Review Article

Current status of robotic single-port surgery

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Abstract

Robotic-assisted laparoscopic surgery in urology is an ever progressing field, and boundaries are constantly broken with the aid of new technology. Advancements in instrumentation have given birth to the era of robotic laparoendoscopic single-site technique (R-LESS). R-LESS however, has not gained widespread acceptance due to technical hurdles such as adequate triangulation, robotic arm clashing, decreased access for the bedside assistant, lack of wrist articulation, continued need for an axillary/accessory port, lack of robust retraction, and ergonomic discomfort. Many innovations have been explored to counter such limitations. We aim to give a brief overview of a history and development of R-LESS urologic surgery and outline the latest advancements in the realm of urologic R-LESS. By searching PubMed selectively for relevant articles, we concluded a literature review. We searched using the keywords: robotic laparoscopic single incision, robotic laparoendoscopic single-site, single incision robotic surgery, and R-LESS. We selected all relevant articles in that pertained to single-site robotic surgery in urology. We selected all relevant articles that pertained to single-site robotic surgery in urology in a table encompassed within this article. The development of the R-LESS procedures, instrumentations, and platforms has been an evolution in progress. Our results showed the history and evolution toward a purpose-built single-port robotic platform that addresses previous limitations to R-LESS. Even though previous studies have shown feasibility with R-LESS, the future of R-LESS depends on the availability of purpose-built robotic platforms. The larger concern is the demonstration of the definitive advantage of single-site over the conventional multiport surgery.

Keywords: Nephrectomy, pyeloplasty, radical prostatectomy, robotic surgery, single-port surgery, single-site surgery

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INTRODUCTION

There has been a great development in practice of urology with the progressive shift from laparoscopic to robotic surgery in past few decades. Single-site surgery is a great leap since the introduction to laparoscopic/robotic surgery. The first surgery using single-port as reported by Hirano *et al.* was retroperitoneoscopic adrenalectomy in 2005.[3] Robotic laparoendoscopic single-site (R-LESS) has undergone remarkable growth since inception, and it addresses numerous issues associated with its predecessor, LESS. There is a significant enhancement in optics and ergonomics. Reports also conclude improved cosmesis and reduced incidence of postoperative complications such as abdominal adhesions and incisional hernias with single-port surgery. At present, R-LESS is applied in various urological procedures,

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including nephrectomy (partial, simple, and radical), pyeloplasty, nephroureterectomy, prostatectomy, and sacrocolpopexy.

Even though R-LESS is still an evolutionary technique, efforts are made to address common complaints regarding difficulties of triangulation and instrument clashing.[2] Numerous efforts are made to overcome these hindrances by developing flexible endoscopes, curved trocars, semi-rigid robotic instruments, multichannel ports, and seven-degree wrist movement of the robotic instruments. The surgical approach has been reconfigured. The extraperitoneal and perineal approach has shown intelligent advantage because of the ability to maneuver the instrument arm about its axis without moving each individual arm. Our group has recently published preclinical study using such approaches.[4] The aim of this paper is to analyze the current status of R-LESS and to discuss its future.

MATERIALS AND METHODS

By searching PubMed selectively for relevant articles, we concluded a literature review. The keywords used in our search were robotic laparoscopic single incision, robotic laparoendoscopic single-site, single incision robotic surgery, and R-LESS. We identified 36 related articles in specifically in the field of urology. We selectively chose only those that pertained to single-site robotic surgery in urology.

RESULTS

We identified and reviewed 36 articles on R-LESS in the field of urology [Table 1]. Although there are substantially more in circulation describing R-LESS use in such procedures as cholecystectomy, colectomy, and hysterectomy we focused on those concentrating on urology. The very first report of R-LESS was in 2008 by Kaouk *et al.* of three patients describing three different urologic procedures using the da Vinci S robotic platform through a multichannel single-port.[5] These three first R-LESS procedures opened the gateway to advance this technique and was driven by the enthusiasm of decreasing the need for visible scars, decreasing postoperative pain during major abdominal surgery. It was also reported that using the robot did enhance surgeon experience, and eased the technicalities of the surgical procedures compared to pure LESS technique. However, this was not without limitations. The first generation da Vinci platform occupied substantial space extracorporeally which caused clashing of the arms and inhibited triangulation which was necessary for laparoscopic surgery. This lack of triangulation was described as "chopstick" that occurs due to the lack of wrist movement.[1]

The few studies that were published the following year in 2009 began to develop the R-LESS using the similar platform. The use of the GelPort was an effort to decrease the problems with the triangulation and arm clashing that was the ever present problem.[7] The access site for the robot did continue to be one of the primary issues with the robotic platform at that time. Won Lee *et al.* described using a glove size seven, and an Alexis wound retractor (Applied Medical, Rancho Santa Margarita, CA, USA) to facilitate further movement and flexibility of the robotic arms but was met with issues such as tearing the glove, loss of air pressure and increased operative time.[17]

Advancements also took place with regards to the robotic instruments. In 2010, our group first described the use of the VeSPA instruments and accessories in a preclinical study in pigs. These instruments were rigid as the standard da Vinci arms were, which allowed them to be flexed and crossed at the fascial level with the aid of curved cannulae. Furthermore, introduced in this study was a newly designed specific-purpose multichannel single-port. The software for the new instruments allowed the right robotic arm to be controlled by the surgeon's left hand and *vice versa*. This eliminated the issues with triangulation. However, these first generation instruments restricted surgeon's freedom and ability of wrist articulation. Soon after, the implementation of slightly shorter trocars and more flexible instruments were redesigned. These second-generation improvements enhanced the laparoscopic environment [Figure 1].

The feasibility of R-LESS for partial nephrectomy in cases with larger tumor burden was first done by Tiu *et al.* in

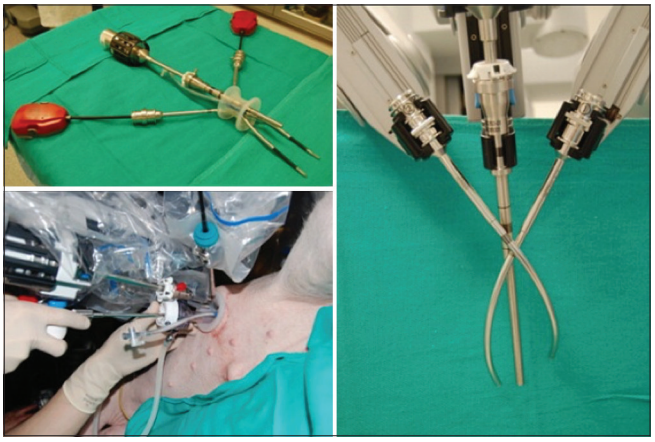

Figure 1: Top left: Photograph of new trocars in a single-site port. Bottom left: Photograph of single-port surgery with use of trocars. Right: Photograph of three trocars with adequate triangulation

Table 1: List of all relevant publications regarding robotic single-port surgery (study size and description is given where applicable)

n	Year	Author	Title	*n*	Description
1	2009	Kaouk *et al*.[5]	Robotic SP transumbilical surgery in humans: Initial report	3	Series study using R-LESS technique in 1 radical prostatectomy, 1 dismembered pyeloplasty, and 1 RN
2	2009	Kaouk and Goel[6]	SP laparoscopic and robotic PN	7	Retrospective review of 7 patients. 5 underwent single-port laparoscopic PN, and 2 patients underwent single-port robotic PN
3	2010	Stein *et al*.[7]	R-LESS using GelPort as the access platform	4	Series study using R-LESS technique in 2 pyeloplasties, 1 RN, and 1 PN
4	2010	Joseph *et al*.[1]	"Chopstick" surgery: A novel technique improves surgeon performance and eliminates arm collision in robotic single-incision laparoscopic surgery	NA	5 surgeons performed 3 different laparoscopic skills and that were monitored, graded, and timed
5	2010	White *et al*.[8]	R-LESS	2	Review article of current literature
6	2010	Haber *et al*.[9]	Novel robotic da Vinci instruments for LESS	16	Series study using R-LESS technique in 4 pyeloplasties, 4 partial nephrectomies, and 8 nephrectomies in a total of 8 farm pigs
7	2010	White *et al*.[10]	R-LESS radical prostatectomy: Technique and early outcomes	20	Retrospective comparative analysis of 10 patients in an R-LESS nephrectomy arm, and 10 patients in a conventional laparoscopy arm
8	2011	White *et al*.[11]	R-LESS RN: Surgical technique and comparative outcomes	10	Retrospective review of 10 patients that underwent R-LESS RN. Compared with matched control group of 10 patients who underwent conventional LESS
9	2011	Spana *et al*.[12]	Is robotics the future of LESS?		Review article
10	2011	Kaouk *et al*.[13]	LESS in urology: Worldwide multi-institutional analysis of 1076 cases	143	Large multi-institutional worldwide series of LESS surgeries. In 143 (13%) the da Vinci robot was used during a portion of the procedure. 1076 were included in the entire study
11	2011	Han *et al*.[14]	Robot-assisted laparoscopic single-site surgery: PN for renal malignancy	16	Retrospective review of 14 cases of R- LESS-PN after 2 were excluded for having AML or XGP
12	2011	Rane and Autorino[15]	Robotic natural orifice translumenal endoscopic surgery and LESS: Current status	NA	Review article of current literature
13	2012	Olweny *et al*.[16]	Perioperative comparison of robotic-assisted LESS pyeloplasty versus conventional LESS pyeloplasty	15	Retrospective comparative analysis of twenty patients that underwent pyeloplasty. Ten patients in the R-LESS arm, and ten patients in the conventional LESS arm
14	2011	Won Lee *et al*.[17]	Urologic robot-assisted LESS using a homade SP device: A single center experience of 68 cases	68	Retrospective review of 68 R-LESS cases using a homemade device. Fifty-one partial nephrectomies, 12 nephroureterectomies, 3 nephrectomies, 2 adrenalectomies
15	2012	Cestari *et al*.[18]	Feasibility and preliminary clinical outcomes of R-LESS pyeloplasty using a new SP platform	9	Retrospective review of nine patients who underwent R-LESS pyeloplasty with the da Vinci single-site platform (multichannel single-port with two curved cannulas)
16	2012	White *et al*.[19]	R-LESS: The way forward	NA	Review article of current literature
17	2012	White *et al*.[20]	R-LESS urological survey: Analysis of 50 consecutive cases	50	Retrospective review of 50 patients who underwent R-LESS. 24 patients underwent renal surgery, 26 patients underwent pelvic surgery
18	2013	Tiu *et al*.[21]	Feasibility of R-LESS PN for renal tumors >4 cm	67	Retrospective comparative study of 67 patients who underwent R-LESS PN, stratified into 2 groups - >4 cm and ≤4 cm
19	2012	Kaouk *et al*.[22]	Robotic single-site kidney surgery: Evaluation of second-generation instruments in a cadaver model	3	Preclinical cadaveric study. 1 pyeloplasty, 1 radical, and 1 partial nephrectomies
20	2012	Verit el al.[23]	R-LESS: From present to future	NA	Review article of current literature
21	2012	Seideman *et al*.[24]	Robot-assisted LESS pyeloplasty: Technique using the da Vinci Si robotic platform	10	Series study using R-LESS technique in 10 pyeloplasty cases outlining surgeon experience
22	2013	Tobis *et al*.[25]	Robot-assisted transumbilical LESS pyeloplasty: Technique and perioperative outcomes from a Single Institution	8	Case series study of 8 patients who underwent R-LESS pyeloplasty
23	2014	Jung *et al*.[26]	Simultaneous robot-assisted LESS-PN and standard radical prostatectomy	3	Case series study-3 patients who underwent simultaneous R-LESS pyeloplasty and radical prostatectomy
24	2013	Merseburger *et al*.[27]	EAU guidelines on robotic and single-site surgery in urology	NA	Review of current literature, and suggested guidelines
25	2014	Mathieu *et al*.[28]	Robotic-assisted LESS-RN: First experience with the novel da Vinci single-site platform	6	First clinical series of 6 R-LESS radical nephrectomies with the novel R-LESS da Vinci platform
26	2014	Komninos *et al*.[29]	R-LESS PN trifecta outcome is inferior to multiport robotic PN: Comparative analysis	58	Retrospective comparative analysis. 58 total patients. Multiport trifecta was seen in 38 patients, 42.7% while the R-LESS group trifecta was seen in 20 patients, 25.6%

Contd...

Table 1: Contd...

n	Year	Author	Title	*n*	Description
27	2013	Autorino *et al*.[30]	Current status and future directions of robotic single-site surgery: A systematic review	NA	Review article of current literature
28	2014	Komninos *et al*.[31]	Robotic-assisted LESS partial nephrectomy with the novel da Vinci single-site platform: Initial experience	3	Series study using R-LESS technique in 3 partial nephrectomies, specifically using the novel R-LESS da Vinci platform
29	2014	Shin *et al*.[32]	LESS RAPN reduces postoperative wound pain without a rise in complication rates	167	Retrospective comparative analysis. 167 patients, 80 patients in the multiport robotic PN group and 79 in the R-LESS PN group
30	2014	Lim *et al*.[33]	LESS robotic-assisted nephroureterectomy: Comparison with conventional multiport technique in the management of upper urinary tract urothelial carcinoma	38	Retrospective comparative analysis. A total of 38 patients included in study, 17 in the R-LESS, and 21 in the multiport
31	2015	Buffi *et al*.[34]	Robotic-assisted, single-site, dismembered pyeloplasty for ureteropelvic junction obstruction with the new da Vinci platform: A Stage 2a study	30	Prospective study of 30 patients who were chosen, from 2 institutions, to undergo R-LESS pyeloplasty. Feasibility, safety, and efficacy were endpoints
32	2014	Kaouk *et al*.[35]	A novel robotic system for SP urologic surgery: First clinical investigation	19	Prospective study of 19 patients with 3-year follow-up. 11 radical prostatectomies, 4 partial nephrectomies, 4 nephrectomies
33	2014	Samarasekera and Kaouk[36]	Robotic single-port surgery: Current status and future considerations	NA	Review article of current literature
34	2016	Lee[37]	Robotic single-site sacrocolpopexy: First report and technique using the single-site wristed needle driver	6	Series study of 6 patients
35	2017	Maurice *et al*.[38]	R-LESS retroperitoneal renal surgery: Initial investigation of a purpose-built SP surgical system	9	Cadaveric series study including 9 procedures. 1 nephrectomy performed, and bilateral partial nephrectomies were performed on 4 cadavers
36	2016	Ramirez *et al*.[4]	Robotic perineal radical prostatectomy and pelvic lymph node dissection using a purpose-built SP robotic platform	3	Preclinical study demonstrating the feasibility of performing perineal radical prostatectomy with pelvic lymph node dissection using the purpose-built da Vinci model SP 1098

R-LESS: Robotic laparoendoscopic single-site surgery, EAU: European Association of Urology, AML: Acute myeloid leukemia, XGP: Xanthogranulomatous pyelonephritis, PN: Partial nephrectomy, RAPN: Robot-assisted partial nephrectomy, SP: Single-port, NA: Not available, RN: Radical nephrectomy

2012.[21] In this retrospective study, patients were stratified into two groups depending on size either >4 m or ≤4 cm. The study reported safety of R-LESS in tumors >4 cm but with longer warm ischemia times (WITs) and length of stay in patients with higher mean nephrometry scores. It was only in 2013 that Komninos *et al*. published the Trifecta outcome study after partial nephrectomies (i.e., WIT <20 min, negative surgical margins, and no surgical complications) showing inferior outcomes for R-LESS compared to multiport surgery.[29] Even though total operation time and WIT are longer in R-LESS, the effect on renal eGFR return was only short-term. The ultimate return of renal function was influenced by the amount of renal mass preserved.[31]

A prospective study of 19 patients that underwent R-LESS in 2010 with published results in 2014 after 3-year follow-up.[35] This study was the first direct clinical application showing feasibility and safety in human population. The latest and perhaps the most dynamic innovation have yet to be released. Preclinical trials are currently undergoing and two studies have described the new purpose-built single-port robotic SP 1098 [Figures 2 and 3].[4] This system holds promise to overcome difficulties with previous techniques and instrumentation. This new platform permits three instruments, and an 8 mm camera, which all individually articulate, to utilize a single 25 mm port. The SP 1098 is designed to be compatible with the Xi side cart. As described by Ramirez *et al*. and Maurice *et al*. the excellence of this design allows instruments to be deployed through at 25 mm port intracorporeally while maintaining all seven degrees of freedom at the wrist.[4,38] These two preclinical studies show that this platform allows complex procedures to be feasible and eliminates several of the previous limitations.

DISCUSSION

The advantages of R-LESS are undisputable with shorter recovery times and less postoperative pain with better cosmetic outcomes. The major shortcomings with the initial laparoscopic single-port surgery were instrument clashing, difficulties with triangulation. This led to single-port surgery attempted with the multiport standard platform with the da Vini S and Si models with the introduction of Gelport. Unfortunately, the robotic arms still limited the triangulation angle which the VeSPA system and automatic instrument reversal techniques showed less external clashing problems but with the sacrifice of wrist movement. What was necessitated was a complete

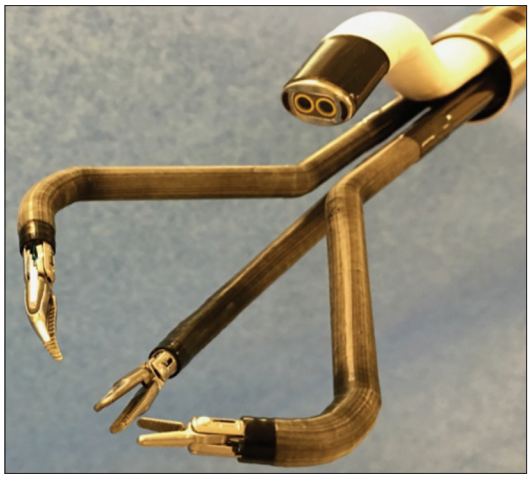

Figure 2: Photograph of single-port specific robotic instruments

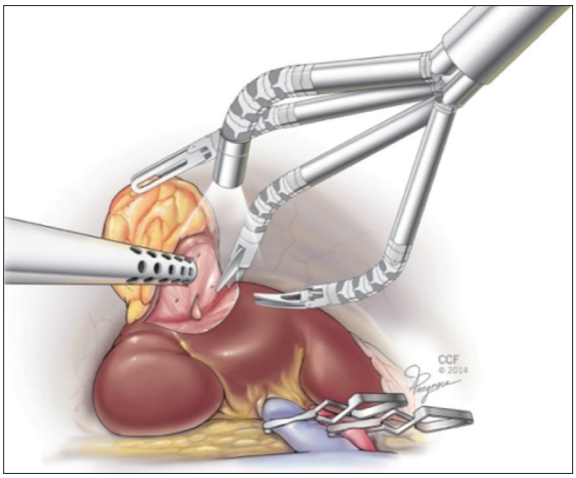

Figure 3: Illustration of single-port robotic instruments at work in a patient. The camera instrument works alongside of the assistant instruments during the surgery

change in the entire robotic platform. This progression of technological need gave birth to the novel da Vinci SP 1098 platform. Specifically developed for single-site surgery is still in preclinical research phase.[4,38] The endowrist technology introduced in 2015 has been a step forward to avoid difficulties with triangulation especially/more so in surgeries with multiple sutures and knot tying.[37] Limitations of R-LESS as reported include a steep learning curve and the level of expertise required to perform these procedures. Moreover, the majority of the studies to date are retrospective analysis with very few prospective studies in small group of patients.

CONCLUSION

Although feasibility and better outcomes are reported with less invasive single-port, there still remains a concern for the demonstration of a clear advantage of single-port over the conventional robotic surgery. There are improvements in technology-mostly that robotic interface is being used now compared to laparoscopy, and that a purpose-built robot is now being developed. Hence with new technology, the authors believe the field of single-port surgery will move toward more efficient surgeries and more innovational operative techniques. Whether such techniques will impact outcomes and decrease morbidity has yet to be seen.

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Conflicts of interest

Jihad H. Kaouk certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (e.g., employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: Endocare, Inc., Intuitive. - J.H. Kaouk (consultant).

REFERENCES

1. Joseph RA, Goh AC, Cuevas SP, Donovan MA, Kauffman MG, Salas NA, *et al.* "Chopstick" surgery: A novel technique improves surgeon performance and eliminates arm collision in robotic single-incision laparoscopic surgery. Surg Endosc 2010;24:1331-5.
2. Autorino R, Stein RJ, Lima E, Damiano R, Khanna R, Haber GP, *et al.* Current status and future perspectives in laparoendoscopic single-site and natural orifice transluminal endoscopic urological surgery. Int J Urol 2010;17:410-31.
3. Hirano D, Minei S, Yamaguchi K, Yoshikawa T, Hachiya T, Yoshida T, *et al.* Retroperitoneoscopic adrenalectomy for adrenal tumors via a single large port. J Endourol 2005;19:788-92.
4. Ramirez D, Maurice MJ, Kaouk JH. Robotic perineal radical prostatectomy and pelvic lymph node dissection using a purpose-built single-port robotic platform. BJU Int 2016;118:829-33.
5. Kaouk JH, Goel RK, Haber GP, Crouzet S, Stein RJ. Robotic single-port transumbilical surgery in humans: Initial report. BJU Int 2009;103:366-9.
6. Kaouk JH, Goel RK. Single-port laparoscopic and robotic partial nephrectomy. Eur Urol 2009;55:1163-9.
7. Stein RJ, White WM, Goel RK, Irwin BH, Haber GP, Kaouk JH. Robotic laparoendoscopic single-site surgery using GelPort as the access platform. Eur Urol 2010;57:132-6.
8. White MA, Haber GP, Autorino R, Khanna R, Altunrende F, Yang B, *et al.* Robotic laparoendoscopic single-site surgery. BJU Int 2010;106(6 Pt B):923-7.
9. Haber GP, White MA, Autorino R, Escobar PF, Kroh MD, Chalikonda S, *et al.* Novel robotic da Vinci instruments for laparoendoscopic single-site surgery. Urology 2010;76:1279-82.
10. White MA, Haber GP, Autorino R, Khanna R, Forest S, Yang B, *et al.* Robotic laparoendoscopic single-site radical prostatectomy: Technique and early outcomes. Eur Urol 2010;58:544-50.
11. White MA, Autorino R, Spana G, Laydner H, Hillyer SP, Khanna R, *et al.* Robotic laparoendoscopic single-site radical nephrectomy: Surgical technique and comparative outcomes. Eur Urol 2011;59:815-22.
12. Spana G, Rane A, Kaouk JH. Is robotics the future of laparoendoscopic

single-site surgery (LESS)? BJU Int 2011;108(6 Pt 2):1018-23.
13. Kaouk JH, Autorino R, Kim FJ, Han DH, Lee SW, Yinghao S, *et al*. Laparoendoscopic single-site surgery in urology: Worldwide multi-institutional analysis of 1076 cases. Eur Urol 2011;60:998-1005.
14. Han WK, Kim DS, Jeon HG, Jeong W, Oh CK, Choi KH, *et al*. Robot-assisted laparoendoscopic single-site surgery: Partial nephrectomy for renal malignancy. Urology 2011;77:612-6.
15. Rane A, Autorino R. Robotic natural orifice translumenal endoscopic surgery and laparoendoscopic single-site surgery: Current status. Curr Opin Urol 2011;21:71-7.
16. Olweny EO, Park SK, Tan YK, Gurbuz C, Cadeddu JA, Best SL. Perioperative comparison of robotic assisted laparoendoscopic single-site (LESS) pyeloplasty versus conventional LESS pyeloplasty. Eur Urol 2012;61:410-4.
17. Won Lee J, Arkoncel FR, Rha KH, Choi KH, Yu HS, Chae Y, *et al*. Urologic robot-assisted laparoendoscopic single-site surgery using a homemade single-port device: A single-center experience of 68 cases. J Endourol 2011;25:1481-5.
18. Cestari A, Buffi NM, Lista G, Lughezzani G, Larcher A, Lazzeri M, *et al*. Feasibility and preliminary clinical outcomes of robotic laparoendoscopic single-site (R-LESS) pyeloplasty using a new single-port platform. Eur Urol 2012;62:175-9.
19. White MA, Autorino R, Hillyer SP, Spana G, Kaouk JH. Robotic laparoendoscopic single-site surgery: The way forward. Arch Esp Urol 2012;65:357-65.
20. White MA, Autorino R, Spana G, Hillyer S, Stein RJ, Kaouk JH. Robotic laparoendoscopic single site urological surgery: Analysis of 50 consecutive cases. J Urol 2012;187:1696-701.
21. Tiu A, Kim KH, Shin TY, Han WK, Han SW, Rha KH. Feasibility of robotic laparoendoscopic single-site partial nephrectomy for renal tumors >4 cm. Eur Urol 2013;63:941-6.
22. Kaouk JH, Autorino R, Laydner H, Hillyer S, Yakoubi R, Isac W, *et al*. Robotic single-site kidney surgery: Evaluation of second-generation instruments in a cadaver model. Urology 2012;79:975-9.
23. Verit A, Rizkala E, Autorino R, Stein RJ. Robotic laparoendoscopic single-site surgery: From present to future. Indian J Urol 2012;28:76-81.
24. Seideman CA, Tan YK, Faddegon S, Park SK, Best SL, Cadeddu JA, *et al*. Robot-assisted laparoendoscopic single-site pyeloplasty: Technique using the da Vinci Si robotic platform. J Endourol 2012;26:971-4.
25. Tobis S, Houman J, Thomer M, Rashid H, Wu G. Robot-assisted transumbilical laparoendoscopic single-site pyeloplasty: Technique and perioperative outcomes from a single institution. J Laparoendosc Adv Surg Tech A 2013;23:702-6.
26. Jung JH, Kim HW, Oh CK, Song JM, Chung BH, Hong SJ, *et al*. Simultaneous robot-assisted laparoendoscopic single-site partial nephrectomy and standard radical prostatectomy. Yonsei Med J 2014;55:535-8.
27. Merseburger AS, Herrmann TR, Shariat SF, Kyriazis I, Nagele U, Traxer O, *et al*. EAU guidelines on robotic and single-site surgery in urology. Eur Urol 2013;64:277-91.
28. Mathieu R, Verhoest G, Vincendeau S, Manunta A, Bensalah K. Robotic-assisted laparoendoscopic single-site radical nephrectomy: First experience with the novel Da Vinci single-site platform. World J Urol 2014;32:273-6.
29. Komninos C, Shin TY, Tuliao P, Yoon YE, Koo KC, Chang CH, *et al*. R-LESS partial nephrectomy trifecta outcome is inferior to multiport robotic partial nephrectomy: Comparative analysis. Eur Urol 2014;66:512-7.
30. Autorino R, Kaouk JH, Stolzenburg JU, Gill IS, Mottrie A, Tewari A, *et al*. Current status and future directions of robotic single-site surgery: A systematic review. Eur Urol 2013;63:266-80.
31. Komninos C, Tuliao P, Kim DK, Choi YD, Chung BH, Rha KH. Robot-assisted laparoendoscopic single-site partial nephrectomy with the novel da Vinci single-site platform: Initial experience. Korean J Urol 2014;55:380-4.
32. Shin TY, Lim SK, Komninos C, Kim DW, Han WK, Hong SJ, *et al*. Laparoendoscopic single-site (LESS) robot-assisted partial nephrectomy (RAPN) reduces postoperative wound pain without a rise in complication rates. BJU Int 2014;114:555-61.
33. Lim SK, Shin TY, Kim KH, Han WK, Chung BH, Hong SJ, *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.
34. Buffi NM, Lughezzani G, Fossati N, Lazzeri M, Guazzoni G, Lista G, *et al*. Robot-assisted, single-site, dismembered pyeloplasty for ureteropelvic junction obstruction with the new da Vinci platform: A stage 2a study. Eur Urol 2015;67:151-6.
35. Kaouk JH, Haber GP, Autorino R, Crouzet S, Ouzzane A, Flamand V, *et al*. A novel robotic system for single-port urologic surgery: First clinical investigation. Eur Urol 2014;66:1033-43.
36. Samarasekera D, Kaouk JH. Robotic single port surgery: Current status and future considerations. Indian J Urol 2014;30:326-32.
37. Lee SR. Robotic single-site® sacrocolpopexy: First report and technique using the single-site® wristed needle driver. Yonsei Med J 2016;57:1029-33.
38. Maurice MJ, Ramirez D, Kaouk JH. Robotic laparoendoscopic single-site retroperitoneal renal surgery: Initial investigation of a purpose-built single-port surgical system. Eur Urol 2017;71:643-7.