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ORIGINAL ARTICLE

Transitioning to robotic partial nephrectomy with a team-based proctorship achieves the desired improved outcomes over open and laparoscopic partial nephrectomy

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Abstract
Proctoring may facilitate a safe transition to robotic-assisted partial nephrectomy (RAPN) for centres performing open (OPN) and laparoscopic partial nephrectomies (LPN). This study compared the 5-year outcomes of RAPN, initiated with a team-based proctorship, with OPN and LPN. Following an observation course at the proctor's institution and a 3-surgeon performance of proctored RAPN in August 2014, a review of 90 RAPN, 29 LPN and 43 OPN consecutively performed by the same team from 2013 to 2019 at National University Hospital, Singapore was conducted. Peri-operative data, functional and oncological outcomes were compared amongst the three groups. Most cases were performed robotically after 2015 with comparable baseline characteristics in all groups. Median RENAL Nephrometry Score was not significantly different between RAPN (8 [IQR 6, 9]) and OPN (9 [IQR 7, 10]) ($P=0.12$) but was significantly lower for LPN (7 [IQR 5, 8]) compared to RAPN ($P=0.002$). RAPN achieved the lowest blood loss (226 ml vs.348 ml and 263 ml for OPN and LPN respectively, $P=0.02$), transfusion rate (3% vs.21% and 17% respectively, $P=0.003$) and median length of stay after surgery (4 vs.6 and 5 days respectively, $P=0.001$). Complication rates, warm ischemic times were similar between the three approaches with no differences in 1-year and long-term renal function. The rate of positive surgical margin was 8%, 8% and 3% for RAPN, LPN and OPN, respectively ($P=0.76$), with a single recurrence in each arm. Despite modest hospital volume, a team-based proctorship facilitated the transition to the Da Vinci robotic platform to perform partial nephrectomies of equivalent complexities as open surgery, achieving improved perioperative outcomes, while maintaining oncological and kidney functional results.

Keywords Proctorship · Robotic partial nephrectomy

Introduction

Robotic partial nephrectomy (RAPN) has been performed with increasing numbers for the treatment of renal masses and good outcomes have been reported at high-volume centres. Data from these centres, reviewed in recent meta-analyses, demonstrate superior outcomes in RAPN when compared to laparoscopic (LPN) and open partial nephrectomies (OPN) [1–3]. However, it is unclear these benefits can be translated to lower volume centres starting their RAPN programs. A 'real world' plan to adopt robotic surgery for partial nephrectomies (PN) is increasingly needed in the current era of increased attention on volume-dependent outcomes [4].

Surgical Proctorship refers to the observation by a proctor for the assessment of skills and knowledge of the surgeon during the initial learning curve of a surgery for the purposes of privileging [5]. The learning curve for RAPN has been reported to be shorter than LPN (about 2 dozen cases) for an experienced surgeon [6, 7]; hence, RAPN may be an ideal procedure for proctoring to evaluate surgical competency for the safe introduction of a RAPN program in a centre with prior experience in OPN, LPN and robotic assisted prostatectomies (RAP). Currently, there are no guidelines for certifying proctors or what a robotic surgical proctorship entail.

At the National University Hospital (NUH), Singapore, RAPN was started in August 2014 following a team-based

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proctorship with an expert proctor. This study aims to assess our 5-year experience of RAPN, kickstarted by the proctorship, by comparing centre specific outcomes before and after the adoption of the Da Vinci Si robotic platform (Intuitive Surgical, Sunnyvale, CA).

Materials and methods

Following Institutional Review Board's approval, a retrospective analysis of clinical data from an institutional nephrectomy database (NUH/2010-0079) was performed for all consecutive PN cases between 2013 and 2019. This period overlapped the period when RAPN was introduced. All surgeries were performed by a team of 3 surgeons who were fellowship trained in RAP and OPN or in LPN and OPN. The surgeon in charge of each patient was designated console surgeons with other members rotating as bedside assistant.

The team-based proctorship included a 1-day live surgery observation course by the 3 surgeons at the proctor's institution (Severence Hospital, Korea) (http://robotmis.iseverance.com/training/brochure/Urology.pdf). Two surgical cases were then performed under proctorship in August 2014 at NUH. All RAPN cases were performed transperitoneally using the da Vinci Si Surgical System with standard 4 arm multiport technique [8], with full arterial clamping and selective venous clamping. Unclamping was performed only after renorrhaphy was completed for both the inner medullary and outer cortical closure using the sliding-clip renorrhaphy technique.

An important feature of the team-based proctorship was close communication between the team and proctor surgeon pre-operatively. Online case selection before the operative date ensured that suitably difficult cases were selected and facilitated discussion of the surgical strategy, operative equipment, theatre, and nursing staff set up. The proctor also previewed the surgical videos of LPN performed by the learner surgeons to understand the team's 'level' and to discuss on nuanced differences in the robotic and laparoscopic techniques. These preparations optimised the opportunities for the team to complete both proctored surgeries themselves. A fourth important feature was a debrief session with follow-up online discussions to ensure the program takes off.

Data analysis

To assess the long-term performance of the surgical team on RAPN following the proctorship, all PN patients from 2013 to 2019 were divided into three groups (OPN, LPN and RAPN) for purposes of comparison. Demographic and clinical characteristics of the patients were summarized using frequencies and percentages for categorical variables, means and standard deviations for normally distributed continuous variables and median and interquartile range (IQR) for skewed continuous variables. Data captured included tumour complexity based on RENAL Nephrometry score (RNS) [9], operative time, warm ischemic time (WIT), estimated blood loss (EBL), length of stay (LOS), estimated glomerular filtration rate (eGFR), new-onset chronic kidney disease (CKD), complications according to Clavien–Dindo classification [10], pathological cell type, grade, stage and margin status. Operative time was defined as the time from first incision to the completion of skin closure and included docking and undocking of the robot. WIT was defined as the time from initial vascular clamping until removal of the final arterial clamp. EGFR was calculated using the CKD-EPI equation [11], and patients were classified as having CKD if eGFR was less than 60 mls/min/1.73m^2 [12]. Fisher's exact test, Chi-square test, independent two-sample *t* test or one-way ANOVA for 3 samples were used for statistical analysis. For non-parametric data, Wilcoxon rank sum and Kruskal–Wallis test were used for two and three sample comparison of the medians respectively. Kaplan Meier survival analysis for new-onset CKD and local recurrence was compared between the 3 surgical approaches using log-rank test. All statistical analyses were generated using STATA software, version 11 (StataCorp LP, College Station, USA).

Results

Baseline characteristics and tumor complexity

There was a total of 169 PN performed for small renal masses (SRM) during the period 2013–2019, including a total of 43 OPN, 29 LPN and 90 RPN. After the proctor program, Fig. 1 shows a clear trend towards an increasing

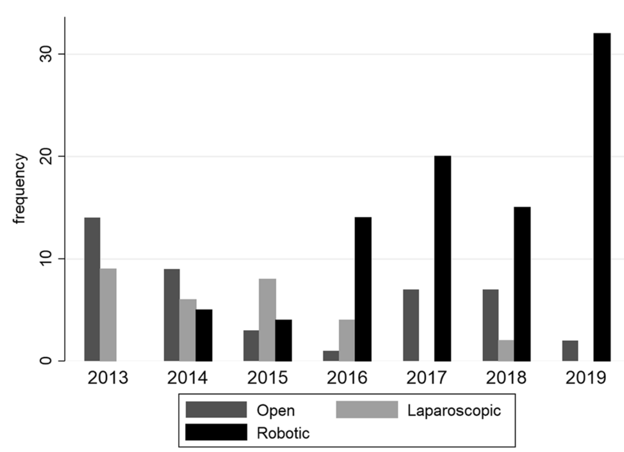

Fig. 1 Bar chart showing a number of PN cases yearly at NUH from 2013 to 2019 for the three different surgical platforms

number of RAPN and decreasing LPN and OPN over the years, with the majority of PN performed robotically by 2016. The use of the robotic platform after proctorship may have also contributed to the overall increase in numbers of PN performed at our institution, qualifying it as a medium volume centre with 15–23 cases a year [4]. As a result of subspecialty and prior fellowship training in kidney surgery but minimal robotic experience, author HYT performed the majority of the PN cases (OPN $n = 22$, 51%, LPN $n = 28$, 97% and RAPN $n = 68$, 76%). Authors EC and LT, who were primarily robotic prostatectomy, did the remaining cases as primary surgeons. However, all three rotated as bedside assistant surgeons for RPN during the study period.

Table 1 shows no significant differences in the distribution of pre-operative patient demographics, co-morbidities, surgical side, body mass index, pre-operative renal function between the approaches, except that a greater proportion of RAPN patients were Chinese (68%). Two RAPN patients had solitary functioning kidneys. Median RNS was significantly lower ($P = 0.002$) between LPN (7 [IQR 5, 8]) and both other groups but it was not significantly different ($P = 0.12$) between OPN (9 [IQR 7, 10] and RAPN (8 [IQR 6, 9]). Similarly, a significantly greater proportion ($P = 0.005$) of patients undergoing LPN (48%) was of low complexity (RNS4-6) compared with OPN (12%) and RAPN (30%). However, the distribution of cases in the 3 RNS complexity categories was not significantly different ($P = 0.07$) between OPN and RAPN alone. Mean radiological tumour size was significantly larger in the open group compared to both minimally invasive groups but there were no differences in tumour polar locations, the proportion of cystic tumours and multiple arteries.

Perioperative and renal function outcomes (Table 2)

Although operative time was not significantly different between all 3 groups, RAPN took significantly longer than OPN by an average of 24 min ($P = 0.03$). There were 3 conversions to open in the LPN (10%) and 1 conversion to radical nephrectomy in RAPN group (1%). Significantly, RAPN achieved the lowest mean estimated blood loss (226 ml vs. 348 ml and 263 ml for OPN and LPN respectively, $P = 0.02$ for RAPN vs. OPN); this corroborated with a significantly lower haemoglobin drop on post-operative day 1 (1.7 g/dL vs. 2.5 g/dL and 2.4 g/dL for OPN and LPN respectively, $P = 0.004$) and lower perioperative blood transfusion rate than both OPN and LPN (3% vs. 21% and 17% respectively, $P = 0.003$). Although overall complication rates were similar in the three groups (approximately 30%, $P = \text{NS}$), the proportion of complications that was Clavien III was lower in the RAPN (21% of 29 complications) compared with the other approaches (31% of 13 complications in OPN and 50% of 8 complications in LPN, $P = 0.05$). There were no Clavien IV and above complications. Median length of hospital stay was 4 (IQR 3, 5) days in RAPN, compared with OPN (6 [IQR 6, 8] days) and LPN (5 [IQR 4, 6] days), ($P = 0.001$).

Mean WIT was comparable between the three approaches (approximately 30 min, $P = \text{NS}$). The proportion of cases achieving WIT below 20 min (11% vs. 21% and 17% respectively, $P = 0.3$) and 30 min (59% vs. 51% and 59% respectively, $P = 0.4$) for RAPN, OPN and LPN was not statistically different. Clinically, the resultant drop in kidney function by eGFR on 1 day and 1 year post surgery was also equivalent. Although the proportion of patients with new-onset CKD at the end of 1 year was apparently lower in the RAPN group (3% vs. 16% in OPN and 12% in LPN), the longer-term survival of patients without CKD at the end of follow up (1st May 2020) was comparable in the three groups (log rank $P = 0.29$) despite the longer follow up period for OPN patients.

Figure 2 shows the trend over consecutive groups of 30 cases for median operative, estimated blood loss and WIT for RAPN only group in a bar chart. The chart shows improvement and gradual stabilization of these parameters over with each group of 30 cases.

Oncological outcomes

A total of 23 patients (13.6%) had benign tumours on final histology and were excluded from our analysis on oncological outcomes (Table 3). Histological findings were similar in all 3 approaches with predominantly clear cell carcinoma histology. Pathological tumour size was significantly larger ($P < 0.001$) for the OPN (mean 3.7 cm) compared to RAPN and LPN (2.6 cm and 2.1 cm respectively). This meant a difference in the distribution of the tumour's pathological stage between pT1a and pT1b between the three arms. However, the proportion of pT3a stage cancers was equivalent between OPN and RAPN (8% and 7% respectively). Importantly, the rate of positive surgical margin was not different between the 3 groups (8% for RAPN vs. 8% for LPN and 3% for OPN, $P = 0.76$) with a resultant low recurrence rate of a case in each arm at the end of follow up period (1st May 2020), as shown by the Kaplan–Meier curves in Fig. 3 (log rank $P = 0.45$). These recurrences were detected on routine follow-up and managed with radical nephrectomy.

The margins, ischemia and complications (MIC) score had been proposed as a new system for evaluating ideal outcomes achievements in partial nephrectomies [13]. According to this system, an ideal PN is accomplished when surgical margins are negative, WIT < or = 20 min and no major (Clavien–Dindo grade III–IV) complications were observed. The proportion of cases achieving MIC success was 10%, 14% and 17% for RAPN, OPN and LPN respectively, $P = 0.42$.

Table 1 Table showing pre-operative patient demographics, clinical history and tumour characteristics of all patients undergoing PN at NUH from 2013 to 2019

Variable	Category	Open	Laparoscopic	Robotic	P
N		43	29	90	
Age, Years	Mean ± SD	58.0±12.2	57.9±13.8	57.0±11.7	**0.90**
Gender, N	Male	32 (74%)	23 (79%)	60 (67%)	**0.36**
Race, N	Chinese	25 (58%)	13 (45%)	61 (68%)	**0.008**
	Malay	10 (23%)	7 (24%)	6 (7%)	
	Indian	3 (7.0%)	7 (24%)	8 (9%)	
	Others	5 (12%)	2 (7%)	15 (17%)	
Kidney side, N	Right	25 (59%)	20 (69%)	51 (57%)	**0.50**
ASA, N	1	2 (5%)	1 (3%)	8 (9%)	**0.12**
	2	33 (76%)	18 (62%)	70 (78%)	
	3	8 (19%)	10 (35%)	12 (13%)	
Past Medical History, N	Diabetes	10 (23%)	6(21%)	24 (27%)	**0.78**
	Hypertension	23 (54%)	17 (59%)	55(61%)	**0.71**
	Heart Disease	9 (21%)	8 (28%)	13 (15%)	**0.27**
	Nephrolithiasis	2 (5%)	0 (0%)	9 (10%)	**0.14**
Smoker, N	No	31 (72%)	19 (66%)	67 (74%)	**0.62**
Body Mass Index	Mean ± SD	25.7 ±4.6	25.0±4.0	26.9±4.4	**0.09**
Pre-Operative eGFR, mls/min/1.73m^2	Mean ± SD	83.0±23.3	85.1±23.6	88.7±20.2	**0.35**
Pre-Op eGFR<60 mls/min/1.73m^2, N		7 (16%)	4 (14%)	9 (10%)	**0.6**
Radiological size (cm)	Mean± SD	4.4±3.9	2.6±1.2	2.9±1.5	**<0.001**
RENAL Score	Median [IQR]	9[7,10]	7[5,8]	8[6,9]	**0.002**
RENAL Score [Open vs. Robot]	Median [IQR]	9[7,10]	[redacted]	8[6,9]	**0.12**
Complexity	Low (4-6)	5 (12%)	14 (48%)	27 (30%)	**0.005**
	Moderate (7-9)	27 (63%)	14 (48%)	43 (48%)	
	High (10-12)	11 (25%)	1 (4%)	20 (22%)	
Complexity (Open vs. Robot)	Low (4-6)	5 (12%)	[redacted]	27 (30%)	**0.07**
	Moderate (7-9)	27 (63%)		43 (48%)	
	High (10-12)	11 (25%)		20 (22%)	
Tumor Location	Upper	18 (42%)	7 (24%)	18 (20%)	**0.35**
	Middle	19 (44%)	9 (31%)	42 (47%)	
	Lower	6 (14%)	13 (45%)	30 (33%)	
Cystic, N		3 (7%)	5 (17%)	14 (16%)	**0.32**
Multiple Arteries, N		7 (16%)	4 (14%)	22 (24%)	**0.54**

Blacked-out laparoscopic column shows the direct comparison between open and robotic only

Table 2 Table showing perioperative and renal function outcomes of all patients undergoing PN at NUH from 2013 to 2019

Variable	Category	Open	Laparoscopic	Robotic	P
N		43	29	90	
Operative Time (Min)	Mean ± SD	223.9±52	234.1±55.0	247.3±61.8	**0.09**
Operative Time (Min) Open vs. Robot	Mean ± SD	223.9±52		247.3±61.8	**0.03**
Estimated Blood Loss (ml)	Mean ± SD	348±408.2	263.3±292.3	226.1±199.1	**0.08**
Estimated Blood Loss (ml) Open vs. Robot	Mean ± SD	348±408.2		226.1±199.1	**0.02**
HB Drop POD1 (g/dL)	Mean ± SD	2.5±1.4	2.1±1.6	1.7±1.0	**0.004**
Blood Transfusions		9 (21%)	5 (17%)	3 (3%)	**0.003**
Complications	Overall	13 (30%)	8 (28%)	29(32%)	**0.89**
	Clavien I	4 (31% of 13)	2 (25% of 8)	21 (72% of 29)	**0.05**
	Clavien II	5 (38%)	2 (25%)	2 (7%)	
	Clavien IIIa	1 (8%)	2 (25%)	4 (14%)	
	Clavien IIIb	3 (23%)	2 (25%)	2 (7%)	
Length of Stay (days)	Median [IQR]	6 [6,8]	5 [4,6]	4 [3,5]	**0.001**
Warm Ischemic Time (Min)	Mean ± SD	30.1±15.9	29.8±15.9	30.4±10.5	**0.98**
WIT<20 min	N	9 (21%)	5 (17%)	10(11%)	**0.3**
WIT<30 min	N	22(51%)	17(59%)	53 (59%)	**0.4**
eGFR POD1, mls/min/1.73m^2	Mean ± SD	64.7±23.2	74.4±24.1	71.5±22.5	**0.19**
eGFR Drop POD1, mls/min/1.73m^2	Mean ± SD	18.3±15.2	10.7±10.2	17.1±16.3	**0.08**
eGFR Drop 1 Year, mls/min/1.73m^2	Mean ± SD	12.3±16.2	10.3±9.4	8.1±9.3	**0.30**
New Onset eGFR<60 mls/min/1.73m^2@1 Year, N		7 (16%)	3 (12%)	3 (3%)	**0.02**
eGFR<60 @ End f/up, N		14 (33%)	7 (25%)	14(18%)	**0.14**
Renal Function f/up Days	Mean ± SD	1305±873	1567±547	754±610	**<0.001**

Blacked-out laparoscopic column shows the direct comparison between open and robotic only

Discussion

In our medium volume institution, adoption of the Da Vinci robotic platform following a team-based proctorship facilitated the performance of partial nephrectomies of equivalent complexities as open surgery with maintained oncological and kidney functional outcomes but significantly lower blood loss, transfusion rate and hospital length of stay. This was not demonstrated by LPN which was performed on selected SRMs of significantly lower complexities.

PN is now the standard treatment for SRM according to all major society guidelines [14]. Systematic reviews have reported superior outcomes in RAPN over both OPN and LPN [1–3]. Our study reported perioperative benefits of RAPN in blood loss, blood transfusion rate and length of stay over both LPN and OPN that are consistent with the above systematic reviews. In addition, hard measures

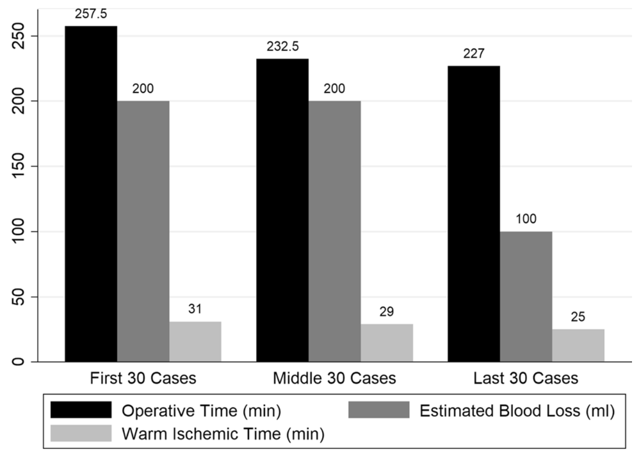

Fig. 2 Bar chart showing the trend in operative time, warm ischemic time, and estimated blood loss for consecutive 90 RAPN cases split into 3 consecutive groups of 30 at NUH

including complication rate and kidney function post-surgery were well preserved with the transition to RAPN. Oncological outcomes in terms of margin positivity and local recurrence was also equivalent in all modalities and reassuringly similar to the oncological outcomes in mature single-institutional series [15]. The strengths of the study are that the use of intra-institutional comparisons between the different platforms and the use of comprehensive outcome measures. We believe this provides clear and relevant quality assurances for the safe transitioning to the robotic platform from laparoscopic or open approaches.

Certainly, there is room for improvement to reduce our MIC rates for RAPN when compared to results from larger leading institutions [16]; The low MIC achievement rates were limited by missing the WIT target of 20 min. During the initial transition to RAPN, we prioritized WIT below achieving negative margins and avoiding complications while mounting the learning curve (Fig. 2), based on recent evidence on the limited impact of controlled ischemia on kidney tissues [17, 18]. If the trifecta criteria were modified for WIT < 30 min whilst maintaining the other factors, the rates of achieving trifecta success for RAPN would improve to 48%, 37% and 38% for RAPN, OPN and LPN respectively, $P = 0.42$. Nevertheless, with Fig. 2 showing plateauing of our WIT improvement, the team plans to adopt early unclamping [19] to further improve our WIT. Criticisms of the MIC system include the absence of more relevant oncologic and functional outcomes as well as the lack of stratification of the scores according to nephrometry risk group categories [20]. Indeed, our tumour complexity as measured by RNS is comparatively high. We, therefore, feel in addition to MIC, the adoption of RAPN needs to be evaluated by comparing with relevant own institutional outcomes of other PN platforms and to consider the concrete, long-term functional and oncological outcomes.

The importance of a careful transition to the robotic platform, despite multiple reports of its advantages, is real and current. With commercial marketing further contributing to the increased utilization and dissemination of robotic surgery, there will be widespread community performance of RAPN. Utilization of RAPN in the United States surpassed OPN in 2012; it accounted for 49% of all PN in that year, compared to only 20% in 2009 [21]. As evidenced by a plenary debate on RAPN during European Association of Urology Congress 2019, RAPN

Table 3 Pathological and oncological outcomes of patients with cancer undergoing PN at NUH from 2013 to 2019

Variable	Category	Open	Laparoscopic	Robotic	*P*
Cancer cases only	*N*	39	25	75	
Histology	Clear cell	34 (79%)	16 (55%)	60 (67%)	0.50
	Papillary	2 (5%)	6 (21%)	8 (9%)	
	Chromophobe	1 (2%)	2 (7%)	3 (3%)	
	Malignant—others	2 (5%)	1 (3%)	4 (4%)	
pT Stage	pT1a	25 (64%)	23 (92%)	62 (82%)	0.018
	pT1b	11 (28%)	0 (0%)	8 (11%)	
	pT3a	3 (8%)	2 (8%)	5 (7%)	
pTumour size, cm	Mean ± SD	3.7 ± 1.5	2.1 ± 0.7	2.6 ± 1.0	< 0.001
WHO grade	1	3 (8%)	2 (8%)	14 (19%)	0.50
	2	15(42%)	15 (50%)	35 (44%)	
	3	16(44%)	8 (32%)	28 (35%)	
	4	2 (6%)	0 (0%)	2 (3%)	
Surgical margin	Positive	1 (3%)	2 (8%)	6 (8%)	0.76
Local recurrence	N	1 (2%)	1 (3%)	1 (1%)	0.72
Cancer F/up, days	Mean ± SD	1285 ± 884	1663 ± 549	589 ± 576	< 0.001
MIC success	All 3 factors	6 (14%)	5 (17%)	9 (10%)	0.55

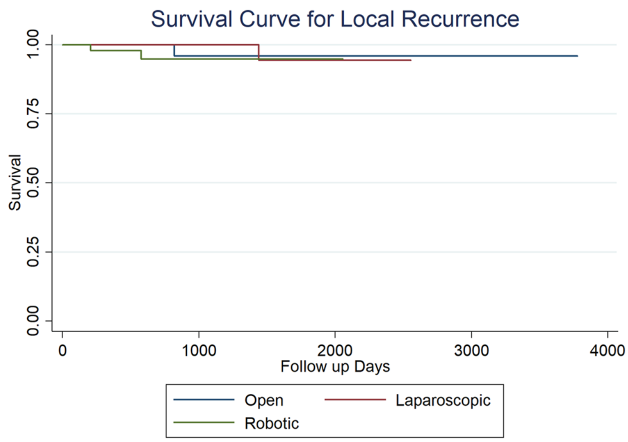

Fig. 3 Kaplan–Meier Survival Curve for local recurrences of kidney cancer patients undergoing PN, stratified by surgical modalities

in low-volume centres potentially can result in decreased patient satisfaction with increased transfusion rates, positive margins and conversion to open surgery [22]. Hence, it was recommended that doctors experienced in open surgery in such centres should stick to the open technique. On the other hand, for surgeons to be able to harness the robotic advantage, there is a corresponding call for improved robotic surgical training and template for robotic proficiency [22]. Several projects are developing a RAPN curriculum but are all pending validation [23]. There are currently also no guidelines for what a RAPN proctorship should entail and it may just be limited to the time the expert surgeon takes out of his/her practice to observe the surgeon learner perform cases [5]. As shown in our study, a proctor program partnered with a high-volume centre and expert surgeon is acutely useful in our settings because it enabled us to use adapt to the robotic platform with confidence on complex cases that would have otherwise been done with OPN (rather than LPN) previously. The benefits of such a proctorship were sustainable over 5 years of the review. Indeed, we felt that the above proctorship was more akin in its detail to a previously described mini fellowship training program for robot-assisted laparoscopic prostatectomy, which also reported durable long-term impact with 86% of participants performing the surgery after 3 years [24]. In addition, our proctorship was structured to be team-based rather than a single learner surgeon for better success. Such observations were also reported by Gamboa et al., who found that partnered attendees in their 5-day program had a higher chance of performing robotic prostatectomy at 3 years than solo attendees [24].

The above proctorship differs from a robotic preceptorship. Preceptoring is a form of training whereby an experienced surgeon scrubs in or supervises the procedure with the intention of guiding the surgeon learner with a hands-on approach [5]. The practicalities and cost of preceptorship is obviously much more difficult and greater than a proctorship. Preceptorship may not be needed for surgeons with prior experience in the performance of OPN, or LPN because the learning curve may be foreshortened for such surgeons [6]. A team-based proctorship as described is adequate for the transition of such surgeons to the robotic platform. Similar reports of proctor environment over three cases had been used for faculty training in paediatric robotic-assisted laparoscopic pyeloplasty [25].

We acknowledged that this is a retrospective review of a medium volume centre on RAPN outcomes and adds minimal new information on its comparative benefits over OPN and LPN. However, there are currently few reports on the role of a simple proctorship framework, as described above, for transitioning to the robotic platform. Such a framework may be more relevant to smaller centres and can potentially be easily translated to other surgical disciplines too. Another limitation of this study was the uneven distribution of caseload between the three team surgeons. The outcomes may therefore be more surgeon specific rather team specific. Nevertheless, the study probably reflects real-world practice where despite different case volumes, robotic surgery requires collaboration between team members to be successful. Lastly, despite similar equivalent tumour complexity scores, it was clear that during this transitional period, the surgeons were selecting the smaller tumours for the LPN and RPN approach with the largest tumours performed with OPN. However, with increased confidence and the progressive reduction in the open approach, we expect that the increasing larger tumours will be tackled robotically.

Conclusions

A comprehensive team-based proctorship is useful for a sustained transition of a medium volume centre to the robotic platform, achieving improved perioperative outcomes despite equally complex cases as the open technique; the same was not achieved laparoscopically. We propose the above program as a potential framework to ensure the safety of patients and surgeons alike when initiating a RAPN at an institution and call for others to report their best practices during the adoption of robotic surgery.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by AC, LT, EC and HYT. The first draft of the manuscript was written by HYT and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration

Conflict of interest The authors declare that they have no conflict of interest.

Human rights statements 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 1964 and its later amendments.

Informed consent Informed consent was waived following review by institutional review board for all patient data was annoymised for study analysis.

References

1. Aboumarzouk OM, Stein RJ, Eyraud R et al (2012) Robotic versus laparoscopic partial nephrectomy: a systematic review and meta-analysis. Eur Urol 62(6):1023–1033
2. Tsai SH, Tseng PT, Sherer BA et al (2019) Open versus robotic partial nephrectomy: systematic review and meta-analysis of contemporary studies. Int J Med Robot Comput Assist Surg MRCAS 15(1):e1963
3. Choi JE, You JH, Kim DK, Rha KH, Lee SH (2015) Comparison of perioperative outcomes between robotic and laparoscopic partial nephrectomy: a systematic review and meta-analysis. Eur Urol 67(5):891–901
4. Xia L, Pulido JE, Chelluri RR et al (2018) Hospital volume and outcomes of robot-assisted partial nephrectomy. BJU Int 121(6):900–907
5. Zorn KC, Gautam G, Shalhav AL et al (2009) Training, credentialing, proctoring and medicolegal risks of robotic urological surgery: recommendations of the society of urologic robotic surgeons. J Urol 182(3):1126–1132
6. Haseebuddin M, Benway BM, Cabello JM, Bhayani SB (2010) Robot-assisted partial nephrectomy: evaluation of learning curve for an experienced renal surgeon. J Endourol 24(1):57–61
7. Hanzly M, Frederick A, Creighton T et al (2015) Learning curves for robot-assisted and laparoscopic partial nephrectomy. J Endourol 29(3):297–303
8. Komninos C, Shin TY, Tuliao P et al (2014) R-LESS partial nephrectomy trifecta outcome is inferior to multiport robotic partial nephrectomy: comparative analysis. Eur Urol 66(3):512–517
9. Kutikov A, Uzzo RG (2009) The R.E.N.A.L nephrometry score: a comprehensive standardized system for quantitating renal tumor size, location and depth. J Urol 182(3):844–853
10. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240(2):205–213
11. Levey AS, Stevens LA, Schmid CH et al (2009) A new equation to estimate glomerular filtration rate. Ann Intern Med 150(9):604–612
12. Levey AS, Coresh J, Balk E et al (2003) National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Ann Intern Med 139(2):137–147
13. Buffi N, Lista G, Larcher A et al (2012) Margin, ischemia, and complications (MIC) score in partial nephrectomy: a new system for evaluating achievement of optimal outcomes in nephron-sparing surgery. Eur Urol 62(4):617–618
14. Campbell SC, Novick AC, Belldegrun A et al (2009) Guideline for management of the clinical T1 renal mass. J Urol 182(4):1271–1279
15. Bertolo R, Garisto J, Dagenais J et al (2019) Transperitoneal robot-assisted partial nephrectomy with minimum follow-up of 5 years: oncological and functional outcomes from a single institution. Eur Urol Oncol 2(2):207–213
16. Lista G, Buffi NM, Lughezzani G et al (2015) Margin, ischemia, and complications system to report perioperative outcomes of robotic partial nephrectomy: a European Multicenter Observational Study (EMOS project). Urology 85(3):589–595
17. Parekh DJ, Weinberg JM, Ercole B et al (2013) Tolerance of the human kidney to isolated controlled ischemia. J Am Soc Nephrol 24(3):506–517
18. Nahar B, Bhat A, Parekh DJ (2019) Does every minute of renal ischemia still count in 2019? unlocking the chains of a flawed thought process over 5 decades. Eur Urol Focus 5(6):939–942
19. Goonewardene SS, Brown M, Challacombe B (2017) Robotic partial nephrectomy and early unclamping: an evolving paradigm. J Robot Surg 11(1):93–94
20. Mottrie AM (2012) Editorial Comment on: margin, ischemia, and complications (MIC) score in partial nephrectomy: a new system for evaluating achievement of optimal outcomes in nephron-sparing surgery. Eur Urol 62(4):617–619
21. Bahler CD, Monn MF, Flack CK, Gramm AR, Gardner TA, Sundaram CP (2018) Assessing cost of robotic utilization in partial nephrectomy with increasing utilization. J Endourol 32(8):710–716
22. Tidman J (2018) Renal cell carcinoma: controversies in care. Eur Urol Today Congr News 23:1–2
23. Larcher A, De Naeyer G, Turri F et al (2019) The ERUS Curriculum for robot-assisted partial nephrectomy: structure definition and pilot clinical validation. Eur Urol 75(6):1023–1031
24. Gamboa AJ, Santos RT, Sargent ER et al (2009) Long-term impact of a robot assisted laparoscopic prostatectomy mini fellowship training program on postgraduate urological practice patterns. J Urol 181(2):778–782
25. Mason MD, Herndon CDA, Herbst KW et al (2014) Proctor environment facilitates faculty training in pediatric robotic-assisted laparoscopic pyeloplasty. J Robot Surg 8(4):365–369