Radical Nephrectomy: Role of Robotic Assisted Approach

A. L. Walsh and B. J. Challacombe

Introduction

While slow to be adopted, robot-assisted laparoscopic nephrectomy (RALN) is gaining momentum for the treatment of large and complex renal tumours. Robotic surgery has a very well established role in urologic surgery with robot-assisted radical prostatectomy and robot-assisted partial nephrectomy (PN) now accounting for 90% and 67% respectively of all prostatectomies and PN's in the UK BAUS audit 2018. The role of robotics in radical nephrectomy is less well defined and consequently we have been slower to adopt the robotic approach regarding radical nephrectomy for large renal tumours. Many would advocate open surgery for large complex tumours with caval involvement and the laparoscopic approach for those with smaller tumours not amenable to or suitable for PN.

Arguments against RALN include the perceived increased cost, more limited access to robotic theatre time, loss of haptic feedback and some report longer operating time of robotic surgery. Arguments for RALN however are numerous and include shorter hospital stay, decreased morbidity and pain, better visualisation of key structures and increased dexterity. RALN can also act as a key training modality for robotic surgeons to allow them to acquire the skills required for more complex renal surgery such as pyeloplasty and robot assisted partial nephrectomy.

Open radical nephrectomy confers significant morbidity on the patient with a large painful incision, either flank/subcostal or midline. This results in increased analgesia requirements, longer length of hospital stay and a higher incidence of wound herniation and chronic wound pain. RALN offers a minimally invasive approach to complex renal tumours. The degree of movement and anatomical control offered by the robot allows for retroperitoneal lymph node dissection and caval

A. L. Walsh (✉) · B. J. Challacombe
Department of Urology, St Georges Hospital, London, UK
e-mail: anna.walsh@stgeorges.nhs.uk; ben.challacombe@gstt.nhs.uk

C. Anderson, M. Afshar (eds.), *Renal Cancer*,
https://doi.org/10.1007/978-3-030-84756-2_12

thrombectomy in the right hands. Both of which are extremely challenging laparoscopic undertakings.

Indications for Radical Nephrectomy

Radical nephrectomy is the gold standard of care for larger renal tumours which are not suitable for nephron-sparing surgery (NSS). This includes where there would be an insufficient volume of parenchyma remaining to maintain the functionality of the kidney or if there is evidence of renal vein thrombosis. EAU guidelines recommend NSS for all T1 renal tumours. There are no reported differences in oncological outcomes between laparoscopic or open radical nephrectomy, however there are no randomised control trials assessing this. Open is traditionally preferred for very large tumours (>T2b), those invading the inferior vena cava or with visible nodal disease. NCCN guidelines state radical nephrectomy can be performed via an open, laparoscopic or robotic approach [1].

Training

RALN provides a training platform for surgeons and fellows to develop their robotic skills prior to performing complex PN resections, nephroureterectomies or tackling larger, more complex tumours. RALN encompasses five of the key eight steps involved in PN, most crucially the dissection of the hilum. It provides an excellent training platform and is not encompassed into the BAUS robotic training curriculum for robotic surgery [2]. RALN enables not only the surgeon but the whole theatre team to increase their familiarity with robotic upper tract surgery prior to embarking on the stressful 'on clamp' dissection at PN.

With the increased availability of the robot and more surgical and fellowship training programmes we see a fall-off in laparoscopic training and skill development. The skill set required to perform complex laparoscopic procedures will not be there and potentially laparoscopic surgery may become a thing of the past.

Large Renal Masses

Minimally invasive radical nephrectomy reduces morbidity and hospital stay when compared to open surgery with equivalent oncological outcomes [3]. The therapeutic indications for minimally invasive surgery continue to expand with surgical experience and technological advances. There are many case series reporting outcomes of laparoscopic nephrectomy for large renal masses which would traditionally have been managed with open surgery [4, 5].

Steinberg et al. examined outcomes in laparoscopic nephrectomy for tumours >7 cm, but all tumours >14 cm were excluded from analysis. Larger tumours did have more blood loss (200 ml v 100 ml in the <7 cm group) but similar operating times, complications rates and length of stay [5]. They reported no open conversions in their series of 65 patients [5]. Pierorazio's series of 64 patients with median tumour size of 12.9 cm reported an average 400 ml blood loss with a 13.8% conversion rate. Abaza et al.'s [6], albeit small, robotic series comprised 15 patients all with tumours >15 cm with no open conversions and a median estimated blood loss of 159 ml, this is compared to 500 ml reported for open nephrectomy in Steinberg's group which had a median tumour size of 9.9 cm. The average reported conversion rate across laparoscopic series is approximately 5% with reasons for conversion being failure to progress, uncontrolled massive bleeding and unknown IVC tumour thrombus.

Reported operative times in laparoscopic series for large tumours range around 192–240 min compared to robotic 234 min robotically for tumours over 15 cm. Laparoscopic resection of these large tumours is extremely challenging and high volume experience is required. A multi-centre study found that of 26 sites included in the trial only 10 centres performed laparoscopic nephrectomy for tumours >7 cm [4]. Robotics allows for easier dissection of the hilum, more dexterity and ability to reach around tight spaces where they may encounter bulky lymph node disease and ease of retraction with the robotic fourth arm. Extreme challenges such as IVC thrombus, lymph node dissection and solid organ invasion can all be managed robotically with only case reports of these challenges reported laparoscopically. These challenges are discussed in later sections.

Lymph Node Dissection

The role of lymph node dissection (LND) for localised RCC is debated with the only randomised control trial to date showing no benefit [7]. Over 70% of the cases in this trial however were T1/T2 tumours and unlikely to have lymph node metastasis and therefore benefit from LND. There was also no data on the number of nodes resected during the trial. With us performing surgery for larger, more advanced tumours, there is a definite need for LND in certain cases to improve chances of disease free survival.

Several large retrospective cohort studies have suggested that in patients with large tumours, visible lymph node disease and even metastatic disease there is a survival benefit with adequate LND [8]. While technically feasible, laparoscopic retroperitoneal lymph node dissection is a challenging undertaking requiring a skilled surgeon and high volume unit. The precision and ergonomics of robotics allows excellent control of tension and planes to facilitate RPLND in this setting. The ability to salvage bleeding from major structures is also far easier to control robotically than laparoscopically.

Evidence suggest that the benefit from LND is proportional to lymph node yield [9] with >12 nodes resulting in almost a 50% increase in the likelihood of detecting a positive node. A more extensive laparoscopic dissection or template is difficult to achieve. To date there are only a few retrospective studies in the literature championing laparoscopic lymph node dissection [10]. This could in part be due to lower stage tumours undergoing laparoscopic nephrectomy and those requiring LND having open nephrectomy as described by Terrone et al.

In those laparoscopic series that do look at LND the yield ranged from 2.7 to 7.8 (Chapman series), with a demonstrable improvement in yield with experience. In comparison to this, Abaza et al. [11] in a smaller series had an average lymph node yield of 13.9 with minimal morbidity equivocal to that with open surgical series highlighting the easier learning curve of this minimally invasive technique.

Caval Thrombectomy

4–10% of locally advanced cases of RCC are found to have IVC thrombosis. This cohort has traditionally been managed with open surgery given the complexity and potential hazards of opening the IVC laparoscopically and performing an adequate lymphadenectomy. Laparoscopically this is a significant undertaking and there are only a small number of studies in the literature reporting laparoscopic IVC thrombectomy and its outcomes. While it is possible, it is extremely challenging and requires immense skill and support.

Robotic-assisted thrombectomy maybe a more appropriate approach to minimally invasive IVC surgery and thrombectomy. The improved ergonomics allow for easier slinging of the cava while the fourth arm allows for easy retraction of the kidney freeing the assistant (see Fig. 1). The quicker suturing time reduces cross clamping time and blood loss is significantly less via the robotic approach. In cases of extensive thrombosis where cross-clamping is required the robot allows for swifter and more dynamic application of a tourniquet.

The largest laparoscopic series from China contains 11 patients, some with level IV IVC thrombus and joint thoracic resections [12]. In total under there are under 100 reported cases of laparoscopic IVC thrombectomy with robot-assisted thrombectomy rapidly taking over and likely halting the progression of the laparoscopic technique. Recently focus has shifted to more challenging robotic cases with IVC patch cavoplasty for caval wall invasion and fogarty balloon occlusion for intra- and retro-hepatic IVC control [13]. Current series are reporting outcomes of level II and III IVC thrombectomy with comparable morbidity to open surgery [14].

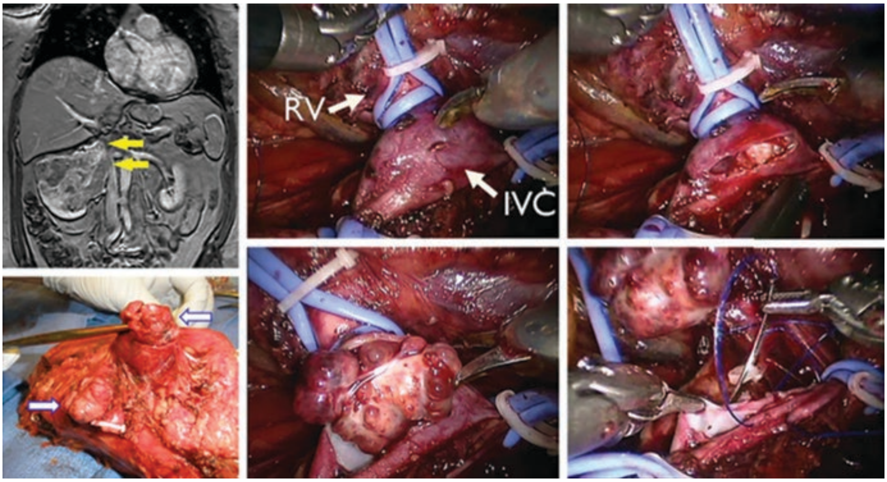

Fig. 1 Patient with two renal veins each with caval tumor thrombus, as seen on magnetic resonance imaging (upper left), after extraction (lower left) and intraoperatively with modified Rommel tourniquets for cross-clamping of the inferior vena cava (IVC) and lightly applied to prevent back bleeding from the right renal vein (RV) to open and deliver lower thrombus in a bloodless filed (right)

Other Challenges: Pushing the Boundaries of Robotic Nephrectomy

RALN enables a minimally invasive surgical approach for large, and even massive renal tumours. With this comes the challenge of caval thrombectomy and lymphadenectomy as described but also solid organ invasion where resection of other organs may also be required. RALN with partial hepatectomy, partial duodenectomy, cholecystectomy and distal pancreatectomy have all been described [15]. While such procedures are not commonplace with increasing robotic experience and skill we can expect more reports.

Recent interest has moved to robotic laparoendoscopic single site surgery (R-LESS). The proposed benefits would be almost no scarring and potentially reduced pain scores and incidence of incisional hernias. The robotic platform may help reduce the main issues of LESS with regards to intra-corporeal triangulation of instruments, external instrument clashes and enhanced ergonomics with reduced working space (see Fig. 2). To date there are several small case series and case reports looking at R-LESS in radical nephrectomy but the jury is out as to its role.

Fig. 2 Access devices to perform robotic laparoendoscopic single-site surgery: (**a**) SILS Port (Covidien), (**b**) Gelpoint (Applied), and (**c**) TriPort (Olympus). Courtesy of Jihad Koauk, Cleveland Clinic, Cleveland, OH, USA

Controversies in RALN

Data from the U.S.A. shows a dramatic increase in the use of RALN since the turn of the century with 1.5% of radical nephrectomies performed robotically in 2003 and 27% in 2015 [16]. While suggested that RALN was associated with a higher operating time and cost than laparoscopic surgery this point has subsequently been disputed. If the robot is already available in the department operating costs do not exceed that of laparoscopy and robotic surgery may actually be more cost effective [17]. Robotic surgery decreases requirements for disposables such as harmonic scalpels as only diathermy is required, ports are re-usable and instruments can be kept to a minimum.

Several analyses to date have proposed that RALN is associated with an increased operating time compared to laparoscopic or open surgery. It is also not however the experience of these authors in our centre. Operating time reflects surgical experience and case complexity and substantial variation has been seen in all three techniques. Often operating time reflects the case load volume of a centre, experience of the surgeon and depends on whether the procedure is performed in a training centre.

Loss of haptic feedback is a concern in robotic surgery across the board. This is not unique to RALN. Undoubtedly caution is required especially at dissection of the hilum to ensure excessive force is not applied to vessels or the tumour. This is a skill that is required of all robotic surgeons and takes time to develop. Similarly off screen injury with instruments in the fourth arm can be a perceived issue in robotic surgery that requires caution to avoid.

Conclusion

RALN it allows for a minimally invasive approach to complex and large renal tumours. It also provides an ideal training platform in the more 'routine' cases prior to surgeons embarking on more complex upper tract cases such as robotic partial nephrectomy or robotic pyeloplasty's. Laparoscopy has limitations even in the most skilled hands when faced with nodal disease, vascular invasion and invasion into other solid organs. To date there is no studies to support the superiority of RALN over LN, likewise many argue that it does not extend indications for minimally invasive surgery. However absence of evidence doesn't equal evidence of absence. Currently we have no level 1 evidence to support RARP or robotic pyeloplasty but both are superseding their open and laparoscopic counterparts.

If we do not try we do not progress.

Robotic surgery is constantly evolving with new robotic systems continuously being developed. The potential is there for quicker, slicker and safer surgery with an increased ability to perform complex cases.

Key Points

1. Robotic radical nephrectomy is feasible and safe.
2. Standard indications include T1a-T2 tumours where partial nephrectomy isn't possible.
3. Robotic radical nephrectomy may act as a training platform for more complex robotic renal procedures.
4. With increasing robotic availability the extra costs associated with robotic nephrectomy are reduced.
5. Robotic nephrectomy may allow for quicker and smoother surgery permitting rapid recovery and minimising hospital stay.
6. Intra-operative complications are more easily correctable with robotics compared to standard laparoscopic surgery.
7. The robotic approach is being extended to include renal tumours with vascular invasion including caval thrombus in experienced centres.

8. Robotic para-caval and para-aortic lymphadenectomy is feasible in selected cases and may be safer than the laparoscopic approach.
9. The intraoperative pneumoperitoneum minimises blood loss from collaterals in larger tumours. This may reduce the overall operative blood loss compared to the open approach.
10. Robotic nephrectomy is a common and important part of the portfolio of the modern upper tract minimally invasive surgeon.

References

1. Motzer RJ, Agarwal N, et al. *NCCN clinical practice guidelines in oncology.* Kidney Cancer Version 2.2019, NCCN Clinical Practice Guidelines in Oncology 2019 [cited 2020 02–01-20]; Available from: www.nccn.org/professionals.
2. Challacombe C, A.K.e.a. *BRITISH ASSOCIATION OF UROLOGICAL SURGEONS (BAUS) ROBOTIC SURGERY CURRICULUM - GUIDELINES FOR TRAINING*. [cited 2020 15-01-2020]; Guideline]. Available from: http://www.baus.org.uk/_userfiles/pages/files/Publications/RoboticSurgeryCurriculum.pdf.
3. Dunn MD, et al. Laparoscopic versus open radical nephrectomy: a 9-year experience. J Urol. 2000;164(4):1153–9.
4. Jeon SH, et al. Comparison of laparoscopic versus open radical nephrectomy for large renal tumors: a retrospective analysis of multi-center results. BJU Int. 2011;107(5):817–21.
5. Steinberg AP, et al. Laparoscopic radical nephrectomy for large (greater than 7 cm, T2) renal tumors. J Urol. 2004;172(6 Pt 1):2172–6.
6. Abaza R, Gerhard RS, Martinez O. Robotic radical nephrectomy for massive renal tumors. J Laparoendosc Adv Surg Tech A. 2020;30(2):196–200.
7. Blom JH, et al. Radical nephrectomy with and without lymph node dissection: preliminary results of the EORTC randomized phase III protocol 30881. EORTC genitourinary group. Eur Urol. 1999;36(6):570–5.
8. Whitson JM, et al. Lymphadenectomy improves survival of patients with renal cell carcinoma and nodal metastases. J Urol. 2011;185(5):1615–20.
9. Terrone C, et al. The number of lymph nodes examined and staging accuracy in renal cell carcinoma. BJU Int. 2003;91(1):37–40.
10. Chapman TN, et al. Laparoscopic lymph node dissection in clinically node-negative patients undergoing laparoscopic nephrectomy for renal carcinoma. Urology. 2008;71(2):287–91.
11. Abaza R, Lowe G. Feasibility and adequacy of robot-assisted lymphadenectomy for renal-cell carcinoma. J Endourol. 2011;25(7):1155–9.
12. Shao P, et al. Laparoscopic radical nephrectomy and inferior vena cava Thrombectomy in the treatment of renal cell carcinoma. Eur Urol. 2015;68(1):115–22.
13. Kundavaram C, et al. Advances in robotic vena cava tumor Thrombectomy: Intracaval balloon occlusion, patch grafting, and vena Cavoscopy. Eur Urol. 2016;70(5):884–90.
14. Chopra S, et al. Robot-assisted level II-III inferior vena cava tumor Thrombectomy: step-by-step technique and 1-year outcomes. Eur Urol. 2017;72(2):267–74.
15. Petros FG, Angell JE, Abaza R. Outcomes of robotic nephrectomy including highest-complexity cases: largest series to date and literature review. Urology. 2015;85(6):1352–8.
16. Jeong IG, et al. Association of Robotic-Assisted vs laparoscopic radical nephrectomy with perioperative outcomes and health care costs, 2003 to 2015. JAMA. 2017;318(16):1561–8.
17. Abaza R, Gonsenhauser I, Box G, Sharp D, Sabsigh A. Robotic nephrectomy is not costlier than standard laparoscopy when a robot is available. J Urol. 2015;193(4S):e388.