First Canadian experience with robotic single-incision pyeloplasty: Comparison with multi-incision technique

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Abstract

Introduction: We compared the outcomes of single-incision, robot-assisted laparoscopic pyeloplasty vs. multiple-incision pyeloplasty using the da Vinci robotic system.

Methods: We reviewed all consecutive robotic pyeloplasties by a single surgeon from January 2011 to August 2015. A total of 30 procedures were performed (16 single:14 multi-port). Two different single-port devices were compared: the GelPort (Applied Medical, Rancho Santa Margarita, CA) and the Intuitive single-site access port (Intuitive Surgical, Sunnyvale, CA).

Results: Patient demographics were similar between the two groups. Mean operating time was similar among the single and multi-port groups (225.2 min vs. 198.9 minutes [p=0.33]). There was no significant difference in length of hospital stay in either group (86.2 hr vs. 93.2 hr [p=0.76]). There was no difference in success rates or postoperative complications among groups.

Conclusions: Single-port robotic pyeloplasty is non-inferior to multiple-incision robotic surgery in terms of operative times, hospitalization time, success rates, and complications. Verifying these results with larger cohorts is required prior to the wide adoption of this technique. Ongoing objective measurements of cosmesis and patient satisfaction are being evaluated.

Introduction

Conventional laparoscopic pyeloplasty for ureteropelvic junction obstruction (UPJO) is a minimally invasive approach that generally requires three or four small abdominal wall incisions. In recent years, laparo-endoendoscopic single-site surgery (LESS) has been developed via a single transumbilical incision, where all instruments are inserted into the abdominal cavity.[1-6]

LESS surgery offers enhanced postoperative cosmetic appearance and is believed to decrease abdominal wall trauma compared with conventional multi-incision procedures. However, difficulties encountered with LESS include lack of triangulation and counterintuitive movement of tools secondary to crossing and clashing of instruments. LESS pyeloplasty is particularly difficult because of the extensive intracorporeal suturing that is required.

By using wristed instrumentation (EndoWrist®) that facilitates suturing in restricted areas, three-dimensional visualization, increased magnification, and tremour filtration, the da Vinci robotic surgical platform (Intuitive Surgical, Sunnyvale, CA, USA) may overcome the challenges of operating through a single incision. Moreover, a wide variety of robotic-LESS (R-LESS) ports and instruments have been developed to facilitate single-incision surgery.

We report the initial Canadian experience with robotic, single-port pyeloplasty. We used and compare two different single-site port devices currently available for R-LESS: the GelPort (Applied Medical, Rancho Santa Margarita, CA) and the Intuitive Surgical single-site (SS) port (Intuitive Surgical, Sunnyvale, CA).

Methods

Subjects and methods

Consecutive patients presenting with symptomatic, primary UPJO were evaluated and suitability for pyeloplasty was determined based on clinical judgment. Radiographic diagnosis of UPJO was obtained by diuretic nuclear renography and computed tomography (CT) scan in all cases. Eligible patients underwent multiple-port robotic pyeloplasty between January 2011 and February 2013, after which R-LESS pyeloplasty was performed until August 2015. Each surgical patient was entered into a prospectively maintained institutional review board-approved database.

A standard data collection spreadsheet was used. The preoperative information collected included basic patient characteristics, such as age and sex. Intraoperative information included

procedure performed, operative time, estimated blood loss, and details of the surgical technique. The postoperative information included complications, hospital length of stay (LOS), objective resolution of obstruction (MAG-3 lasix renogram), and pain.

Pyeloplasty surgical technique

The da Vinci Si Surgical System was used for all procedures. Ureteric stents were placed immediately prior to the pyeloplasty procedure. Patients were positioned in lateral decubitus position. After insertion of the trocars and insufflation, the da Vinci robot was docked as previously described (Fig. 1).[7] The UPJ was mobilized, dismembered, and the ureter brought anterior to any crossing vessels. The ureter was then spatulated and re-anastomosed to the renal pelvis in an Anderson-Hyne technique using 4-0 PDS sutures in running continuous fashion.[7] Drains were placed through the umbilical port in R-LESS cases (Fig. 2).

Robotic laparoendoscopic single-site technique

R-LESS pyeloplasty was performed through a single incision through the umbilicus measuring approximately 1.5–4.0 cm in length. Either a GelPort or SS port was placed through the single umbilical incision, and a total of four trocars (camera trocar, two robot working trocars, and the accessory trocar) were inserted through the port (Fig. 3), followed by insufflation of the abdominal cavity with carbon dioxide gas. The daVinci robot was docked with the first setup joint locked in a straight position in order to facilitate proper insertion of the working instruments (Fig. 1). Eight millimeter (8 mm) wristed robotic arms were utilized with the GelPort cases. Two flexible 5 mm non-wristed arms were placed into short curved trocars in the SS cases. This permitted the functional arms to cross and triangulate in order to prevent clashing (Fig. 4).

Robotic multi-port technique

Multi-port pyeloplasty was performed through four intraperitoneal port sites. Individual trocars were inserted as previously described.[7]

Statistical analyses

Preoperative, intraoperative, and postoperative outcomes were compared between each of the two groups. Complications were classified according to the Clavien-Dindo classification scheme. Variables were analyzed using a one-way analysis of variance. A significance level of ≤ 0.05 was chosen for each test. GraphPad Prism v.5.0 (GraphPad Software, San Diego, U.S.) was used for statistical analyses.

Results

Demographics

Sixteen (16) patients underwent R-LESS pyeloplasty between April 2013 and August 2015 (Group 1). Of the R-LESS surgeries, nine were performed with the GelPort and seven

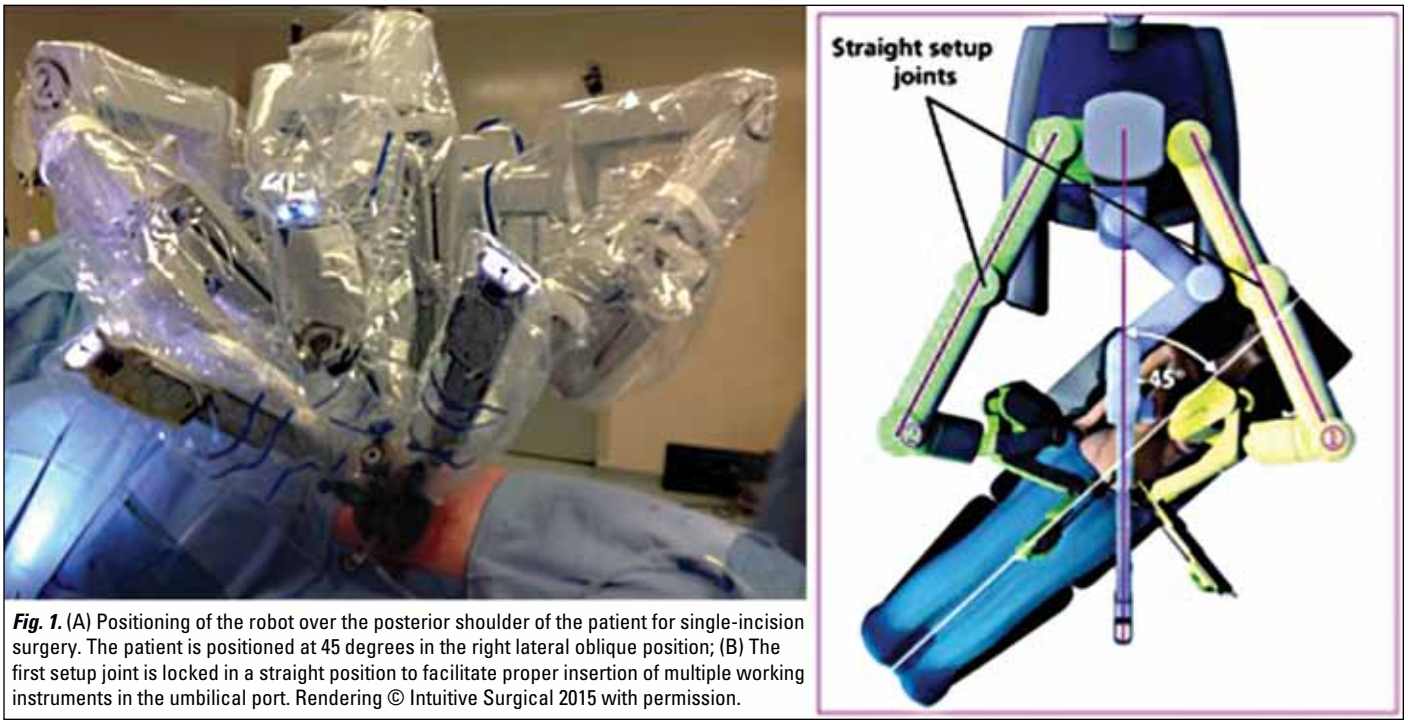

Fig. 1. (A) Positioning of the robot over the posterior shoulder of the patient for single-incision surgery. The patient is positioned at 45 degrees in the right lateral oblique position; (B) The first setup joint is locked in a straight position to facilitate proper insertion of multiple working instruments in the umbilical port. Rendering © Intuitive Surgical 2015 with permission.

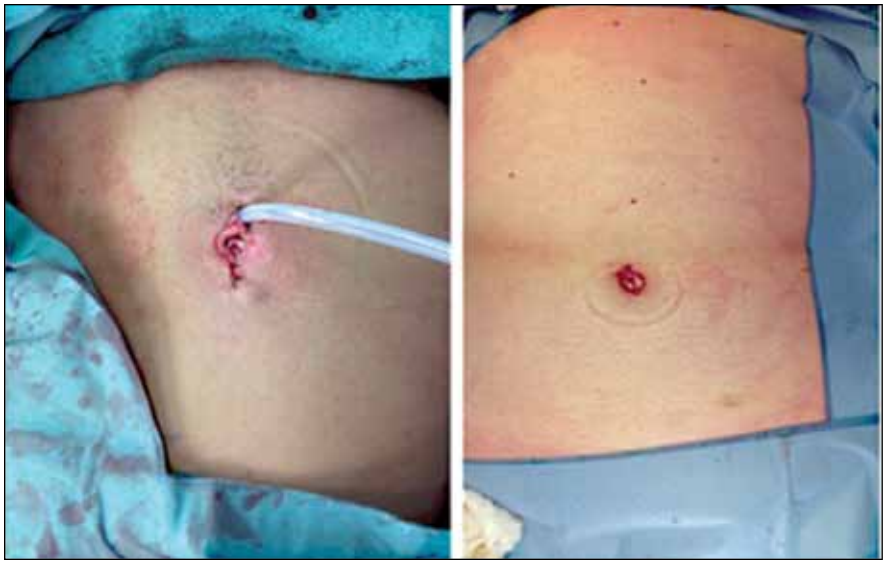

Fig. 2. (A) Placement of Hemovac drain through the umbilical incision (GelPort platform); (B) Umbilical incision post-single site platform R-LESS surgery (Intuitive Surgical).

with the SS port. Data for this group were compared with the 14 most recent consecutive patients who underwent conventional robotic, multi-port pyeloplasty (Group 2). Patient demographics are listed in Table 1. The groups were similar with regard to baseline demographics and clinical features. There were no significant differences between male:female ratio or mean age of patients. All surgeries but one of the multi-port pyeloplasty cases was unilateral; otherwise, there was no significant difference in the laterality of procedures between the two groups (Table 1).

Outcomes

Perioperative outcomes are outlined in Table 2. Mean operative time (including robotic docking) using the GelPort (231.6 ± 25.3 min) or the SS port (217.0 ± 58.8 min) was not significantly different compared to robotic, multi-port pyeloplasty (198.9 ± 57.8 min) (p=0.33). There were no conversions to standard laparoscopy in any of the groups.

Fig. 3. (A) Placement of inner phalange using GelPort device; (B) Disposable and 8 mm robotic ports placed through the GelPort device.

Estimated blood loss in the GelPort and SS port groups was not significantly different from the multiple incision group (p=0.71). None of the patients in the two groups required blood transfusion during the procedures. Length of stay in hospital for the GelPort (86.2 ± 52.0 hours) and SS port group (74.3 ± 16.6 hours) was also not significantly different compared with the multi-port group (93.2 ± 53.0 hours) (p=0.76).

Clinical outcomes were favourable for both groups (Table 3). In the multi-port pyeloplasty group, 13 of 14 patients were asymptomatic after stent removal, and the most recent MAG-3 lasix renogram scans showed improved drainage when compared to the preoperative study (postop six months in all). One of 14 patients developed recurrent flank pain, which required balloon dilatation of the UPJ. In the R-LESS group, 15 of 16 patients had obstructive symptoms resolve postoperatively. More specifically, eight of nine patients in the GelPort group and all of the patients in the SS port group had resolution of symptoms. The solitary patient in the GelPort group developed recurrent flank pain and was investigated with ureteroscopy demonstrating a wide open UPJ.

There were five postoperative complications among the 14 patients in the robotic, multi-port group, compared to four complications among 16 patients in the R-LESS group. For the multi-port group, all of the complications were Clavien-Dindo Grade 2. The complications included urinary tract infection (UTI) (two patients), pyelonephritis (two patients), and cellulitis of the umbilical would (one patient). In the R-LESS GelPort group, three patients had UTI requiring antibiotic treatment and one of these patients also required blood transfusion, but did not necessitate surgical re-intervention (Clavien-Dindo Grade 2). Of the Intuitive Surgical port group, one patient had a postoperative UTI requiring antibiotics. Overall, there was no significant difference in number of complications among the GelPort, SS or multi-port groups (p=0.76).

Discussion

Up to now, case series and reports demonstrated feasibility of the R-LESS approach in performing dismembered pyeloplasty.[1-6] The current study is the first study comparing R-LESS pyeloplasty with robotic, multiple-incision pyeloplasty. Moreover,

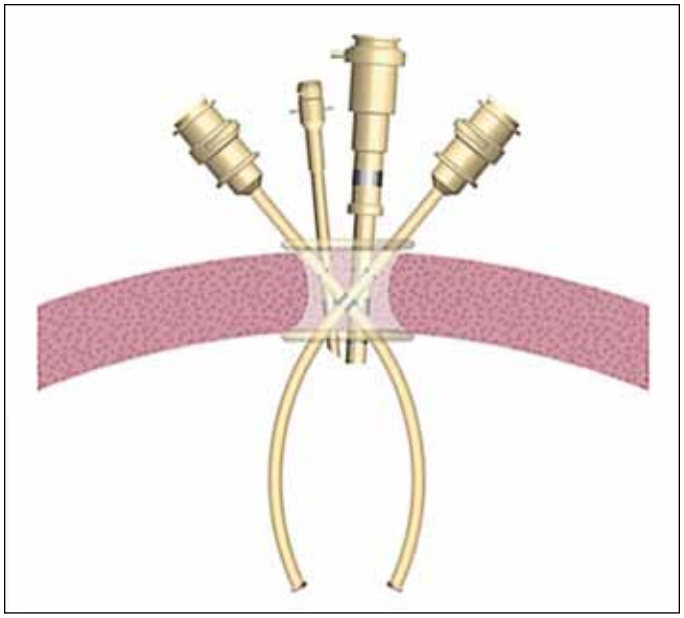

Fig. 4. Diagram showing the orientation of the single-site device (Intuitive). Note that the curved working ports house the flexible instruments. The working ports cross one another mid-fascia at the fulcrum, requiring the software of the da Vinci Si robot to reorient the working arms of the robot with the controls at the console. Rendering © Intuitive Surgical 2015 with permission.

most investigations to date have been performed with the GelPort device.[1,2,4,5] The novel SS robotic surgery platform was evaluated critically for R-LESS pyeloplasty for the first time in North America at our centre. To our knowledge, this is the first series comparing the SS system to the GelPort system.

The GelPort contains a gelatin platform for trocar placement. The advantages compared to other platforms include a limitless number of potential trocar configurations and the ability to accommodate different abdominal wall thicknesses. A large working profile reduces external clashing and instruments can be spaced apart to obtain better triangulation. Importantly, the robotic instruments using endo-wristed tools are also compatible with the GelPort (Fig. 5A).

The SS access port is a five-lumen port that contains two curved cannulas that allow for the robotic instruments to cross over one another within the trocar so that the right-entering instrument becomes the left-sided operative instrument in the abdominal cavity and vice versa (Fig. 4). Advantages of this setup are that the arms are further separated intracorporeally, thus reducing instrument collision and allowing triangulation of the target tissue (Fig. 5B). The software of the Si system corrects for the right to left crossover of the arms, making for more natural hand-eye coordination. Furthermore, the initial incision required (~1.5–2.5 cm) is smaller than what is required for the GelPort. There are two additional trocars with straight cannulas for a 8.5 mm endoscope and a 5/10 mm assistant trocar in addition to one insufflation valve. At the time of our study, there were no endo-wristed instruments available, and monopolar cautery was only available on the endoscopic L-hook device.

Regarding operative times, we found no significant difference in mean operative time among the GelPort, SS, or multi-port pyeloplasty. Patients were not selected for SS or GelPort access and as a result, patient demographics did not differ. Our mean operative time for R-LESS pyeloplasty was 225.2 ± 42.2 min and is consistent with most published reports.[1,2,4,5] However, the authors note that without the endo-wristed instruments, R-LESS pyeloplasty was significantly more challenging with the SS system. The curved cannulas also needed to be pulled further out of the SS port to facilitate completion of the pyeloplasty procedures in some smaller patients, which also reduced the ability to triangulate the working instruments.

In terms of safety, no intraoperative complications were reported for either R-LESS or the robotic, multiple-incision groups. The postoperative complication rate was low, with all complications being Grade 2 according to the Clavien-Dindo classification. We observed no significant difference in postoperative complication rates among each of the single-port approaches and multi-port pyeloplasty. In general, postoperative complications reported by other groups have been low-grade, although urine leak requiring a nephrostomy tube has been described in a some cases.[1,2,5]

As for length of hospital stay, we found no significant dif-

Table 1. Patient characteristics

	Type of robotic pyeloplasty					
	Group 1 (Single-port)[1]			Group 2 (Multi-port)[2]	Total	*p* value
	GelPort	SS[3]	Combined			
Number of patients	9	7	16	14	30	0.93
Male:Female	3:6	4:3	7:9	7:7	14:16	0.94
Mean age of patient, years (SD)	35.8 (15.3)	43.6 (17.6)	39.3 (16.3)	34.1 (19.8)	36.2 (18.2)	0.53
Laterality, left:right	3:6	3:4	6:10	7:8	13:18	0.97

[1]Four of the single-port procedures required an extra port ("single +1 procedure"); [2]One of the multiple-port procedures was a bilateral pyeloplasty; [3]Single-site platform (Intuitive Surgical). SD: standard deviation; SS: single-site.

Table 2. Perioperative outcomes

	Type of robotic pyeloplasty					
	Group 1 (Single-port)			Group 2 (Multi-port)	Total	*p* value
	GelPort	SS	Combined			
Number of patients	9	7	16	14	30	0.93
Mean OR time, minutes (SD)	231.6 (25.3)	217.0 (58.8)	225.2 (42.2)	198.9 (57.8)	213.5 (51.8)	0.33
Mean estimated blood loss, mL (SD)	141.7 (156.2)	92.9 (60.8)	115.3 (101.2)	115 (74)	119.1 (102.9)	0.71
Conversion to laparoscopy	0	0	0	0	0	1.0
Mean LOS, hours (SD)	86.2 (52.0)	74.3 (16.6)	86.67 (46.1)	93.2 (53.0)	87.8 (46.5)	0.76

LOS: length of stay; OR: operating time; SD: standard deviation; SS: single-site.

ferences among the GelPort or SS port compared with multi-port surgery, although there seemed to be a trend towards a shorter stay for those who had undergone R-LESS pyeloplasty. The length of postoperative stay from this operation likely relates with postoperative protocols rather than resolution of ileus or limitations of incisional pain, as evidenced in the literature, which demonstrates hospital stay being anywhere between one to greater than five days.[6] In terms of functional results, over 93% of patients experienced a resolution of symptoms as well as an improved $T_{1/2}$ on lasix renogram post-R-LESS procedures, consistent with success rates of open, laparoscopic, robotic and LESS pyeloplasty.[6]

There were a number of disadvantages with both of the single-site access ports used. With the GelPort, robotic cases were associated with instrument crossing and difficulty in placement of the accessory instruments used for suction or retraction. The GelPort also requires a larger initial incision (~3–4 cm) for positioning of the inner ring. By comparison, the major drawback of the SS system is that the tools currently do not have endo-wrist articulation, which hinders one of the important advantages of the surgical robot. Unlike the GelPort, there is less flexibility in the number, size, and configuration of instruments that can be placed. Moreover, there is less flexibility for adapting to different abdominal thicknesses and the port is prone to air leaks as well. In order to facilitate suturing, one of the curved ports was often removed and replaced by a standard endo-wrist instrument through the 10 mm assistant port in a hybrid approach.

This study reports the first and only Canadian experience with R-LESS pyeloplasty to date and the only North American experience with the SS system for pyeloplasty. The limitations of this study include the small number of patients and that cosmetic results were not evaluated due to lack of validated assessment tools. Larger series and prospective studies are necessary to properly define the role of the R-LESS technique. Despite reasonable operative times and functional results with two different R-LESS access ports, we believe this approach remains more technically challenging than conventional robotic, multiple-incision pyeloplasty. Ongoing refinement of this technique is critical prior to promotion and widespread adoption. Re-evaluation of robotic platforms specifically designed for single-incision surgery will be necessary going forward.

Conclusion

This study has demonstrated that our early experience with both R-LESS and robotic, multiple-incision pyeloplasty are comparable in terms of surgical safety, as well as perioperative and postoperative outcomes.

Competing interests: Dr. Sener has received grants/honoraria from CONMED, Eli Lily, and FirstKIND; and is the co-founder of Clearwater Clinical Limited. The remaining authors declare no competing financial or personal interests.

Table 3. Postoperative outcomes

	Type of robotic pyeloplasty					
	Group 1 (Single-port)			Group 2 (Multi-port)	Total	*p* value
	GelPort	SS	Combined			
Number of patients	9	7	16	14	30	0.93
Patients with persistent obstruction post-pyeloplasty on renogram	1/9	0/7	1/16	1/14	2/30	0.63
Number of patients requiring reintervention	1/9	0/7	1/16	1/14	2/30	0.63
Number of complications	4	1	5	5	10	0.76

SS: single-site.

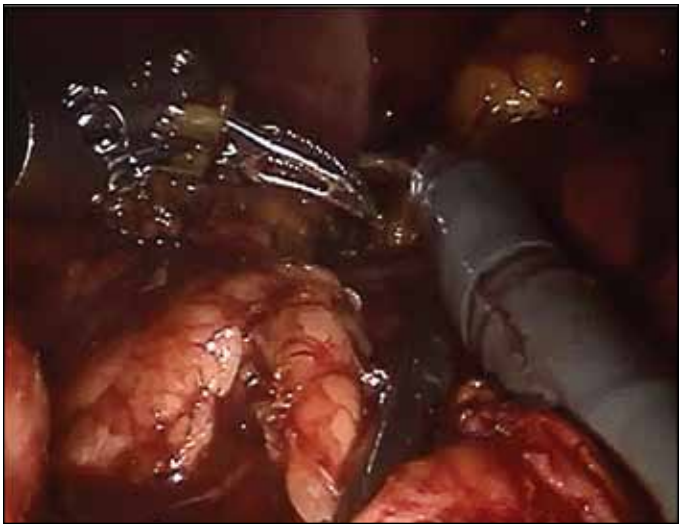

Fig. 5A. Laparoscopic image demonstrating view of target tissues using the GelPort system. The instruments are standard articulating tools, providing good dexterity. In order to separate the instruments, the umbilical incision needs to be 3–4 cm long instead of 1.5–2.5 cm required for the single-site platform.

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This paper has been peer-reviewed.

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Fig. 5B. Image of the single-site (Intuitive) ports and instruments. The instruments cross at the level the fascia. The curved ports and flexible instruments provide separation between instruments and the camera. However, dexterity is limited by the lack of wristed instruments for the current platform. Rendering © Intuitive Surgical 2015 with permission.

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