Review Article

Application of the single-port robotic platform during radical nephroureterectomy for upper tract urothelial carcinoma: feasibility of the single-port robot in the multi-quadrant setting

Antony A. Pellegrino[1,2,3]^, Mahmoud Mima[3], Simone Crivellaro[3]

[1]Division of Experimental Oncology, Department of Urology, Urological Research Institute, IRCCS Ospedale San Raffaele, Milan, Italy; [2]Vita-Salute San Raffaele University, Milan, Italy; [3]Department of Urology, University of Illinois at Chicago, Chicago, IL, USA

Contributions: (I) Conception and design: S Crivellaro, AA Pellegrino; (II) Administrative support: S Crivellaro, M Mima; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: None; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Antony A. Pellegrino, MD. Division of Experimental Oncology, Department of Urology, Urological Research Institute, IRCCS San Raffaele Scientific Institute, Via Olgettina 60, 20132 Milan, Italy; Vita-Salute San Raffaele University, Milan, Italy; Department of Urology, University of Illinois at Chicago, Chicago, IL, USA. Email: pellegrino.antony@hsr.it.

Abstract: Urothelial carcinoma of the upper tract (UTUC) is a malignancy that accounts for 5–10% of all urothelial carcinomas. Radical surgery is the primary treatment option due to the high rate of invasive stages at the time of diagnosis. Nephroureterectomy (NU) with bladder cuff excision is the current standard of care. While laparoscopic NU has been established since 1991, many centres still perform open surgery due to the complexity of laparoscopic instrumentation and the steep learning curve for excising the bladder cuff. With the increasing adoption of the multi-port (MP) robotic surgery, NU has increasingly been performed using this platform. The use of MP robotic systems for NU has been challenged by the need for patient repositioning and/or redocking of the robot, which can consume valuable operative time. The transition from the daVinci Si to the daVinci Xi system has seen a noticeable reduction in redocking and patient repositioning. However, owing to the multi-quadrant nature of the surgery in question, the use of multiple ports and external instrument clashing are still persistent problems. Moreover, there is a growing interest in utilizing a retroperitoneal approach for robot-assisted NU due to its potential benefits such as improved control of hilar structures, reduction of blood loss, shorter operative time and hospital stay, reduced complications and decreased postoperative discomfort. The application of the daVinci single-port (SP) robotic platform during radical NU for UTUC is feasible and has the potential to improve the current surgical approach. Indeed, the use of a SP platform may solve the problem of patient repositioning and redocking of the robot, improve superficial aesthetic outcome and minimize external instrument clashing. While maintaining an optimal oncological control, the retroperitoneal approach, which has been difficult to replicate and adopt using the MP approach, may become standard practice. However, more studies are needed to confirm the benefit of this approach and ultimately determine the impact of the daVinci SP on the management of UTUC.

Keywords: Upper tract urothelial carcinoma; robotic surgery; multi-quadrant surgery; daVinci single-port

Submitted Jan 20, 2023. Accepted for publication Jul 26, 2023. Published online Aug 16, 2023.
doi: 10.21037/tau-23-48
View this article at: https://dx.doi.org/10.21037/tau-23-48

^ ORCID: 0000-0002-0898-1953.

Introduction: the challenges faced by the multi-port (MP) robotic systems

Urothelial carcinoma of the upper tract (UTUC) is a malignancy that accounts for 5–10% of all urothelial carcinomas and its incidence is increasing, driven mostly by demographic changes. Radical surgery is the primary treatment option due to the combination of a unique anatomy of the upper urothelial tract (no muscular layer coupled with a thin lamina) and intrinsic oncological aggressiveness, resulting in a high rate of invasive stages at the time of diagnosis (1).

Nephroureterectomy (NU) with bladder cuff excision is the standard of care for most cases of UTUC (1). While laparoscopic NU has been established since 1991, many centres still perform open surgery due to the complexity of laparoscopic instrumentation and the steep learning curve for excising the bladder cuff (2). With the increasing adoption of MP robotic surgery, NU has increasingly been performed using this platform. Various approaches for robot-assisted NU have been reported, with the most common being the transperitoneal approach (3). Here, patients are typically positioned in the lateral/modified lateral flank position as it allows for better surgical exposure and access to the kidney via mobilization of the bowel by paracolic incision of the dorsal peritoneum.

In the past—as well as in present-day—a combination of robotic and open or laparoscopic approaches were used to complete the NU and bladder cuff excision (3). This may also require repositioning the patient from lateral flank to lithotomy position (4). Naturally, as the technique progressed, there have been reports of entirely robotic-assisted nephroureterectomy (RANU) being performed without intra-operative patient repositioning. Even in these instances, a time-consuming redocking of the robot to isolate the distal ureter and excise bladder cuff is necessary (5,6). Overall, intra-operative patient repositioning or redocking of the robot can consume approximately 30 minutes of valuable operative time (7). The transition from the daVinci Si to the daVinci Xi system has seen a noticeable reduction in redocking and patient repositioning (6). Indeed, there are numerous techniques described in literature to attempt to solve these problems. For instance, various port configurations have been proposed to avoid patient repositioning and redocking and allow multi-quadrant surgery minimising external collisions. Darwiche *et al.* proposed a configuration of four 8 mm robotic ports positioned in an oblique straight line starting below the costal margin just lateral to the rectus abdominis muscle (8). On the other hand, Patel *et al.* a port placement configuration which utilizes four 8 mm robotic ports placed linearly along the lateral border of the rectus muscle in addition to one 12 mm assistant port placed 2–3 cm cranial to umbilicus (6). Most techniques reported require at least four to six ports to perform a trans-peritoneal RANU. Moreover, owing to the bulky robotic framework, external instrument clashing is a persistent problem.

Finally, despite the prevalence of the transperitoneal approach, there is a growing interest in utilizing a retroperitoneal approach for RANU due to its potential benefits such as improved control of hilar structures, reduction of blood loss, shorter operative time and hospital stay, reduced complications and decreased postoperative discomfort (9). Moreover, a retroperitoneal approach might be preferred for patients with previous abdominal surgery to avoid intraperitoneal adhesions (10). However, to date, there have been very few reported cases of a complete RANU with bladder cuff excision using the retroperitoneal approach, owing mostly to the aforementioned issues, coupled with the added difficulty of working within a small area such as the retroperitoneum, noticeably reducing MP instrument triangulation and dexterity. Indeed, a major hurdle to this approach is difficulty in MP placement and subsequent instrument clashing, making the operation burdensome and difficult to replicate. Of note, at the time of publishing this article, there is only a single publication describing a completely retroperitoneal robotic NU with bladder cuff excision, authored by Sparwasser *et al.*, who performed surgery on 5 patients using the daVinci Xi (11). Here, the patient was placed in a lateral flank position and the trocars were placed parallel to the costal arch, following a line mimicking Kocher's incision, with subsequent balloon dilation used to create space to accommodate the different robotic arms. Intra-operative redocking was necessary, with the authors noting that initial trocar placement took approximately 30 minutes, while intra-operative redocking took 7 minutes. Notwithstanding this novel port placement, the authors reported noticeable instrument clashing during the procedure.

The initial impact of the daVinci single-port (SP) in urology

The predecessor of the daVinci SP system in urologic surgery was the robot-assisted laparoendoscopic single-site (LESS) NU. When compared to traditional multiport techniques, LESS NU was found to have similar oncological and perioperative outcomes, however, it had higher levels of intraoperative blood loss (12). The adoption of LESS-NU has been limited due to the need for specialized instruments and reduced instrument triangulation, making the procedure technically challenging.

There is currently limited literature on NU with bladder cuff excision using the daVinci SP robotic system, and the studies available have fewer than 5 patients which had undergone the procedure and are retrospective in nature. The two studies describe a technique similar to that adopted by the daVinci Xi. The patient is placed in the lateral/modified lateral position and access to the kidney and ureter is obtained with a transperitoneal approach. No patient repositioning or redocking is necessary, however the operating time is comparable to multiport techniques, likely due to the novelty and to the learning curve of the daVinci SP (13,14).

Despite being a relatively new technology, the daVinci SP system has immediately demonstrated an advantage over multiport systems in surgeries involving confined spaces, due to easy access and single port placement. A study by Abaza *et al.* showed that among patients who underwent partial nephrectomy, those who had surgery with the SP had a higher chance of same-day discharge compared to multiport, 83% versus 17% (13).

A recent meta-analysis compared the role of the daVinci SP with conventional daVinci Si/Xi in partial nephrectomies (15). The analysis included 586 patients across 6 studies. They showed that the two methods had comparable outcomes with regards to safety, with SP partial nephrectomies associated with a marginally shorted length of hospital stay and less blood loss, 0.35 days and 27 mL, respectively. There were no differences in operative time, transfusion rates and intraoperative and post-operative complications.

Therefore, at first glance one may conclude that the SP is simply a less invasive alternative to the already well-established MP. On this regard, when considering the use of the daVinci SP system, there are a few key points to keep in mind. Firstly, it is important to note that the learning curve for any new surgical system can be significant, especially when compared to established methods. Secondly, the advantages of the SP system may be particularly pronounced in small and confined spaces such as the retroperitoneum, an area where the study did not perform a sub-analysis comparing MP and SP. Finally, it is worth noting that the study examined partial nephrectomies, which require a single surgical quadrant. Performing a retroperitoneal RANU is technically challenging due to its multi-quadrant nature.

Initial single institution experience of retroperitoneal SP surgery

We may translate the benefits captured during other urologic procedures and hypothesize that the daVinci SP may allow for an effective way to develop a fully retroperitoneal RANU. At our institution, we started performing SP RANU using a traditional transperitoneal approach, with the patient positioned in the traditional lateral decubitus position (16). Briefly, a 3 cm vertical incision lateral to the umbilicus was used as an entry point. Once access to the peritoneal cavity was obtained, the Alexis retractor and 'Access Port kit' were inserted into the incision. A 12 mm Airseal assistant port was placed in a "sidecar" fashion, where the port was inserted into the same skin incision as the SP trocar but was then diverted into a separate fascial incision. The SP robotic camera was then inserted into the SP trocar at the 12 o'clock position. Here, the white line of Toldt was incised and the colon was reflected to expose the kidney. A plane just above the psoas muscle was dissected superior to the iliac vessels, and the ureter was identified. The ureter was then followed proximally until the renal hilum was dissected out and exposed. The artery and the vein were then ligated. Once satisfaction with hemostasis was achieved, the fascial attachments around the kidney were released until it was fully mobilized. The ureter was then dissected down to the bladder level, and subsequent bladder cuff excision and bladder closure were performed. With this technique, compared to the MP trans-peritoneal RANU, we have noted that there is a large amount of mobility within the abdomen. Thanks to the ability of the boom to pivot 360 degrees around the SP trocar, allowing the instruments access to both quadrants easily via a single incision. Moreover, the 12 mm sidecar allows safe operation with the Gia with acceptable articulation. Obviously, the range of motion is not comparable to a plus one (separate skin and fascial incision), albeit we found it to meet our needs.

However, more recently we have started performing all RANU cases with a retroperitoneal approach. Briefly, we use a novel anterior retroperitoneal access (17), all while maintaining the patient in a supine position, without the need of intra-operative patient repositioning. This allows a rapid, optimal and replicable port placement. The initial

Figure 1 SP port placement during a left retroperitoneal RANU. The cranio-caudal direction is left to right, with the patient placed in a supine position. SP, single-port; RANU, robotic-assisted nephroureterectomy.

retroperitoneal space is obtained through finger-assisted blunt dissection. After which, we position the 'SP Access Port kit' and introduce the camera and robotic arms. No balloon dilation is needed, as the initial space required for SP operation is minimal, unlike its MP counterpart. This ensures an accurate dissection from the start, avoiding unnecessary trauma otherwise caused by the balloon.

Switching from the renal to bladder cuff quadrant is simple and rapid, albeit requires assistance to relocate. Initial impressions using this novel retroperitoneal approach are promising and we will shortly have sufficient data to establish a pilot feasibility study. *Figure 1* shows a typical port placement using the SP during RANU.

Conclusions

In conclusion, the application of the SP robotic platform during RANU for UTUC is a feasible option that has the potential to improve the current surgical approach. The use of a SP platform may solve the problem of patient repositioning and redocking of the robot and eliminate the issue of external instrument clashing. Taken together, this should allow a greater adoption of a standard retroperitoneal approach, possibly improving patient experience and making outcomes more homogenous between surgeons.

As we have presented, the SP robotic platform has advantages over the MP robotic systems for patients such as reduced surgical trauma, smaller incision, improved cosmesis, reduced pain and faster recovery. On the other hand, for surgeons, the retroperitoneal approach offers benefits such as improved control of hilar structures, reduction of blood loss, shorter operative time and hospital stay, reduced complications and decreased postoperative discomfort, and should therefore pursued (9).

However, it is important to note that the SP robotic platform is a relatively new technology and further studies with larger patient populations, preferably in a multi-institutional setting, are needed to confirm the feasibility and safety of the SP robot in the multi-quadrant setting. The learning curve for any new surgical system can be significant even for experienced surgeons, especially when compared to established methods. Therefore, it is important for surgeons to be well-trained and experienced with the SP robotic platform before performing complex surgeries such as RANU, as it requires an extensive knowledge of the powerful features unique to the SP platform.

Finally—as always—the priority when discussing novel oncological techniques should be its oncological effectiveness. Further studies are needed to assess the long-term oncologic outcomes, including recurrence and survival rates, of the SP robotic platform compared to traditional open and MP surgery. To this end, it is also important to note that lymph node dissection during SP-RANU has not been studied extensively, and there are no data regarding this. Further research is needed to determine the feasibility, lymph node yield and safety of lymph node dissection during such procedure.

In summary, the SP robotic platform may be a viable option for the treatment of UTUC. We feel this holds true especially in the retroperitoneal approach. It offers improved patient outcomes, reduced surgical trauma and improved surgical access. However, more studies are needed to confirm the safety and efficacy of the SP robotic platform in the multi-quadrant setting.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned

by the Guest Editors (Ram A. Pathak and Ashok K. Hemal) for the series "Upper Tract Urothelial Cancer" published in *Translational Andrology and Urology*. The article has undergone external peer review.

Peer Review File: Available at https://tau.amegroups.com/article/view/10.21037/tau-23-48/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-23-48/coif). The series "Upper Tract Urothelial Cancer" was commissioned by the editorial office without any funding or sponsorship. SC is a consultant for Intuitive Surgical, Inc. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Rouprêt M, Babjuk M, Burger M, et al. European Association of Urology Guidelines on Upper Urinary Tract Urothelial Carcinoma: 2020 Update. Eur Urol 2021;79:62-79.
2. Clayman RV, Kavoussi LR, Figenshau RS, et al. Laparoscopic nephroureterectomy: initial clinical case report. J Laparoendosc Surg 1991;1:343-9.
3. Veccia A, Antonelli A, Francavilla S, et al. Robotic versus other nephroureterectomy techniques: a systematic review and meta-analysis of over 87,000 cases. World J Urol 2020;38:845-52.
4. Hu JC, Silletti JP, Williams SB. Initial experience with robot-assisted minimally-invasive nephroureterectomy. J Endourol 2008;22:699-704.
5. Pugh J, Parekattil S, Willis D, et al. Perioperative outcomes of robot-assisted nephroureterectomy for upper urinary tract urothelial carcinoma: a multi-institutional series. BJU Int 2013;112:E295-300.
6. Patel MN, Aboumohamed A, Hemal A. Does transition from the da Vinci Si to Xi robotic platform impact single-docking technique for robot-assisted laparoscopic nephroureterectomy? BJU Int 2015;116:990-4.
7. Lim SK, Shin TY, Rha KH. Current status of robot assisted laparoscopic radical nephroureterectomy for management of upper tract urothelial carcinoma. Curr Urol Rep 2013;14:138-46.
8. Darwiche F, Swain S, Kallingal G, et al. Operative technique and early experience for robotic-assisted laparoscopic nephroureterectomy (RALNU) using da Vinci Xi. Springerplus 2015;4:298.
9. Zhu D, Shao X, Guo G, et al. Comparison of Outcomes Between Transperitoneal and Retroperitoneal Robotic Partial Nephrectomy: A Meta-Analysis Based on Comparative Studies. Front Oncol 2021;10:592193.
10. Arora S, Heulitt G, Menon M, et al. Retroperitoneal vs Transperitoneal Robot-assisted Partial Nephrectomy: Comparison in a Multi-institutional Setting. Urology 2018;120:131-7.
11. Sparwasser P, Epple S, Thomas A, et al. First completely robot-assisted retroperitoneal nephroureterectomy with bladder cuff: a step-by-step technique. World J Urol 2022;40:1019-26.
12. Lim SK, Shin TY, Kim KH, et al. Laparoendoscopic single-site (LESS) robot-assisted nephroureterectomy: comparison with conventional multiport technique in the management of upper urinary tract urothelial carcinoma. BJU Int 2014;114:90-7.
13. Abaza R, Murphy C, Bsatee A, et al. Single-port Robotic Surgery Allows Same-day Discharge in Majority of Cases. Urology 2021;148:159-65.
14. Kim KH, Ahn HK, Kim M, et al. Technique and perioperative outcomes of single-port robotic surgery using the da Vinci SP platform in urology. Asian J Surg 2023;46:472-7.
15. Li KP, Chen SY, Wang CY, et al. Perioperative and oncologic outcomes of single-port versus conventional robotic-assisted partial nephrectomy: an evidence-based analysis of comparative outcomes. J Robot Surg 2023;17:765-77.
16. Lai A, di Meo NA, Chen G, et al. Single port robot

assisted nephroureterectomy. Urology Video Journal 2023;18.
17. Crivellaro S. Anterior Retroperitoneal Approach for Upper Urinary Tract Reconstructive Surgery Using a Single Port Robotic Platform. Chicago: American Urological Association Congress; 2023.

Cite this article as: Pellegrino AA, Mima M, Crivellaro S. Application of the single-port robotic platform during radical nephroureterectomy for upper tract urothelial carcinoma: feasibility of the single-port robot in the multi-quadrant setting. Transl Androl Urol 2023;12(9):1469-1474. doi: 10.21037/tau-23-48

