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ORIGINAL ARTICLE

Therapeutic supine robotic retroperitoneal lymph node dissection for post-chemotherapy residual masses in testicular cancer: technique and outcome analysis of initial experience

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Abstract
Retroperitoneal lymph node dissection (RPLND) is a therapeutic standard of care for post-chemotherapy residual masses in testicular cancer. While a robotic approach to this procedure has the potential of decreasing the morbidity associated with this major endeavour, it is often criticised for its inability to provide a bilateral complete template resection without redocking and repositioning the patient. Herein, we present the technique and initial outcomes of a supine approach to Robotic RPLND (R-RPLND) using the da Vinci Xi® system, which obviates the need for repositioning or redocking for a bilateral full template resection. Three patients (age 21–36) with nonseminomatous germ cell tumours of the testis underwent R-RPLND for post-chemotherapy residual retroperitoneal masses with normalised tumor markers. Salient steps of the procedure were as follows: port placement in supine Trendelenburg position, docking of the da Vinci Xi® system from one side, exposure of retroperitoneum, dissection of paracaval, retrocaval, interaortocaval, paraaortic and bilateral common iliac templates, and excision of gonadal vein. Mean console time and estimated blood loss were 257 (190–305) minutes and 333 (300–400) ml, respectively. Mean lymph node yield was 52 (29–94). One patient had a common iliac vein injury which was managed robotically without further consequence. No drains were placed in all three. There were no postoperative complications and all of them were advanced to a normal diet within 24 h and discharged on the second postoperative day. Histopathology reports were suggestive of necrosis and mature teratoma without any viable tumour. There have been no recurrences in these patients at a mean follow-up of 14 (1–22) months. R-RPLND in the supine position is practical, safe and feasible in the post-chemotherapy setting of testicular cancer. It eliminates the need for repositioning the patient or redocking the robot to achieve a complete resection with adequate lymph node yields, while preserving the benefits of a minimally invasive surgical approach.

Keywords Retroperitoneal lymph node dissection · Da Vinci Xi® system · Post-chemotherapy residual masses in testicular cancer · Robotic RPLND

Introduction

Retroperitoneal lymph node dissection (RPLND) is the staging and/or therapeutic procedure for various stages of nonseminomatous germ cell tumours (NSGCT) [1]. Indications for RPLND can either be in a primary setting for stage 1 or stage 2 NSGCT or in a post-chemotherapy (PC) setting for residual masses after chemotherapy [1]. For seminomas, guidelines from the European consensus conference on diagnosis and treatment of germ cell cancer (EGCCCG) recommend surgical resection or salvage chemotherapy for 2-18fluoro-deoxy-D-glucose positron emission tomography (FDG PET) positive residual masses larger than 3 cm with or without histological diagnosis [2]. However, there is a high chance of requirement of additional procedures during post-chemotherapy RPLND (PC-RPLND) in seminomatous masses, which can be in the form of nephrectomy, IVC resections or arterial grafts, bowel or hepatic resection [3]. In light of these, EGCCCG recommends that PC-RPLND for seminomatous masses should be performed at high-volume centres only [2].

RPLND, like most other procedures in urologic oncology, has not remained untouched by the relentless march of

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minimally invasive surgery in the last two decades. In this era, this procedure has progressed from a conventional open approach to a laparoscopic to a robotic approach. A post-chemotherapy setting is not an exception to this. Though a robotic approach has been used for PC-RPLND, it has often been criticised as being more prone to result in incomplete resection ('cherry picking'). This is in view of the fact that most described techniques entail repositioning the patient to a contralateral position with the requisite need for reorienting and redocking the robotic system.

The recent description of supine RPLND using the da Vinci Xi® system (Intuitive Surgical, Sunnyvale, California, USA) prompted us to adapt this technique to the PC setting to explore the possibility of achieving a complete resection without changing the patient's position or redocking the robot [4]. At present, the global experience of this procedure is limited to a few small case series only. In this technology update, we have tried to focus on the step by step technique of bilateral full template PC-RPLND in a supine position with the da Vinci Xi® system, without repositioning the patient or redocking the robot. We have analysed our results of three such cases in terms of intraoperative and postoperative parameters and included their short-term follow-up as well.

Materials and methods

Three patients with testicular cancer (age range 21–36 years), with post--chemotherapy residual masses, underwent bilateral full template RPLND in a supine position using the da Vinci Xi® system at our tertiary care centre (Table 1). All three cases were performed by a single surgical team with previous experience of approximately 700 robotic urologic oncology procedures. All of them had NSGCT with normalised tumour markers after cisplatin-based chemotherapy. The first one had a left side testicular primary with a $2.4 \times 1.7 \times 2$ cm residual mass in a paraaortic location after seven cycles of chemotherapy (chemotherapy was given outside following which patient was referred to our centre). The second patient had a residual mass of $5.7 \times 5.4 \times 6.4$ cm in the interaortocaval region after three cycles of chemotherapy for right-sided testicular NSGCT (Fig. 1). The third patient had a 1.6×1 cm residual mass in the aortocaval window after 3 cycles of chemotherapy for right-sided testicular embryonal carcinoma.

Table 1 Demographic profile, intraoperative and postoperative data

	Patient 1	Patient 2	Patient 3	Mean
Age (years)	27	36	21	31.5
Side of primary	Left	Right	Right	
Type of tumour	NSGCT	NSGCT	NSGCT	
Number of chemotherapy cycles	7	3	3	
Tumour markers after chemotherapy	Normalised	Normalised	Normalised	
Size of residual mass on CT (cm)	2.4×1.7×2	5.7×5.4×6.4	1.6×1	
Approach	Supine bilateral template RPLND with da Vinci Xi® system without redocking or repositioning	Supine bilateral template RPLND with da Vinci Xi® system without redocking or repositioning	Supine bilateral template RPLND with da Vinci Xi® system without redocking or repositioning	
Console time (minutes)	275	305	190	257
Estimated blood loss (ml)	400	300	300	333
Drain	No	No	No	
Intra-operative complications	Left common iliac vein injury—repaired intra-operatively	Nil	Nil	
Blood transfusion	Nil	Nil	Nil	
Open conversion	NA	NA	NA	
Post-operative complications (30 days)	Nil	Nil	Nil	
Day of discharge (days)	2	2	2	2
Lymph node yield	32	29	94	52
Histopathology	Necrosis	Mature cystic teratoma	No viable tumour	
Follow-up (months)	18—no recurrence	22—no recurrence	1	14

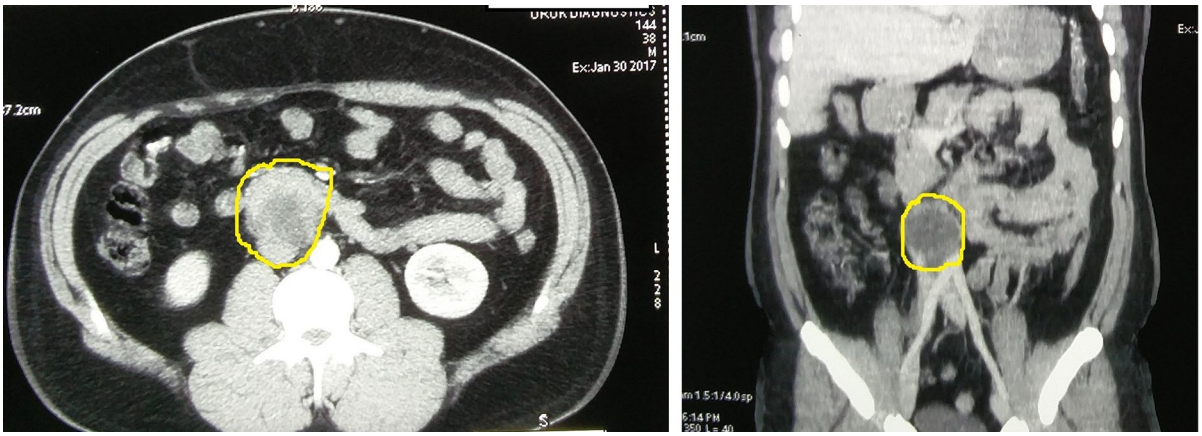

Fig. 1 Computed tomography showing precaval and preaortic residual mass after chemotherapy

Procedural steps for supine robotic RPLND

Patient positioning

After induction of general anaesthesia, the patient is placed in a supine Trendelenburg position and catheterised. All pressure points are padded well. Bilateral arms are tucked in laterally under the drapes. The Trendelenburg position helps in displacing the small bowel cephalad. Robot is docked from the side of the patient. It is a good habit to keep a rescue stitch ready while venturing into these cases.

Port placement

Pneumoperitoneum is created using a Veress needle to keep a standard working pressure of 15 mm Hg. For right-sided primary, all four robotic ports are placed in a straight line starting from right iliac fossa going diagonally upwards towards left flank maintaining a distance of 6–8 cm between adjacent ports and keeping all ports infraumbilically (Fig. 2). Central two ports are placed equidistant from midline. 12 mm assistant port is placed in left iliac fossa. This arrangement of ports is designed to provide access for ipsilateral gonadal vein excision. For a left -sided primary, a mirror image of this port arrangement is utilised. Sequence of instruments from right to left is fenestrated bipolar forceps, camera, monopolar scissors and Cadiere forceps, respectively. 30° scope, in the 'down' configuration, is used for the entire procedure.

Exposure

An initial incision is created in the posterior peritoneum from the cecum towards the ligament of Treitz. A monofilament suture on straight needle is inserted from the anterior abdominal wall on either side, passed through the edge of

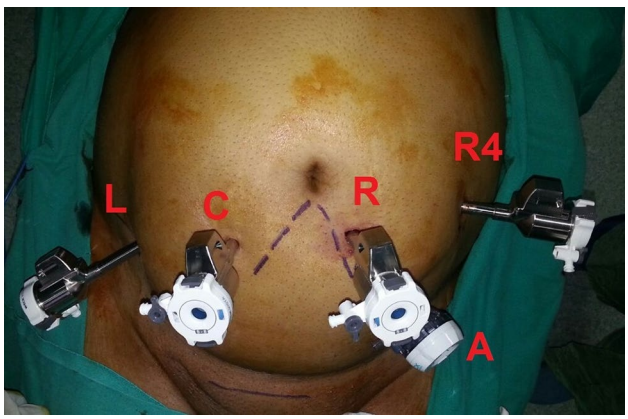

Fig. 2 Port placement for (right testicular primary with post-chemotherapy residual mass) L—left arm (8 mm) (fenestrated bipolar forceps), C—camera arm (8 mm), R—right arm (8 mm) (monopolar curved scissors), R4—fourth arm (8 mm) (Cadiere forceps), A—12 m assistant port

the reflected peritoneum and brought out again from the abdominal wall to elevate the bowel and provide maximum exposure to the retroperitoneum (Fig. 3a, b). This also frees up the fourth arm (Cadiere forceps) for other purposes.

Retroperitoneal dissection

Principles of dissection are exactly the same as open RPLND. In a post-chemotherapy setting, we perform a bilateral complete template dissection without aiming for nerve sparing. Dissection is limited between two ureters on both sides with renal hilum being the uppermost boundary and iliac bifurcation being the lower limit. This dissection abides by the core principle of split and roll technique described by Donohue [5]. Dissection is carried out in a sequential manner from paracaval, precaval, paraaortic, preaortic, interaortocaval and bilateral common iliac zones

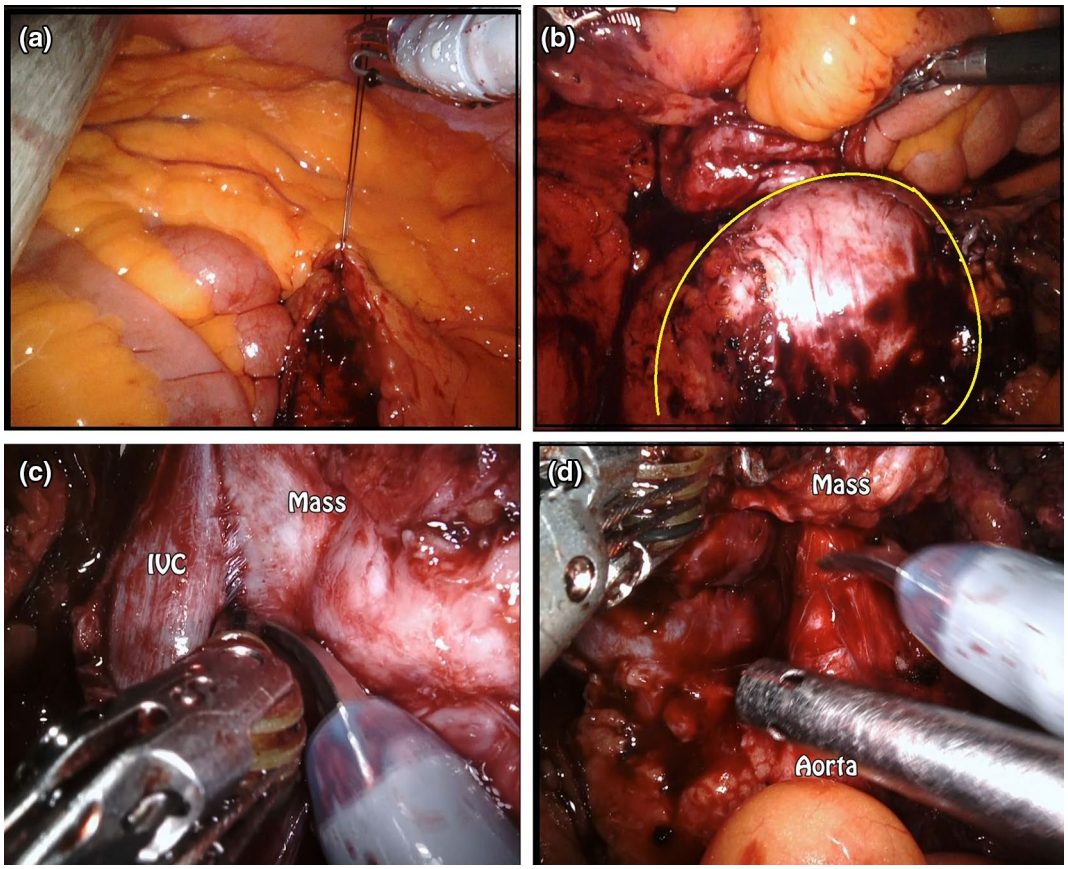

Fig. 3 Intra-operative photographs for demonstration. **a** Straight needle on monofilament suture for traction of peritoneal edge. **b** Overview of mass after retraction of peritoneal edges on both sides. **c** Sharp dissection of mass from IVC. **d** Sharp dissection of mass from aorta

from caudal to cephalad direction (Figs. 3c, d, 4a–c). In the paraaortic location, the inferior mesenteric artery (IMA) is dissected from the mass (Fig. 4a). If need be, IMA can be clipped and divided in cases of dense adhesions. Utmost precaution is taken to achieve simultaneous hemostasis. Thermal energy is used whenever required, as nerve sparing is not the aim in this setting. Lymphatics are taken care of simultaneously either by ligation or coagulation to avoid leak. Significantly sized lumbar vessels are clipped and divided using Hem-o-lok® or metallic clips (Fig. 4c). Free silk ties can also be used for this depending upon personal preference [6]. After this, the retrocaval and retroaortic dissection is completed by giving appropriate traction to the major vessels. A vessel loop placed around the great vessels may assist in providing this traction [6]. After completing retroperitoneal dissection, the pelvic peritoneum is incised on the side of the primary to dissect the ipsilateral gonadal vein which is clipped near the deep ring and removed with the specimen. The abdomen is inspected for hemostasis and specimens are placed separately in previously marked retrieval bags as per their sites of origin (Fig. 5).

Specimen extraction

Specimen is extracted from a Pfannenstiel incision. No drain is placed.

Post-operative management

The patient is started on oral liquids 4 h after the procedure and advanced to a low-fat soft diet on postoperative day (POD) 1. Catheter is removed on POD 1 and the patient is discharged on POD 2 subject to an uneventful recovery. Follow-up is as per the defined guidelines [7].

Results

Three patients (age range 21–36 years) underwent robotic supine RPLND for post-chemotherapy residual masses (Table 1). Mean console time and estimated blood loss were 257 (190–305) minutes and 333 (300–400) ml, respectively. No transfusions were needed. The procedures were successfully completed without open conversion. No drain

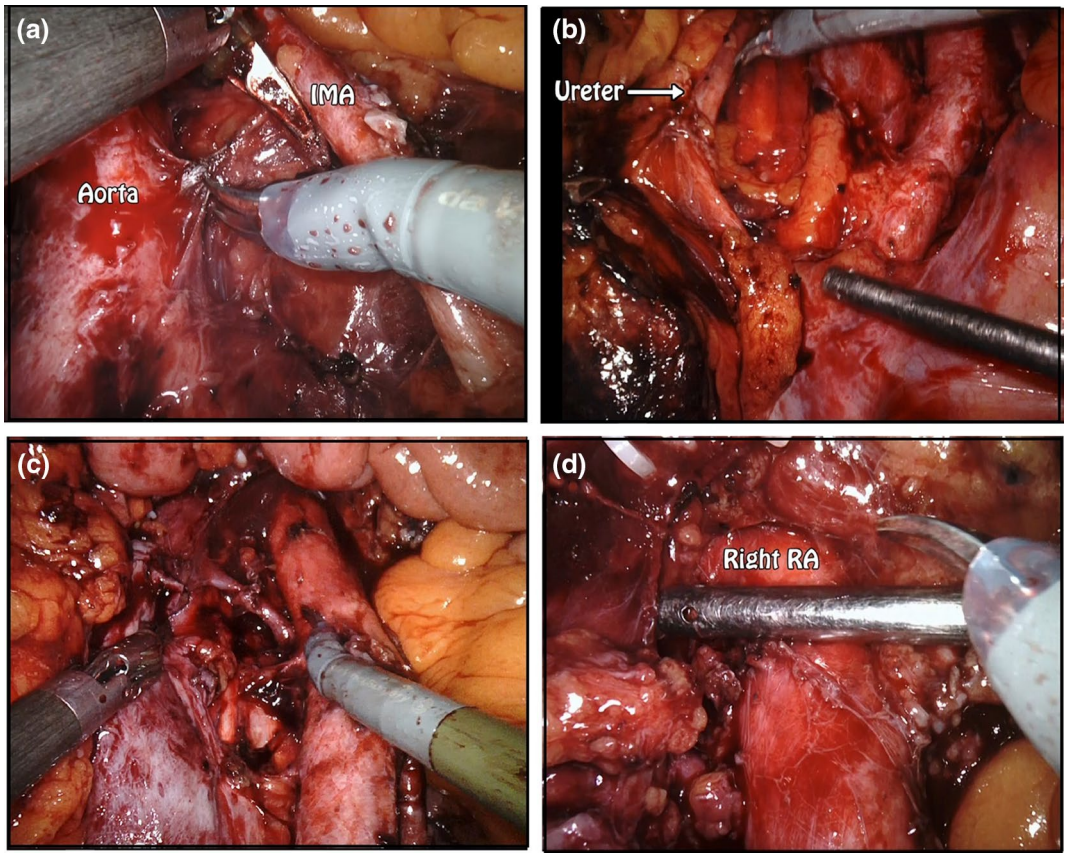

Fig. 4 Intra-operative photographs for demonstration. **a** Paraaortic dissection sparing inferior mesenteric artery. **b** Right paracaval dissection limited by ureter on right side. **c** Interaortocaval dissection—showing lumbar veins before clipping. **d** Upper extent of dissection—renal artery

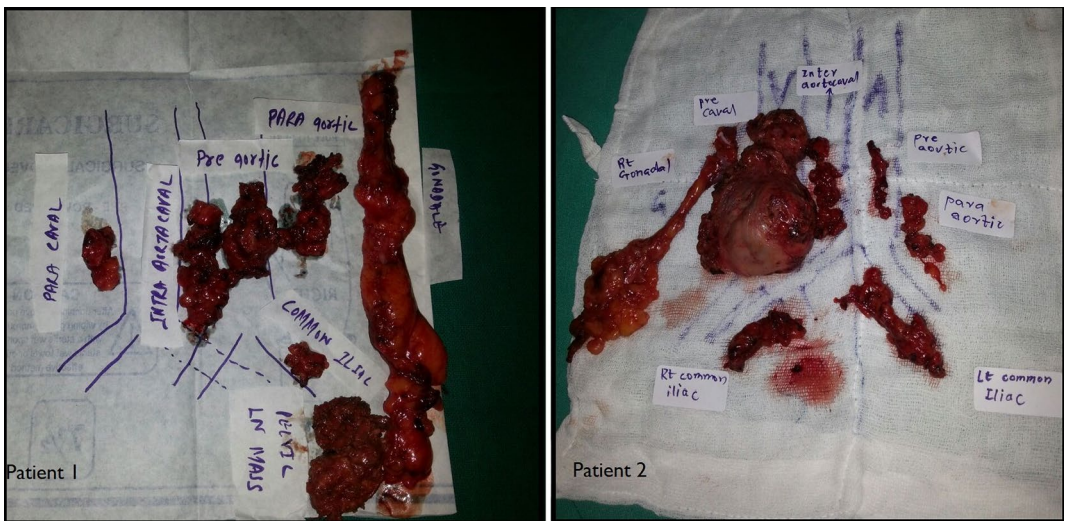

Fig. 5 Representation of specimen as per the location in initial two patients

was placed and all three patients were discharged on post-operative day 2 (POD) on a soft diet. One patient with left-sided tumour had a left common iliac vein injury which was sutured intra-operatively. There were no postoperative complications. The first patient had necrosis in the final pathology, whereas the second patient had mature cystic teratoma. The third one also did not show any viable tumour out of all 94 lymph nodes in the final pathology. Mean lymph

node yield was 52 (29–94) and the largest size of the lymph node removed was 6.5 cm. All three are free of recurrence at a mean follow-up of 14 months (1–22). Patients were regularly followed up as per the protocol by cross-sectional imaging (computed tomography) and tumour marker evaluation as per the standard norms.

Discussion

In the current study, we have described our experience of three consecutive testicular cancer patients undergoing post-chemotherapy robot-assisted RPLND in a supine position without repositioning of the patient or redocking of the robot using the da Vinci Xi® system. We found this procedure to be a viable alternative to open surgery in terms of technical feasibility, safety and short-term oncological measures, while simultaneously preserving the benefits of a minimally invasive approach in terms of faster patient recovery and early discharge. Albeit a small series, we do believe that it has several important points worthy of note.

First, this represents one of the very few case series published till date which address the use of a robotic approach for post-chemotherapy RPLND [4, 6, 8–14] (Table 2). The era of minimally invasive RPLND started in 1992 when Rukstalis and Chodak performed the first laparoscopic RPLND [15]. With the advent of newer technology and with growing experience, indications of minimally invasive RPLND have expanded over the last two decades. This journey has evolved from unilateral template dissection to bilateral template dissection to complete bilateral dissection in a supine position to avoid the need for repositioning. Robotic approach was used for the first time by Davol et al. [16]. Magnified vision and improved dexterity were the distinct advantages of this platform. After these initial reports, it was realised that it would be advantageous to devise techniques to complete the bilateral dissection in a single position to minimise the operating time and potential problems related to patient repositioning during the procedure. Two prominent groups worked on completing the procedure in a lithotomy position using the da Vinci S® or Si® system [6, 8]. These workers found distinct advantages with this approach as compared to the flank approach [8]. Apart from the feasibility of bilateral dissection without patient repositioning, they mentioned that a lithotomy position enabled better access to great vessels for intricate dissection and for ease of managing vascular injuries. They also felt that emergency open conversions were much easier in a lithotomy position. As a flip side, however, they sensed difficulty in initial docking and problems with anaesthesia access, as the robot was docked from the head end of the patient [8]. In addition, the robot was required to be redocked from between the legs for completing the ipsilateral gonadal vein dissection [6].

To overcome this issue, Stepanian et al. described the technique of robot-assisted bilateral template RPLND in a supine position [4]. Their series is the best example of serial modifications in methodology that commensurates with technological advances. They operated an initial 11 patients in flank position (da Vinci Si® system) after which they switched to a supine position ($n=7$) with the same system, to avoid patient repositioning. For initial retroperitoneal dissection, they docked the robot from over the left shoulder after which they redocked the robot along the ipsilateral leg for the gonadal vein dissection. The last two cases in their series were operated using the da Vinci Xi® system in a complete supine position without need for repositioning or redocking. Out of this, one patient had post-chemotherapy residual mass. This was possible because of multi-quadrant improved access due to the boom rotation feature of da Vinci Xi® system. We used the same technique in our patients who had post-chemotherapy retroperitoneal masses with NSGCT as the primary testicular tumour.

At present, only a limited number of series has used a robotic approach for post-chemotherapy RPLND (PC-RPLND). To the best of our knowledge, only two cases have been reported for PC-RPLND operated in the supine position with the da Vinci Xi® system [4, 10] (Table 2). The recent description of robot-assisted supine extraperitoneal RPLND (RASE-RPLND) is quite promising though it needs validation across other centres for reproducibility. Our experience, albeit an initial one in itself, represents the utilisation of technological advances in robotics in a clinically complex scenario. We could reciprocate the technique described by Stepanian et al. with acceptable morbidity, while maintaining all the benefits of minimally invasive surgery [4]. All three of our patients were discharged on post-operative day 2 without any post-operative complications.

Overall rate of intraoperative complications and additional procedures in PC-RPLND is to the tune of 29.3% [17]. For a laparoscopic approach in PC setting, one of the pioneering series published had a 25% complication rate in the form of either chylous ascites or lymphocele [18]. However being a technically challenging procedure, certain other series for laparoscopic PC-RPLND have described even higher complication rates or open conversion rates [19, 20]. Robotic approach is no exception to this, though the numbers of complications in different robotic series are comparable to the contemporary descriptions of open approach (Table 2). Though we encountered an intraoperative complication in the form of injury to common iliac vein in our first patient, we could manage it robotically, without significant blood loss or open conversion. Median (or mean) lymph node yield described till date in PC-RPLND varied from 6 to 26.5 in robotic cases, which is comparable to a large experience of open PC-RPLND of 628 cases which had median lymph node yield of 25 [21]. In the same evaluation,

Table 2 Summary of different series of robot-assisted retroperitoneal lymph node dissection for post-chemotherapy residual masses for germ cell tumours of testis

Author and year	Total, *n*	Post chemotherapy, *n*	Type of GCT	System	Position	Fourth arm location in supine position (patient side)	Template bilateral, *n* (%)	Nerves spared	OR time, (min), *n* (range)/ (SD)	EBL (ml)	Open conversion	Drain	LOS days, *n* (range) / (SD)	LN yield, *n* (range) / (SD)	Complications	f/u (months), *n* (range)	f/u local recurrence	LN + *n* (viable or teratoma)
Stepanian et al. [4] (2016)	20[a]	3	NSGCT	18—Si 2—Xi	11—lateral 9—supine[c]	Si—left Xi—left	5 (25)	Yes	293 (214–382)	50 (50–150)	No	NR	1 (1–4)	19.5 (3–50)	1 major[k]	49 (12–91)	No	8
Kamel et al. [8] (2016)	12	12	9-NSGCT 3-SGCT	S and Si	6—flank 6—lithotomy[d]	Left	3 (25)	Yes	312 (205–408)	475 (50–1800)[h]	1[i]	No	3.2 (2–5)	12 (5–21)	1 major 2 minor	31 (5–39)	No	5
Cheney et al. [6] (2015)	18	8	17-NSGCT 1[b]	Si	Lithotomy[e]	Right	11 (61)	Yes	343 (61)	172 (222)	3[j]	No	3 (2.3)	20 (10)	3 minor No major	22 (1–58)	No	8
Singh et al. [9] (2017)	13	13	NSGCT	Si	12—lateral 1—supine[f]	Left	2 (15.3)	Yes	200 (NR)	120 (NR)	No	Yes	4 (3–5)	20 (NR)	2 major[l] 2 minor	23 (3–58)	No	3
Overs et al. [12] (2017)	11	11	NSGCT	Si	Lateral	NA	No[n]	Yes	150 (45–300)	120 (5–300)	No	NR	3 (2–4)	7 (1–24)	1 minor	4 (1–48)	NR>	1
Lee et al. [11] (2015)	1	1	NSGCT	Si	Lateral	NA	No	Yes	420	NR	No	Yes	4	20	Nil	18	No	1
Stout et al. [14] (2016)	2	2	NSGCT		Lateral	NA	Yes	Yes	375 (300–450)	150	No	NR	2.5 (2–3)	26.5 (24–29)	Nil	24	No	2
Pooleri et al. [10] (2018)	1	1	NSGCT	Xi	Supine[g]	All ports in right lower quadrant	Yes	Yes	240	60	No	Yes	3	NR	1 major	NR	NR	1

Table 2 (continued)

Author and year	Total, *n*	Post chemotherapy, *n*	Type of GCT	System	Position	Fourth arm location in supine position (patient side)	Template bilateral, *n* (%)	Nerves spared	OR time, (min), *n* (range)/ (SD)	EBL (ml)	Open conversion	Drain	LOS days, *n* (range) / (SD)	LN yield, *n* (range) / (SD)	Complications	f/u (months), *n* (range)	f/u local recurrence	LN + *n* (viable or teratoma)
Bora et al. [13] (2016)	1	1	NSGCT	Si	Lateral	NA	Yes	Yes	360	500	No	NR	8	6	1 minor	12	No	1
Our series	3	3	NSGCT	Xi	Supine	Left	2	No	257 (190–305)[o]	333 (300–400)	No	no	2	52 (29–94)	Nil[m]	14 (1–22)	No	1

> 6 patients operated till 2015 had no recurrence till 24 months

NR not reported, *NSGCT* non-seminomatous germ cell tumour, *SGCT* seminomatous germ cell tumour

[a]19 patients with 20 procedures

[b]Paratesticular rhabdomyosarcoma

[c]In Si system, initial docking is in supine position over left shoulder. In Si system, the robot is repositioned and redocked parallel to ipsilateral leg for spermatic cord dissection

[d]Lithotomy with Trendelenburg position with robot docked from head end

[e]Robot docked from head, lithotomy with mild Tendelenberg with one side slightly down (for left side dissection—right side down and vice versa) (redocked in cases of bilateral dissection)—redocked between legs for ipsilateral spermatic cord dissection

[f]Robot is docked from behind the patient in flank approach. The robot is docked from head end in supine approach

[g]Robot-assisted supine extraperitoneal RPLND (RASE-RPLND)

[h]Blood transfusion—two patients (SGCT)

[i]Open conversion for IMA injury

[j]Open conversion for robot malfunction, poor exposure, haemorrhage, respectively

[k]Intra-operative ureter transaction—repaired over double J stent (counted as a major complication)

[l]Two open exploratory laparotomies were required for chyle leak. One patient had intraoperative aortic injury which was repaired (not counted in post-operative complication rates). Five patients developed paralytic ileus in post-operative phase

[m]One intra-operative complication (common iliac vein injury—sutured), no post-operative complication

[n]Modified template dissection

[o]Console time

authors mentioned that number of lymph nodes removed is an independent prognostic factor for disease recurrence after PC-RPLND [21]. Two year relapse-free probabilities were 90%, 95% and 97% for 10, 30 and 50 lymph nodes retrieved, respectively. In our patients, mean lymph node yield was 52 which is on par with other published series of open or robotic approach for this surgery (Table 2). In comparison to contemporary series of a laparoscopic approach for PC-RPLND, lymph node yield seems higher in a robotic approach [19]. For the comparison of contemporary open series, the estimated blood loss, length of stay, recovery of bowel functions, there was a striking difference in favour of our series as compared to open series though the numbers can not be compared creating a potential bias [22]. Cheney et al. have compared primary robotic RPLND versus PC robotic RPLND, wherein they conclude that all the parameters are comparable (lymph node yield, estimated blood loss, length of stay) except for operative time which is higher in PC setting [6].

Controversy still exists regarding complete bilateral template dissection versus modified template dissection in post-chemotherapy setting [23]. From the evaluation of a large database of 532 patients from Memorial Sloan-Kettering Cancer Centre, the authors have mentioned that at least 7–32% patients will have a teratoma or a viable tumour outside the boundaries of a modified template. For similar reasons, many still consider full bilateral template dissection as the desired approach in PC setting [24]. Opponents of this concept do believe that nerve-sparing modified template dissection could be an option for limited disease in retroperitoneum [25]. We ascribe to the former school of thought and therefore performed a complete bilateral template dissection in both our patients without considering nerve sparing.

The limitations of our study include a small number, an initial phase of experience in this procedure, lack of long-term follow-up and lack of a comparative arm. However, we do believe that the description of our technique and results represents a successful and safe adaption of advanced robotic technology to decrease the morbidity of this complex procedure on our patients, while keeping oncological principles intact. As time goes by, we are sure that the reproducibility of this technique will be demonstrated all over the world in greater numbers and comparative analysis with other techniques will provide us with more information regarding the applicability of this procedure in a larger setting.

Conclusion

A robotic complete bilateral template retroperitoneal lymph node dissection in a supine position eliminates the need for redocking or repositioning. It is technically feasible, reproducible and can safely be applied to a post-chemotherapy setting for testicular tumours. Further comparative evaluation of this technique, preferably in a multi-institutional setting, is likely to increase the acceptability of this procedure in the future.

Compliance with ethical standards

Conflict of interest Author Ashwin Sunil Tamhankar, Author Saurabh Patil, Author Surya Prakash Ojha, Author Puneet Ahluwalia and Author Gagan Gautam declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all patients for being included in the study.

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