laparoscopic approach is quickly becoming the procedure of choice. Compared to open PN, the laparoscopic approach has comparable oncological outcomes with less morbidity and generally a faster recovery from surgery [2].

Both robotic assisted and traditional laparoscopic PN have steep operator learning curves [3]. Current systematic reviews of the literature indicate robotic assisted PN has significantly reduced warm ischaemic time. Research has not shown clear differences in other peri-operative and oncological outcome differences between the two approaches [4]. Limitations from the recent systematic reviews indicate these comparative studies are often heterogenous, use small sample sizes (<50 patients) and often results being user dependant [5]. Porpiglia et al 2016 who carried out a large systematic review comparing the two approaches highlighted the significant lack of single surgeon studies in the current literature [6]. Many studies reviewed multiple different operators with significantly different operative experience and included centres with large differences in volume leading to bias of data.

To the best of our knowledge there has only ever been one previous single surgeon study carried out in this domain comparing RAPN with LAPN [7]. This study by Haber et al was published in 2010, when robotic surgery was in its infancy and operators were at this time much more experienced with laparoscopic approach. In this study, no significant benefits were found with RAPN compared to LAPN. Our study contributes a more recent single surgeon series comparing peri-operative outcomes of robotic assisted and laparoscopic PN in a decade where robotics is more familiar and utilised. The current study aims to reduce intra-operator bias while maintaining an adequate sample size to assess the differences in outcomes between the two approaches.

Materials and Methods

Study design

We retrospectively reviewed all robotic assisted and traditional laparoscopic partial nephrectomy cases carried out at two separate hospitals. There was no exclusion based on patient factors or tumour factors. Analysis included all robotic and laparoscopic partial nephrectomies that took place between June 2017 to June 2021. Patient demographics, peri-operative and post-operative outcomes were assessed. All procedures included were performed by a single specialist surgeon with over 15 years' experience in laparoscopic and robotic assisted PN. All operations were transperitoneal using either robotic or laparoscopic. Robotic or laparoscopic arms of the study were randomly allocated based on the referring hospital. All data obtained for analysis was approved by an institutional review board meeting ethical standards.

Outcomes

Patient demographics assessed included age in years, weight in kilograms (kg), gender, pre-operative renal function calculated by glomerular filtration rate, mean tumour size (based on pre-operative CT imaging) and medical/surgical co-morbidities. Peri-opera-

tive outcomes included operation time, blood loss, haemoglobin drop and warm ischaemic time. Post-operative outcomes assessed included length of stay, significant post-operative bleed defined as those needing embolization and change in eGFR both at day 1 and after 3 months. Because there was not exclusion based on alignant or benign indications for partial nephrectomy, we did no assess positive margins.

Statistical analysis

All numerical results from each outcome and group were combined for statistical analysis using GraphPad Prism (version 7.03). Comparisons in outcomes between both groups were performed using Mann-Whitney (unpaired, non-parametric) U tests. Chi squared test and Fisher's exact test were used for bivariate analysis. A p value of <0.05 was considered statistically significant.

Results

A total cohort of 95 patients underwent laparoscopic assisted (N = 49) or robotic assisted (N = 46) partial nephrectomy between the dates June 2017 to June 2021. All partial nephrectomy cases were carried out by a single consultant urologist either in The Gold Coast Hospital or Gold Coast Private Hospital. All cases had a radiologically diagnosed renal mass which was targeted for resection. In some cases, these masses were known to be benign eg angiomyolipoma.

Patient_demographics

Patient demographics between both groups are summarized in Table 1. The robotic and laparoscopic cohorts had similar age, co-morbidities and pre-operative renal function. Prevalence of diabetes and hypertension was higher in the laparoscopic group however cardiovascular disease was more prevalent in the robotic group. The robotic cohort was found to have a higher percentage of males compared to the laparoscopic cohort (65% and 51% male respectively).

	Robotic (N = 46)	Laparoscopic (N = 49)	P-value
Age, mean (%)	63.3	62.1	
<55	7 (15)	11 (22)	
55 – 64	16 (35)	16 (31)	
>64	23 (50)	22 (43)	
Gender			
Male (%)	30 (65)	25 (51)	P=0.21
Female (%)	16 (35)	24 (49)	
Co-morbitidies			
Hypertension	20 (43)	29 (59)	P=0.15
Cardiovascular disease	8 (17)	4 (8)	
Diabetes	6 (13)	12 (24)	
Mean pre-op GFR (ml/min/1.73m2)	80	78.8	

Table 1: Patient demographics of patients undergoing either laparoscopic or robotic partial nephrectomy

Tumour characteristics

The radiological location and size of renal masses are summarized in Table 2. Post-operative histological sections were used for diagnosis of tumours and are also summarized in Table 2. There was no significant difference in the mean tumour size between groups. Clear cell RCC was the most common tumour type in both groups. The robotic group had a larger proportion of benign lesions excised compared to the laparoscopic.

	Robotic (N = 46)	Laparoscopic (N = 49)
Mean tumour size (cm)	2.5 (Max: 6.2)	2.6 (Max 5.6)
Tumour location (%)		
Side	Right: 22 (48) Left: 24 (52)	Right: 26 (53) Left: 23 (47)
Upper pole	20 (43)	16 (33)
Inter polar	13 (28)	18 (37)
Lower pole	13 (28)	15 (31)
Tumour Type		
Clear cell RCC	17 (37)	24 (49)
Papillary Type 1	7 (15)	8 (16)
Papillary Type 2	4 (9)	4 (8)
Chromophobe	4 (9)	3 (6)
Other	0 (0)	2 (4)
Benign	14 (30)	8 (16)

Table 2: Tumour characteristics; Tumour size and location based on pre-operative radiological imaging with either computerised tomography imaging or magnetic resonance imaging. Histological diagnosis from pathology specimens of lesion post-operatively

Peri-operative outcomes

The peri-operative outcomes measured are summarized in Table 3. Skin to skin mean operative time was significantly reduced in the RAPN group compared to the LAPN group. RAPN significantly reduced operative time by 15.2 minutes (141.8 vs 157.0, p=0.02). This operative time included the time for docking of the robotic arms which on average lasted 3.9 minutes. Mean blood loss was not always recorded in operative notes and therefore was likely under-estimated in both groups. Despite this, blood loss in the RAPN cohort was reduced compared to the LAPN group (15.5 vs 29.4, p=0.43). Warm ischaemia time (clamp time) was significantly reduced by 2.5 minutes in the RAPN group compared with the LAPN group (13.9 vs 16.4, p=0.0046).

	Robotic (N=46)	Laparoscopic (N=49)	P-value
Mean operative time	141.8 min (2:21hrs)	157.0 min (2:37hrs)	P=0.02*
Mean blood loss (ml)	15.5	29.4	P=0.43
Mean clamp time (min)	13.9	16.5	P=0.0046**

Table 3: Peri-operative outcomes of robotic assisted and laparoscopic assisted PN groups

Post-operative outcomes

Post-operative outcomes for the RAPN and LAPN groups are summarized in Table 4. Length of stay (LOS) of patients was significantly reduced by 1.3 days in the RAPN group compared to LAPN groups (2.4 vs 3.7, P=0.0013). Bleeding complication rates were similar between both groups. Post-operative bleed rates were diagnosed with CT imaging post-operatively showing a new haematoma. Post-operative bleed requiring PRBC was lower in the RAPN compared to the LAPN groups (7% vs 10%). Post-operative bleeding requiring embolization was also similar between RAPN and LAPN groups (7% vs 4%). Acute renal function deterioration was calculated from the difference in pre-operative glomerular filtration rate (GFR) and day 1 (D1) post-operative GFR. Chronic renal function deterioration was calculated from the difference in pre-operative GFR and the GFR taken 6 months post-operatively when GFR tends to plateau following surgery. Acute D1 renal function deterioration was significantly less in the RAPN group compared to the LAPN group 6.1 vs 13.5, P = 0.029). There was no significant difference in chronic renal function deterioration between either group however the RAPN group tended to have more preserved renal function long-term compared to LAPN group (9.1 vs 10.7, P=0.81). There was no significant difference in positive margins rates between RAPN and LAPN groups (11% vs 8%).

	Robotic (N = 46)	Laparoscopic (N=49)	P-value
Mean LOS (days)	2.4	3.7	P=0.0013**
Bleed requiring PRBC	3 (7)	5 (10)	
Bleed requiring embolization	3 (7)	2 (4)	
Acute (D1) GFR reduction (%)	6.1	13.5	P=0.029*
Long-term GFR reduction	9.1	10.7	P=0.81
Positive margins	5 (11)	4 (8)	P=0.74

Table 4: Post-operative outcomes of RAPN and LAPN cohorts

Discussion

The current standard of care recommends PN for T1 renal masses. PN has similar oncological outcomes to RN while sparing the kidney and renal function. This becomes extremely useful where renal masses have not had prior biopsy and may represent benign or indolent tumours. The advent of laparoscopic technology has led to a push towards using this minimally invasive approach to carry out PN. LAPN is proven to be a safe alternative to open PN with comparable oncological outcomes and improved cosmetic, functional outcomes and reduced hospital stays8. The main limitations of LAPN include the increased operative complications and the requirement of advanced laparoscopic skills. Another significant drawback is the need for clamping of hilar vessels and creating a warm ischaemia in the renal tissues for the duration of renal tumour excision and renorrhaphy. Current studies in the field indicate a warm ischaemia time over 30 minutes is associated with renal atrophy and irreversible ischaemic insult to the parenchyma9. Introducing robotic surgery into the realm of renal surgery was in an attempt to ameliorate these limitations acknowledged in LAPN. Robotic surgery represents an evolving and expanding area in many surgical specialties including urology. In 2000, the Da Vinci surgery system became the first FDA approved robotic surgical system to be utilised for laparoscopic operations. Robotics allowed for high resolution, three-dimensional magnified vision, improved dexterity and less tissue contact to improve infection risk. Regarding PN, there is currently a need for ongoing studies to assess if these perceived benefits of robotics can translate into significant improvements in intra-operative and post-operative outcomes compared to the traditional laparoscopic approach.

RAPN have certainly been described in the current literature. Multiple systematic reviews in the field indicate RAPN to be a safe and effective alternative to LAPN. There is evidence that RAPN can reduce warm ishcaemia time compared to LAPN10. Additionally, the benefits of RAPN may be more pronounced in complex renal tumours. Long et al found RAPN was associated with significantly reduced conversion to radical nephrectomy and also reduced deterioration in GFR post-operatively compared to LAPN in complex tumours with high nephrometry scores (≥7)11. Current literature has been useful in displaying some of the benefits in RAPN however when comparing the two approaches there remains inherent inter-operator bias in all the large scale trials. Porpiglia et al

who conducted a large systematic review voiced the significant lack of single surgeon studies in the literature comparing RAPN to LAPN. We aimed to remove inter-operator bias seen in these previous studies while maintaining adequate sample sizes to compare more accurately the two approaches.

In the current study, we compared two groups of demographically similar patients undergoing either RAPN or LAPN. Groups were similar in age, co-morbidities, renal function and tumour sizes. We demonstrated RAPN allowed for a quicker operating time and reduced warm ischemia time. This correlated with significantly improved renal function acutely at day 1. RAPN was also associated with significantly shorter hospital stays compared to the LAPN cohort. Both approaches had acceptable bleeding complication rates and no significant difference was found in intra-operative blood loss or post-operative significant bleeding. Blood loss in the current study was likely under-estimated due some incomplete documentation.

The last single surgeon study was carried out in 2010 by Haber et al when robotics was in its infancy12. This study was a quality retrospective study with good sample size of 150 patients. At this time, they found no significant advantages with RAPN compared to LAPN. While the study was useful in displaying RAPN to be safe and effective, surgeon experience with RAPN was deemed to be inferior to the laparoscopic approach which could under-represent benefits of the robotic approach. In our study, we consider comparisons between both groups to be more accurate with surgeon experience being extensive and equal in both robotic and laparoscopic surgery. Thus, in contrast to this previous study we were able to highlight a multitude of benefits to using RAPN.

The leading limitation of the present study include the retrospective. One such example of this is intra-operative blood loss. Retrospectively reviewed documentation found often incomplete documentation of blood loss and so both groups likely had under-estimated numbers. Sample size is an inherent difficulty in single surgeon series. While our sample was deemed adequate for statistical analysis, a larger sample could improve quality of the paper. The utilisation of a single operator minimized inter-operator and surgical bias between the two approaches. Although two different hospitals were utilised to obtain an adequate sample size, our team was confident medical care was similar in both locations and feel this should not skew results.

Conclusion

RAPN is a safe and effective approach which in our study displayed multiple benefits compared to LAPN. Benefits of RAPN include quicker operative times, reduced clamp time, earlier hospital discharge and improved acute renal function. This represents the first single surgeon study to highlight these advantages. Further large-scale prospective trials are required to further explore the role of robotics in renal preservation surgery.

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