

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

Tan, JLS;Sathianathen, N;Cumberbatch, M;Dasgupta, P;Mottrie, A;Abaza, R;Ho Rha, K;Yuvaraja, TB;Parekh, DJ;Capitanio, U;Ahlawat, R;Rawal, S;Buffi, NM;Sivaraman, A;Maes, KK;Gautam, G;Porpiglia, F;Turkeri, L;Bhandari, M;Challacombe, B;Roscoe Porter, J;Rogers, CR;Moon, DA

Title:

Outcomes in robot-assisted partial nephrectomy for imperative vs elective indications

Date:

2021-12-01

Citation:

Tan, J. L. S., Sathianathen, N., Cumberbatch, M., Dasgupta, P., Mottrie, A., Abaza, R., Ho Rha, K., Yuvaraja, T. B., Parekh, D. J., Capitanio, U., Ahlawat, R., Rawal, S., Buffi, N. M., Sivaraman, A., Maes, K. K., Gautam, G., Porpiglia, F., Turkeri, L., Bhandari, M., ... Moon, D. A. (2021). Outcomes in robot-assisted partial nephrectomy for imperative vs elective indications. BJU International, 128 (S3), pp.30-35. <https://doi.org/10.1111/bju.15581>.

Persistent Link:

<https://hdl.handle.net/11343/299068>

Title: Outcomes in robotic-assisted partial nephrectomy for imperative versus elective indications.

Authors:

Tan J.¹, Sathianathan N.¹, Cumberbatch M.¹, Dasgupta P.², Mottrie A.³, Abaza R.⁴, Rha K.H.⁵, Yuvaraja T.B.⁶, Parekh D.J.⁷, Capitanio U.⁸, Ahlawat R.⁹, Rawal S.¹⁰, Buffi N.M.¹¹, Sivaraman A.¹², Maes K.K.¹³, Gautham G.¹⁴, Porpiglia F.¹⁵, Turkeri L.¹⁶, Bhandari M.¹⁷, Challacombe B.¹⁸, Porter J.¹⁹, Rogers C.²⁰, and Moon D.¹

Affiliations: ¹Peter MacCallum Cancer Centre, Division of Cancer Surgery, Genitourinary Oncology, Melbourne, Australia, ²King's College, DMRC Centre of Transplantation, London, United Kingdom, ³ORSI Academy, Dept of Urology, Melle, Belgium, ⁴Dublin Methodist Hospital, Dept of Urology, Ohio, United States of America, ⁵Yonsei University Health System, Dept of Urology, Seoul, South Korea, ⁶Kokilaben Dhirubhai Ambani Hospital, Dept of Urology, Mumbai, India, ⁷University of Miami Health System, Dept of Urology, Miami, United States of America, ⁸San Raffaele Hospital, Milan, Italy, Dept of Urology, Milan, Italy, ⁹Medanta The Medicity Hospital, Dept of Urology, New Delhi, India, ¹⁰Rajiv Gandhi Cancer Institute and Research Centre, Dept of Urology, New Delhi, India, ¹¹Humanitas Research hospital, Dept of Urology, Milan, Italy, ¹²Apollo Hospitals, Dept of Urology, Chennai, India, ¹³Center for Robotic and Minimally Invasive Surgery, Hospital Da Luz, Dept of Urology, Luz Saúde, Portugal, ¹⁴Max Institute of Cancer Care, Max Hospital, Dept of Urology, New Delhi, India, ¹⁵San Luigi Gonzaga Hospital of Orbassano, Dept of Urology, Turin, Italy, ¹⁶Acibadem Hospitals Group, Dept of Urology, Istanbul, Turkey, ¹⁷Vattikuti Foundation, Dept of Urology, Detroit, United States of America, ¹⁸Guys and St Thomas' Hospital, London, United Kingdom, ¹⁹Swedish Medical Centre, Seattle, WA, USA, ²⁰Henry Ford Hospital, Detroit, MI, USA.

Corresponding author: Dr Jo-Lynn Tan

Email: jolynnstan@gmail.com

Keywords: Partial nephrectomy, robotic-assisted, imperative indications, renal cancer

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/bju.15581](https://doi.org/10.1111/bju.15581)

This article is protected by copyright. All rights reserved

Received Date:

Revised Date:

Accepted Date:

Article Type: Original Article

Abstract:

Objectives: To assess and compare perioperative outcomes of patients undergoing robotic-assisted partial nephrectomy (RAPN) for imperative versus elective indications.

Patient and methods: We retrospectively reviewed a multinational database of 3,802 adult patients who underwent RAPN for elective and imperative indications. Laparoscopic or open PN were excluded. Baseline data for age, gender, BMI, ASA and PADUA score were examined. Patients undergoing RAPN for an imperative indication were matched to those having surgery for an elective indication using propensity scores in a 1:3 ratio. Primary outcomes included organ ischaemic time, operative time, estimated blood loss, rate of blood transfusions, Clavien-Dindo complications, conversion to radical nephrectomy (RN) and positive surgical margins.

Results: After propensity score matching for baseline variables, a total of 304 patients (76 imperative vs 228 non-imperative indications) were included in the final analysis. No significant differences were found between groups for ischaemic time (19.9min vs 19.8min, $p=0.94$), operative time (186min vs 180min, $p=0.55$), estimated blood loss (217mL vs 190mL, $p=0.43$), rate of blood transfusions (2.7% vs 3.7%, $p=0.51$), or Clavien-Dindo complications ($p=0.31$). A 38.6% (SD 47.9) decrease in Day 1 post-operative eGFR was seen in the imperative indication group and a 11.3% (SD 45.1) decrease in eGFR seen in the elective indications group, $p<0.005$; no recorded cases of permanent or temporary dialysis were seen. There were no conversions to RN in the imperative group and 5.6% ($n=7$) conversions in the non-imperative group ($p=0.69$). Positive surgical margins were seen in 1.4% (1/76) of the imperative group and 3.3% of the non-imperative group (7/228), $p=0.69$.

Conclusion: RAPN is feasible and safe for imperative indications and demonstrates similar outcomes to elective indications.

Introduction

Partial nephrectomy (PN) is the standard treatment for kidney tumours in imperative settings.⁽¹⁾ These can be defined as situations in which there is a congenital or acquired single kidney, moderate to advanced chronic kidney disease (CKD), and the presence of bilateral tumours or hereditary renal cancers where the risk of developing future tumours after surgery is high e.g. von Hippel-Lindau (VHL) disease. The primary goals of treatment are to eradicate the cancer, whilst maximally preserving renal function and avoiding the need for dialysis or transplantation.

Open PN (OPN) is historically the ‘gold standard’ treatment for tumour resection in solitary kidneys (2,3) and available long-term oncological data comparing robotic-assisted PN (RAPN) to OPN is limited and mixed (4,6-7). Compared to OPN, RAPN has been shown to offer reduced complications, shorter length of hospital stay, and fewer positive margins, even when performed for renal tumours in imperative indications (8–10). RAPN has been shown to be safe and efficacious for complex renal tumours (11), although published data on its outcomes in imperative indications remains limited (5,12). It has steadily replaced laparoscopic partial nephrectomy with the superior image resolution, enhanced dexterity of robotic instrumentation, use of immunofluorescence for selective clamping, and the integrated ultrasonography during RAPN.

An overall observed trend in the gradual increase in offering of RAPN for solitary renal tumours has therefore been seen (13), yet it remains that fewer RAPN than OPN are offered for imperative indications as they are regarded as “high stakes” scenarios. For many of these patients, the treatment options have traditionally consisted of major open surgery, or ablative therapies which are not considered the gold standard. Yet many of these patients present with multiple comorbidities, making the reduced complication rate and enhanced recovery of minimally invasive surgery a far more attractive option. Given the time passed since the advent of robotic surgery, surgeon skillset and experience has also grown. We hypothesize that peri-operative and surgical outcomes after RAPN for renal tumours in imperative indications are now comparable to elective PN for ‘usual’ indications.

We aimed to compare the peri-operative and surgical outcomes in RAPN for imperative versus elective indications by conducting the largest to date retrospective assessment using the Vattikuti Collective Quality Initiative (VCQI) multinational database.

Patients and Methods

We conducted a retrospective review of the multinational Vattikuti Collective Quality Initiative (VCQI) database for all adult patients who underwent RAPN for elective and imperative indications between September 2006 to March 2020. Imperative indications were defined as those who underwent RAPN with a solitary kidney, had bilateral renal tumours, and known CKD. Using K/DIGO 2012 Clinical Practice Guidelines, CKD was defined by an estimated glomerular filtration rate (eGFR) of <45mL/min. Our studied cohort included RAPN cases performed by 19 surgeons across 19 centres, and from 9 different countries (USA, Australia, UK, Italy, India, Portugal, Belgium, South Korea and Turkey). Laparoscopic and open partial nephrectomy were excluded.

The VCQI is an international collaboration of medical institutions, whose focus is on improving the quality of care in robotic surgery around the world. Ethics committee approval for data collection was obtained at each participant centre.

Baseline data collected included age (age in years at date of surgery), gender (male or female), BMI (kg/m²), American Society of Anesthesiologists (ASA) physical status classification, and Preoperative Aspects and Dimensions Used for Anatomical classification (PADUA) scores. Perioperative and operative outcomes used were:

warm ischaemic time (defined as the number of minutes passed from the clamping of the main renal artery until the unclamping in patients who had clamping without the use of regional hypothermia), operative time (number of minutes from first skin incision to placement of the last skin suture), estimated intraoperative blood loss (mL), need for intraoperative conversion to radical nephrectomy (RN), blood transfusions (number of units received during entire hospital admission), change in Day 1 eGFR (mL/min), Clavien-Dindo classification grade for post-operative complications,(14) and surgical margin status (positive or negative). Further analysis of ‘trifecta outcomes’ was performed. This was defined as having a warm ischaemic time of less than 20 minutes, negative surgical margins, and no intraoperative complications immediately post-op or within 3 months of RAPN.(25) An imperative indication for RAPN was defined by having a solitary kidney, CKD,

Due to the large multinational nature of this database, the authors attempted to obtain any missing data by contacting the VCQI database manager. All complete and retrievable datasets were analysed. Differences between the imperative and elective indication groups were compared using Student’s t test for continuous variables and chi-square test for categorical variables. We then performed a propensity score analysis with direct matching to address the differences in baseline characteristics between the groups (Appendix 1). The propensity score was developed by including relevant baseline patient and tumour characteristics including age, gender, BMI, ASA score and PADUA classification. Patients undergoing RAPN for an imperative indication were then matched to those undergoing RAPN for an elective indication using the nearest neighbour method in a 1:3 ratio without replacement. Balance of covariates was assessed both numerically and graphically using the standardized difference of means of the propensity score and a histogram of score distribution. We then performed bivariable and multivariable analyses for our primary outcomes. All *p* values were two-sided and statistical significance set at the 0.05 level. Data analysis was performed in R (R Foundation for Statistical Computing, Vienna, Austria) version 3.4.

Results

3,802 patients underwent RAPN between September 2006 and March 2020. Of these, 102 RAPN were performed for imperative indications and 3699 were small renal masses for elective indications. After matching for baseline characteristics, our final studied cohort consisted of 304 subjects (76 imperative vs 228 non-imperative indications). Of those with imperative indications for RAPN, 31 subjects had a solitary kidney, 20 had bilateral renal tumours and none had reported pre-op CKD. The descriptive baseline characteristics for both groups are summarized in Table 1.

Using bivariate and multivariate models of analysis, no significant differences were found between groups for ischaemia time (19.9min vs 19.8min, *p*=0.94; MVM -0.3 min, *p*=0.84). Similarly, operative time (186min vs 180min, *p*=0.55; MVM 12.2minutes, *p*=0.47), estimated blood loss (217mL vs 190mL, *p*=0.43; MVM 22.3mL, *p*=0.43), the need for blood transfusions (2.7% vs 3.7%, *p*=0.51), or recorded Clavien-Dindo grade of post-operative complications (*p*=0.31) were very similar between both groups. The large majority of patients in both groups did not experience any post-operative complications (87.3% vs 92.8% for imperative vs elective indication), and Clavien-Dindo Grade 2 and 3 complications were seen in 3/76 (4.2%) of the imperative group and 5/228 (2.5%) of the non-imperative group. A 38.6% (SD 47.9) decrease in Day 1 post-operative eGFR was seen in the imperative indication

group and a 11.3% (SD 45.1) decrease in eGFR seen in the elective indications group, $p<0.005$. There were no recorded cases of post-operative need for permanent or temporary dialysis, and no deaths. No statistically significant difference between groups was detected on analysis of trifecta outcomes ($p=0.45$). Table 2 provides a summary of the analysed operative and perioperative variables.

There were no conversions to RN in the imperative group and 5.6% ($n=7$) in the non-imperative group required intraoperative conversion to RN ($p=0.69$). Positive surgical margins were seen in 1.4% (1/76) of the imperative group and 3.3% of the non-imperative group (7/228), $p=0.69$.

Discussion

There are several key findings to highlight from our present study. To our knowledge, our study represents the largest published matched cohort comparing outcomes in RAPN for imperative versus elective indications. This further validates earlier published findings from the VCQI database where data highlighted that RAPN in solitary kidneys demonstrated a good trifecta of outcomes; those being negative surgical margins, low warm ischaemic time (less than 25min), and low operative and perioperative complications and morbidity.(25) Having performed a propensity score-matched analysis, our present data adds robustness to current available evidence. In addition to comparable WIT, EBL and hospital length of stay, our outcomes also indicate that the conversion rates to RN in RAPN for imperative indications remain low and are similar if not superior to OPN. This has been shown in previous studies comparing RAPN and OPN for elective indications.(22) There were no conversions from RAPN to RN or open surgery in our cohort. One explanation may be that these “higher stakes” surgeries are being performed by more experienced operators, and at high-volume tertiary centres. This likely accounts for the low rate of positive surgical margins (PSM) seen in our cohort compared to previously published data, as higher-volume centres (>60 cases/year) as well as surgical technique (OPN vs minimally-invasive PN) have both been found to be independent predictors of PSMs.(26) The overall rate of PSMs encountered in PNs is 0-7%(27) but much higher in imperative settings where it has been reported to be up to 27%.(2) Although imperative indications have been suggested to be an independent predictor of PSM, our data illustrates that other variables such as operator experience may be at play. A drawback to this analysis of PSM is that our data did not account for tumour clinical or pathological stage, or lymphovascular invasion.

PN for imperative indications are clinically challenging scenarios as nephron-sparing approaches are necessary to maximizing renal functional outcomes. OPN was the traditional gold standard treatment in these “high stakes” settings, as patients who have a single kidney, CKD, or bilateral tumours have historically demonstrated worse post-operative and oncological outcomes compared to those undergoing PN for elective indications.(4,12,15) Decreased functional outcomes have been reported after RAPN(23, 28), with a reported reduction in eGFR of up to 9%, and up to 12.7% experiencing acute renal failure (29). This may be attributed to potentially larger and more complex tumours, a more comorbid patient population, and a lower baseline renal reserve. However, good overall preservation of long-term renal function has been reported, and the need for permanent dialysis remains an uncommon outcome.(12,17) This finding was similarly observed in our matched cohort, where none of the patients

required long-term dialysis. A key limitation of our study was the lack of meaningful renal functional outcomes, having 57/304 (19%) of our studied cohort lacking data on pre- and/or post-operative renal functional outcomes (eGFR and/or serum creatinine). This precluded a robust comparison of change in post-operative renal function between the groups.

Up to 6% of imperative PN cases require surgical correction for complications, such as bleeding, urinary fistula or radical nephrectomy(12, 17), further emphasising the challenging nature of this clinical setting. The introduction of laparoscopic surgery thus paved the way for initial attempts at performing minimally invasive PN, aimed at reducing the morbidity associated with open approaches. In an early series of 1,800 patients, Gill et al (2007) compared postoperative outcomes in laparoscopic versus OPN. Although the OPN group had higher surgical and physiological risk profiles at baseline, perioperative outcomes such as operative time, blood loss and length of hospital stay were superior in the laparoscopic group. Despite promising results, longer ischaemic times and higher complication rates remained a challenge in the laparoscopic group.(6) Since then, the emergence of robotic-assisted surgery has offered a superior operating platform, with improved vision and instrumentation. Comparisons between RAPN and OPN have yielded equivalent, if not superior perioperative outcomes and less morbidity with the robotic approach.(8,9,16) Thus, a transition towards the robotic-assisted approach in many high-volume laparoscopic centres was seen.

Along with increasing availability of the surgical robot, and an overall observed trend of more RAPN being performed,(18) came a growing body of literature demonstrating the safety of RAPN. Equivalent, if not superior, perioperative outcomes in RAPN compared to OPN have been reported in large cohort studies, not only for small renal masses, but also in complex renal tumours.(7,16,19–21) A large prospective multi-centre French series compared the outcomes of 1800 patients who underwent RAPN versus OPN for renal tumours with comparable RENAL scores seen in both groups. The authors demonstrated better perioperative outcomes (lesser intraoperative blood loss and fewer haemorrhagic complications, and reduced warm ischaemic time) and reduced morbidity, as well as a shorter length of hospital stay in the RAPN group.(16) Choi et al (2015), in a recent systematic review and meta-analysis, demonstrated superior outcomes from RAPN compared to laparoscopic approaches in terms of lower conversion rates to RN, shorter hospital length of stay and a reduced WIT.(22) A recent publication by Bradshaw et al (2020) similarly reports comparable outcomes in RAPN for clinical T2a renal masses when compared with minimally-invasive RN, demonstrating the value of a robotic approach whilst maximising renal function.(30)

Although there is data demonstrating the advantages of minimally invasive over open surgical techniques for PN in localized renal tumours, published data specific to populations where imperative indications are present is more limited. Our findings support and build on previous reports on the safety and efficacy of a robotic-assisted approach for clinical situations where PN is absolutely indicated. Heinze et al (2018) investigated the perioperative, functional and oncological outcomes in RAPN for imperative indications, and found RAPN to deliver similar outcomes in both imperative and elective indications. This was despite their imperative indications group being slightly older and with

higher CCI and ASA scores.(5) Takagi et al (2017) conducted a propensity score-matched analysis of outcomes between RAPN and OPN in a small group of patients with CKD (40 subjects in each group) and reported comparable outcomes in terms of renal functional preservation and rate of perioperative complications. Similarly positive perioperative and functional outcomes have been reported in RAPN for small renal masses in patients with CKD(23,24) as well as when comparing outcomes between RAPN and OPN in the setting of solitary kidneys.(10)

Although beyond the scope of this study, there is a spectrum of clinical scenarios that lie between “elective” versus “imperative” indications, such as localised unilateral RCC with the coexistence of urinary lithiasis or uncontrolled diabetes. In clinical practice, the decision for PN involves case-by-case discussion and consideration of multiple patient and other factors. Future studies addressing this sub-population will add to our knowledge base for RAPN.

The lack of long-term data and prospective randomized controlled trials remain the gaps in current literature. Limitations of our study include the short follow-up timeframe, lack of randomization and retrospective analysis. Furthermore, data on renal functional outcomes and long-term oncological data on survival and disease recurrence were not available. Further studies reporting on long-term functional, oncological and survival outcomes after RAPN for imperative indications, as well as those investigating various surgical approaches such as a transperitoneal versus retroperitoneal approaches, or unclamped RAPN in imperative indications may provide insight into greater optimization of outcomes in RAPN for imperative indications. Early engagement of urologists is vital to ensuring trial success with clinically translatable outcomes for surgical practice.(31)

In conclusion, RAPN is a safe and feasible option in imperative indications (single kidney, bilateral tumours or CKD) and demonstrates comparable outcomes to RAPN performed for elective indications.

Conflict of Interest

James R. Porter and Alexander Mottrie received honorarium from Intuitive Surgical Inc., CA, USA. Ronney Abaza reports grants from Conmed Inc., grants from Intuitive Surgical Inc., outside the submitted work; and Educational program support from Intuitive Surgical Inc. All other authors have no conflict of interest.

Acknowledgements

The Vattikuti Foundation and Vattikuti Collective Quality Initiative (VCQI).

References

1. Leslie S, Goh AC, Gill IS. Partial nephrectomy--contemporary indications, techniques and outcomes. Nat Rev Urol. 2013 May;10(5):275-83.

2. Ljungberg B, Albiges L, Abu-Ghanem Y, Bensalah K, Dabestani S, Fernández-Pello S, et al. European Association of Urology Guidelines on Renal Cell Carcinoma: The 2019 Update. *Eur Urol*. 2019 May;75(5):799-810. doi: 10.1016/j.eururo.2019.02.011.
3. Campbell S, Uzzo RG, Allaf ME, Bass EB, Cadeddu JA, Chang A, et al. Renal Mass and Localized Renal Cancer: AUA Guideline. *J Urol*. 2017 Sep;198(3):520-529. doi: 10.1016/j.juro.2017.04.100.
4. Coffin G, Hupertan V, Taksin L, Vaessen C, Chartier-Kastler E, Bitker MO, et al. Impact of elective versus imperative indications on oncologic outcomes after open nephron-sparing surgery for the treatment of sporadic renal cell carcinomas. *Ann Surg Oncol*. 2011 Apr;18(4):1151-7.
5. Heinze A, Larcher A, Umari P, Fossati N, Piccolo J, De Groote R, et al. Assessing perioperative, functional and oncological outcomes of patients with imperative versus elective indications for robot-assisted partial nephrectomy: Results from a high-volume center. *Int J Urol*. 2018 Sep;25(9):826-831. doi:10.1111/iju.13754.
6. Gill IS, Kavoussi LR, Lane BR, Blute ML, Babineau D, Colombo JR, et al. Comparison of 1,800 Laparoscopic and Open Partial Nephrectomies for Single Renal Tumors. *J Urol*. 2007 Jul;178(1):41-6. doi: 10.1016/j.juro.2007.03.038.
7. Xia L, Wang X, Xu T, Guzzo TJ. Systematic Review and Meta-Analysis of Comparative Studies Reporting Perioperative Outcomes of Robot-Assisted Partial Nephrectomy Versus Open Partial Nephrectomy. *J Endourol*. 2017 Sep;31(9):893-909. doi: 10.1089/end.2016.0351.
8. Tan JL, Frydenberg M, Grummet J, Hanegbi U, Snow R, Mann S, et al. Comparison of perioperative, renal and oncologic outcomes in robotic-assisted versus open partial nephrectomy. *ANZ J Surg*. 2018 Mar;88(3):E194-E199. doi: 10.1111/ans.14154.
9. Takagi T, Kondo T, Tachibana H, Iizuka J, Omae K, Kobayashi H, et al. Robot-assisted laparoscopic versus open partial nephrectomy in patients with chronic kidney disease: A propensity score-matched comparative analysis of surgical outcomes. *Int J Urol*. 2017 Jul;24(7):505-510. doi: 10.1111/iju.13363.
10. Zargar H, Bhayani S, Allaf ME, Stifelman M, Rogers C, Larson J, et al. Comparison of perioperative outcomes of robot-assisted partial nephrectomy and open partial nephrectomy in patients with a solitary kidney. *J Endourol*. 2014 Oct;28(10):1224-30. doi: 10.1089/end.2014.0297.
11. Rogers CG, Singh A, Blatt AM, Linehan WM, Pinto PA. Robotic Partial Nephrectomy for Complex Renal Tumors: Surgical Technique. *Eur Urol*. 2008 Mar;53(3):514-21. doi: 10.1016/j.eururo.2007.09.047.
12. Long JA, Bernhard JC, Bigot P, Lanchon C, Paparel P, Rioux-Leclercq N, et al. Partial nephrectomy versus ablative therapy for the treatment of renal tumors in an imperative setting. *World J Urol*. 2017 Apr;35(4):649-656. doi: 10.1007/s00345-016-1913-4.
13. Ghani KR, Sukumar S, Sammon JD, Rogers CG, Trinh QD, Menon M. Practice patterns and outcomes of open and minimally invasive partial nephrectomy since the introduction of robotic partial nephrectomy: results from the nationwide inpatient sample. *J Urol*. 2014 Apr;191(4):907-12. doi:10.1016/j.juro.2013.10.099.

14. Clavien PA, Barkun J, De Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The clavien-dindo classification of surgical complications: Five-year experience. *Annals of Surgery*. 2009 Aug;250(2):187-96. doi: 10.1097/SLA.0b013e3181b13ca2.
15. Panumatrassamee K, Kaouk JH, Autorino R, Lenis AT, Laydner H, Isac W, et al. Cryoablation versus minimally invasive partial nephrectomy for small renal masses in the solitary kidney: Impact of approach on functional outcomes. *J Urol*. 2013; Mar;189(3):818-22. doi: 10.1016/j.juro.2012.09.075.
16. Peyronnet B, Seisen T, Oger E, Vaessen C, Grassano Y, Benoit T, et al. Comparison of 1800 Robotic and Open Partial Nephrectomies for Renal Tumors. *Ann Surg Oncol*. 2016 Dec;23(13):4277-4283. doi:10.1245/s10434-016-5411-0.
17. Long JA, Lee B, Eyraud R, Autorino R, Hillyer S, Stein RJ, et al. Robotic partial nephrectomy: Imperative vs elective indications. *Urology*. 2012 Oct;80(4):833-7. doi: 10.1016/j.urology.2012.06.045.
18. Patel HD, Mullins JK, Pierorazio PM, Jayram G, Cohen JE, Matlaga BR, et al. Trends in renal surgery: Robotic technology is associated with increased use of partial nephrectomy. *J Urol*. 2013 Apr;189(4):1229-35. doi: 10.1016/j.juro.2012.10.024.
19. Komninos C, Shin TY, Tuliao P, Kim DK, Han WK, Chung BH, et al. Robotic partial nephrectomy for completely endophytic renal tumors: Complications and functional and oncologic outcomes during a 4-year median period of follow-up. *Urology*. 2014 Dec;84(6):1367-73. doi: 10.1016/j.urology.2014.08.012.
20. Ficarra V, Minervini A, Antonelli A, Bhayani S, Guazzoni G, Longo N, et al. A multicentre matched-pair analysis comparing robot-assisted versus open partial nephrectomy. *BJU Int*. 2014 Jun;113(6):936-41. doi:10.1111/bju.12570.
21. Caristo J, Bertolo R, Dagenais J, Sagalovich D, Fareed K, Fergany A, et al. Robotic versus open partial nephrectomy for highly complex renal masses: Comparison of perioperative, functional, and oncological outcomes. *Urol Oncol*. 2018 Oct;36(10):471.e1-471.e9. doi: 10.1016/j.urolonc.2018.06.012.
22. Choi JE, You JH, Kim DK, Rha KH, Lee SH. Comparison of perioperative outcomes between robotic and laparoscopic partial nephrectomy: A systematic review and meta-analysis. *European Urology*. 2015 May;67(5):891-901. doi: 10.1016/j.eururo.2014.12.028.
23. Guilloteau J, Yakoubi R, Long JA, Klink J, Autorino R, Hillyer S, et al. Robotic partial nephrectomy for small renal masses in patients with pre-existing chronic kidney disease. *Urology*. 2012 Oct;80(4):845-51. doi: 10.1016/j.urology.2012.05.038.
24. Dalela D, Barod R, Gandaglia G, Abaza R, Adshead J, Ahlawat R, et al. Outcomes of robot-assisted partial nephrectomy in patients with complex renal tumours and pre-existing chronic kidney disease in a multi-institutional, multinational database. *Eur Urol Suppl*. 2016 Mar 15(3): e412. doi:10.1016/S1569-9056(16)60414-1.
25. Arora S, Abaza R, Adshead JM, Ahlawat RK, Challacombe BJ, Dasgupta P, et al. 'Trifecta' outcomes of robot-assisted partial nephrectomy in solitary kidney: a Vattikuti Collective Quality Initiative (VCQI) database analysis. *BJU Int*. 2018 Jan;121(1):119-123. doi: 10.1111/bju.13967.

26. Schiavina R, Mari A, Bianchi L, Amparore D, Antonelli A, Artibani W, et al. Predicting positive surgical margins in partial nephrectomy: A prospective multicentre observational study (the RECORd 2 project). *Eur J Surg Oncol*. 2020 Jul;46(7):1353-1359. doi: 10.1016/j.ejso.2020.01.022.
27. Borghesi M, Brunocilla E, Schiavina R, Martorana G. Positive surgical margins after nephron-sparing surgery for renal cell carcinoma: Incidence, clinical impact, and management. *Clinical Genitourinary Cancer*. 2013 Mar;11(1):5-9. doi: 10.1016/j.clgc.2012.09.010.
28. Thompson RH, Lane BR, Lohse CM, Leibovich BC, Fergany A, Frank I, Gill IS et al. Renal function after partial nephrectomy: effect of warm ischemia relative to quantity and quality of preserved kidney. *Urology*. 2012 Feb;79(2):356-60. doi: 10.1016/j.urology.2011.10.031.
29. Kural AR, Demirkesen O, Onal B, Obek C, Tunc B, Onder AU et al. Outcome of nephron-sparing surgery: elective versus imperative indications. *Urol Int*. 2003;71(2):190-6. doi:10.1159/000071845.
30. Bradshaw AW, Autorino R, Simone G, Yang B, Uzzo RG, Porpiglia F, et al. Robotic partial nephrectomy vs minimally invasive radical nephrectomy for clinical T2a renal mass: a propensity score-matched comparison from the ROSULA (Robotic Surgery for Large Renal Mass) Collaborative Group. *BJU Int*. 2020 Jul;126(1):114-123. doi: 10.1111/bju.15064.
31. Lawrentschuk, N. (2019), Urology trial success – get urologists involved early. *BJU Int*, 124: 4-4. <https://doi.org/10.1111/bju.14933>

Table 1. Baseline characteristics of patients who underwent RAPN for absolute and non-absolute indications (after propensity score matching).

	Absolute Indication (n=76)	Not Absolute Indication (n=228)	<i>p</i> -value
Median Age	63 (IQR 17)	64 (IQR 18)	0.60
Gender			0.82
Male	55 (72.4)	170 (75.6)	
Female	21 (27.6)	58 (25.4)	
Mean BMI	28.9 (SD 4.45)	28.7 (SD 5.4)	0.77
ASA Score			0.81
1	12 (15.8)	31 (13.6)	
2	33 (43.4)	108 (47.4)	
3	31 (40.8)	89 (39.0)	
PADUA Risk			0.90
Low	25 (32.9)	85 (37.3)	
Intermediate	26 (34.2)	81 (35.5)	
High Risk	25 (32.9)	62 (27.2)	

Table 2. Bivariate and multivariate model analysis for comparison of outcomes in RAPN for absolute and non-absolute indications.

Variable	Bivariate analysis			Multivariate model analysis	
	Absolute	Non-absolute	<i>p</i> -value	Absolute indication	<i>p</i> -value
Ischaemia time, minutes (SD/SE)	19.9 (6.8)	19.8 (11.9)	0.94	0.3 (1.48)	0.84
Operative time, minutes (SD)	186 (72.5)	180 (62.6)	0.55	12.2 (17.1)	0.47
Estimated blood loss, mL (SD)	217 (273)	190 (191)	0.43	22.3 (28.5)	0.43
Bloods transfusions, n (%)	2 (2.7)	8 (3.7)	0.51	OR 0.47 [95%CI 0.02-3.10]	
Clavien-Dindo Grade, n (%)			0.31	-	-
No complication	62 (87.3)	180 (92.8)			
Grade 1	6 (8.5)	8 (4.1)			
Grade 2	3 (4.2)	3 (1.5)			
Grade 3	0 (0)	2 (1.0)			
Grade 4	0	1 (0.05)			
Grade 5	0	0			
Conversion to RN, n (%)	0	7 (5.6)	0.30	-	-
Positive Surgical Margin, n (%)	1 (1.4)	7 (3.3)	0.69	-	-
Trifecta outcomes, n (%)	31 (45.6)	101 (51.8)	0.45		
Change in Day 1 post-op eGFR, percentage (SD)	-38.6 (47.9)	-11.3 (45.1)	<0.005		

*SD standard deviation; SE standard error; RN radical nephrectomy.