Minimally invasive post-chemotherapy retroperitoneal lymph node dissection for nonseminoma

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Introduction: *We present our experience with minimally-invasive retroperitoneal lymph node dissection (MI-RPLND) in the post-chemotherapy (PC) setting for residual masses in patients with nonseminoma.*

Materials and methods: *Nineteen men who underwent PC MI-RPLND (14 – laparoscopic, 5 – robotic) for low-volume residual disease (no more than 5 clinically enlarged retroperitoneal masses, size < 5 cm, no adjacent organ or vascular invasion) between 2006 and 2011 were identified. Clinicodemographic information and pathological outcomes were reported.*

Results: *Median age of our study population was 32 (interquartile range [IQR]: 28-39). Most patients presented with clinical stage II disease (63%) and were categorized as good risk (90%) by the International Germ Cell Consensus Classification. Median size of residual masses on PC imaging was 2.1 cm (IQR: 1.7-3). Full-template bilateral RPLND was completed in 53% of cases, and modified left-sided RPLND in 47%. Median operative time was 370 minutes (IQR: 320-420), and median estimated blood loss was 300 cc (IQR: 150-450). Median length of stay was 3 days (IQR: 2-3). Five patients (26%) experienced a postoperative 30 day complication, but none were higher than Clavien grade II. On final pathology, median number of lymph nodes removed was 12 (IQR: 8-23), and 8 patients (42%) had residual teratoma. No patient experienced a recurrence at median follow up of 24 months (IQR: 5-76).*

Conclusions: *PC MI-RPLND is a feasible option in a select group of patients with acceptable patient morbidity and short-term outcomes. Longer follow up is required to determine the oncologic efficacy of this approach.*

Key Words: testicular cancer, robotic surgery, post-chemotherapy, nonseminoma, laparoscopic surgery

Introduction

Lymph node dissection (LND) for residual retroperitoneal masses after primary chemotherapy forms an important part of the treatment armamentarium in metastatic testicular cancer.[1] Complete resection of persistent retroperitoneal lymph nodes (LN) is necessary since 50% of cases contain mature teratoma, 40% contain necrotic-fibrotic tissue, and 10% contain viable germ cell tumor.[2,3] Post-chemotherapy (PC) surgery additionally provides important staging information that might guide future treatment and optimizes long term oncological outcomes of this patient group through a curative benefit.[3-5]

The European Association of Urology (EAU) and National Comprehensive Cancer Network (NCCN) recommend removal of all residual retroperitoneal disease > 1 cm in the PC setting for nonseminomatous germ cell testicular cancer (NSGCT).[6,7] Post-chemotherapy retroperitoneal lymph node dissection (PC-RPLND), however, is a complex and challenging

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procedure owing to the dense fibrotic reaction which obliterates the natural planes of dissection in addition to the complex vascular and neuroanatomy of the retroperitoneum. Open PC-RPLND results in a longer recovery time and a large midline abdominal scar, which can be aesthetically unappealing in the younger patient population that is typically affected by this disease.[8]

Minimally-invasive retroperitoneal lymph node dissection (MI-RPLND) using either a laparoscopic or robotic approach is increasingly being utilized as a primary treatment option for early stage NSGCT.[9-11] Primary MI-RPLND, when performed by experienced laparoscopic or robotic surgeons, can safely accomplish the objectives of open surgery with decreased postoperative morbidity, quicker convalescence, better cosmetic results, higher patient satisfaction, and better short term quality of life (QOL) than open primary RPLND.[12-14] Despite these advantages, MI-RPLND is a technically challenging and difficult procedure with a steep learning curve, and patient selection is extremely important.

The use of MI-RPLND for low-volume residual disease in the PC setting has also been reported and is technically feasible, but its adoption has been limited due to significant perioperative morbidity and high open conversion rates.[15-18] The objective of this study was to report on our institutional experience with minimally-invasive post-chemotherapy retroperitoneal lymph node dissection (MI-PC-RPLND) in a highly select group of patients with NSGCT and to assess its feasibility in terms of perioperative and short term oncological outcomes.

Materials and methods

Institutional experience

We began performing MI-RPLND at our institution (Moffatt Cancer Center) using a pure laparoscopic approach beginning in 2004 and using a robotic-assisted laparoscopic approach beginning in 2008. All cases were performed by a single surgeon. Considerable laparoscopic and robotic experience was initially gained with the successful completion of over 15 cases of laparoscopic primary RPLND from 2004-2006 and over 10 cases of robotic-assisted laparoscopic primary RPLND from 2008-2010. All primary cases were performed for patients with stage IB and IIA disease in the setting of negative tumor markers.

Patient selection

Only patients without previous abdominal surgeries and with low-volume residual disease on imaging studies were offered a minimally invasive approach. Low-volume disease was defined as any residual retroperitoneal mass < 5 cm after chemotherapy. Additionally, no patient could have more than five clinically significant enlarged (> 1 cm) retroperitoneal masses on imaging. Any patient with suspected vascular or adjacent organ invasion that may require additional procedures was excluded. No pre-determined cut offs in regards to patient body mass index (BMI) or patient comorbidities/performance status were made.

Patients were scheduled for a right or left-sided template PC-RPLND corresponding to the side of their primary testicular lesion. Two patients with right-sided tumors, however, had evidence of residual retroperitoneal disease outside of a normal landing site, and they were scheduled upfront for bilateral template PC-RPLND.

Surgical technique

Laparoscopic PC-RPLND

All laparoscopic PC-RPLND procedures were performed in a modified flank position through a transperitoneal approach. Three 12 mm ports were placed on either the right or left side ipsilateral to the location of the primary testicular tumor. The camera port was placed lateral to the umbilicus, the first working port lateral to the rectus muscle, and the second working port approximately 10 cm caudal to the camera port. Two additional 12 mm ports were placed in the anterior axillary line to provide assistance with retraction.

The retroperitoneum was fully exposed after wide mobilization of the right or left colon, and a complete right, left, or bilateral template dissection was performed. All templates were bounded by the renal vessels cranially, the ureter laterally, and crossing of the ureter with the common iliac artery caudally. For right-sided tumors, the template included the tissue around the vena cava, and the interaortocaval, pre-aortic, and para-aortic LNs cranial to the inferior mesenteric artery. For left-sided tumors, the template included the interaortocaval, pre-aortic, and para-aortic LNs. Ipsilateral common iliac LNs were not routinely removed. Frozen section of enlarged (> 1 cm) LNs was performed in all cases, and if suspicious LNs were positive for malignancy or the presence of teratoma, a full bilateral template dissection was always completed with patient repositioning. In both right and left-sided cases, the gonadal vein was clipped and transected at its origin on the corresponding side. The spermatic vessels with its contiguous nodal and

fibro-adipose tissue were sharply dissected down to the internal inguinal ring where they were removed with the spermatic cord remnant left behind at the time of radical orchiectomy. Non-nerve sparing procedures were performed in all cases.

Robotic-assisted laparoscopic RPLND

Robotic-assisted laparoscopic PC-RPLND was also performed in a modified flank position through a transperitoneal approach, and five ports were used. The 12 mm camera port was placed lateral to the umbilicus, and three 8 mm ports for the robotic arms were placed on the ipsilateral side of the primary testicular tumor. One robotic port was placed in a subcostal position, one below the umbilicus, and one more laterally two fingerbreadths medial to the iliac crest. A 12 mm assistant port was placed on the contralateral side between the camera port and the inferior robotic port. For right-sided tumors, an additional 5 mm port was placed in the midline just below the xiphoid process for retraction of the liver. The rest of the dissection proceeded as described above for laparoscopic PC-RPLND.

Postoperative care

All patients were started on a clear liquid diet the evening of surgery and advanced to a regular diet as tolerated. A Foley catheter was left indwelling the first night after surgery, but it was removed the following morning. Intravenous antibiotics were continued for the first 24 hours after surgery. Patients were discharged after tolerating a regular diet and after appropriate pain control on oral pain medications.

Data source

Patients who had a successfully completed MI-PC-RPLND were retrospectively identified in an Institutional Review Board (IRB) approved, departmental testicular cancer database. This database prospectively collects all demographic information, clinical data, and postoperative follow up on patients that undergo RPLND at Moffitt Cancer Center. It is updated by a dedicated departmental data analyst, and follow up is maintained through postoperative clinical notes.

Study variables

Study variables analyzed included patient demographics such as age, smoking status, BMI, American Society of Anesthesiologists (ASA) score, and age-adjusted Charlson Comorbidity Index (CCI). BMI was based on the patient's height and weight at the time of surgery, and ASA score was determined by the anesthesiologist's assessment of the patient 2 to 3 hours before surgery. CCI was determined retrospectively based on the patient's past medical history during the last preoperative clinic visit.

Disease-specific characteristics were reported such as side and histology of the primary testicular tumor, clinical stage at presentation, International Germ Cell Consensus Classification (IGCCC) risk category, patient's prior chemotherapy regimen, and number and size of clinically enlarged (> 1 cm) retroperitoneal masses seen on PC imaging, which was obtained within 30 days prior to MI-PC-RPLND. All outside histology slides were re-reviewed by our institution's pathologists with expertise in genitourinary malignancy, and staging was assigned according to the 2004 American Joint Committee on Cancer system, which is based on the TNM stage and degree of initial tumor marker elevation. The IGCCC risk category was assigned based on the reported stratification criteria, which included the site of primary tumor, presence of nonpulmonary visceral metastases, and post-orchiectomy tumor markers.[19]

Relevant intraoperative and postoperative factors were abstracted including the surgical template used, operating room (OR) time, estimated blood loss (EBL), use of a blood transfusion during surgery, presence of intraoperative and postoperative complications within 30 days of surgery, and length of stay (LOS). Complications and LOS were captured via retrospective chart review of the patient's postoperative course (i.e. discharge summary) and subsequent clinic visits up to 30 days after MI-PC-RPLND. The Clavien-Dindo scoring system was used to categorize 30 day complications, and LOS was defined from the date of surgery until the date of initial discharge.[20]

Pathological and short term oncological outcomes were also reported including the histolopathological diagnosis of removed retroperitoneal LNs, the total number of LNs removed, the total number of LNs that were positive for disease, and the development of any local or distant recurrence during available follow up. Disease recurrence was defined as any clinical evidence of new tumor based on imaging, physical examination, or biopsy, and follow up was defined from the time of surgery until the date of last contact or date of death.

Follow up

After PC-RPLND, clinic visits were scheduled every 3 months for the first 2 years, then every 6 months for the next 3 years, and annually thereafter. Each follow up visit included a history, physical examination, tumor markers, and a chest x-ray. Cross-sectional imaging of the abdomen and pelvis was performed

every 6 to 12 months for the first 2 years and only when indicated thereafter. For patients who followed up with outside physicians, contact was maintained through outside medical records to keep track of their disease status.

Statistical analysis

Continuous variables were reported as medians and interquartile ranges (IQRs), and categorical variables were reported as frequency counts and percentages. Statistical analyses was performed with the Statistical Package for the Social Sciences (SPSS) software package version 21.0 (IBM Corporation, Armonk, NY, USA).

Results

Patient population

One hundred and nine patients with NSGCT and residual retroperitoneal masses > 1 cm after chemotherapy underwent PC-RPLND at our institution between 1993 and 2011. From 2006 to 2011, MI-PC-RPLND was attempted in 21 patients and completed in 19. There were two conversions from laparoscopy to the open procedure due to a failure to progress over an hour period. The first 14 cases of MI-PC-RPLND were completed using a laparoscopic approach, and the subsequent five cases (beginning in mid-2010) were completed using a robotic-assisted laparoscopic approach.

Patient demographics and clinical characteristics

The demographic and clinical features of our study population are provided in Table 1. Median age was 32 (interquartile range [IQR]: 28-39), and median BMI was 29 (IQR: 24-32). Most cases were left-sided (74%), and most patients were good risk per the IGCCC (90%). Clinical stage II disease was seen in 63% of patients, and stage III disease in 37%. Most patients had a solitary enlarged retroperitoneal LN on PC imaging (79%), and median LN size was 2.1 cm (IQR: 1.7-3).

All patients received prior cisplatin-based chemotherapy. Eleven patients (60%) received bleomycin, etoposide, and cisplatin (BEP), 5 (26%) received etoposide and cisplatin (EP), and 3 (16%) received etoposide, ifosfamide with mesna, and cisplatin (VIP). All patients, however, had normalization of their tumor markers after chemotherapy.

Surgical outcomes

The surgical outcomes of our study population are listed in Table 2. A complete bilateral template PC-RPLND was performed in 10 cases (53%), and all other cases were full left-sided templates. No isolated right-

TABLE 1. **Demographic and clinical data**

Variables	**MI-PC-RPLND n = 19**
Median age, years (IQR)	32 (28-39)
Smoker, no. (%)	11 (58)
Median body mass index kg/m^2 (IQR)	29 (24-32)
American Society of Anesthesiologists, no. (%)	
1	1 (5)
2	16 (84)
3	2 (11)
Age-adjusted Charlson Comorbidity Index, no. (%)	
6	12 (63)
7-9	6 (32)
> 10	1 (5)
Laterality, no. (%)	
Right	5 (26)
Left	14 (74)
Histology: orchiectomy specimen, no. (%)	
Pure embryonal	3 (16)
Pure teratoma	1 (5)
Pure yolk sac	-
Pure choriocarcinoma	-
Mixed germ cell tumor	15 (79)
Clinical stage, no. (%)	
IIA	4 (21)
IIB	7 (37)
IIC	1 (5)
IIIA	3 (16)
IIIB	1 (5)
IIIC	3 (16)
IGCCC risk category, no. (%)	
Good	17 (90)
Intermediate	1 (5)
Poor	1 (5)
Prior chemotherapy regimen, no. (%)	
EP x 4	5 (26)
BEP x 3	9 (47)
BEP x 4	2 (11)
VIP x 3	1 (5)
VIP x 4	2 (11)
Median size of residual mass, cm (IQR)	2.1 (1.7-3)
Number of residual masses, no. (%)	
1	15 (79)
2	3 (16)
3	1 (5)

MI-PC-RPLND = minimally-invasive post-chemotherapy retroperitoneal lymph node dissection; IQR= interquartile range; IGCCC = International Germ Cell Consensus Classification; EP = etoposide and cisplatin; BEP= bleomycin, etoposide, ciplatin; VIP = etoposide, ifosfamide with mesna, cisplatin

TABLE 2. **Surgical and pathological outcomes**

Variables	MI-PC-RPLND n = 19
Extent of dissection, no. (%)	
Right-sided	-
Left-sided	9 (47)
Bilateral	10 (53)
Median OR time, minutes (IQR)	370 (320-420)
Median EBL, cc (IQR)	300 (150-450)
Blood transfusion, no. (%)	2 (11)
Intraoperative complications, no. (%)	1 (5)
Postoperative complications, no. (%)	
None	14 (74)
I	3 (16)
II	2 (11)
III	-
IV	-
V	-
LOS, days (IQR)	3 (2-3)
Histology: residual mass, no. (%)	
Necrosis	11 (58)
Teratoma	8 (42)
Viable germ cell tumor	-
Total LN removed, median (IQR)	12 (8-23)
Total LN positive, median (IQR)	2 (1-4)
Recurrence, no. (%)	0 (0)
Median follow up, months (IQR)	24 (5-76)

MI-PC-RPLND = minimally-invasive post-chemotherapy retroperitoneal lymph node dissection; OR = operating room; IQR = interquartile range; EBL = estimated blood loss; LOS = length of stay; LN = lymph node

sided templates were performed in this study. Eight patients (5 left-sided, 3 right-sided) had a positive frozen section requiring conversion to a full bilateral template dissection. Median OR time was 370 minutes (IQR: 320-420), and median EBL was 300 cc (IQR: 150-450). Two patients (11%) received a blood transfusion intraoperatively.

The overall median number of LNs removed was 12 (IQR: 8-23). In patients who had a left-sided template dissection the median number of LNs removed was 9 (IQR: 6-26) versus 15 (IQR: 12-21) in patients who had a bilateral template dissection. No residual disease was seen in 11 patients (58%) on final pathology, and 8 patients (42%) had mature teratoma. Of those cases with positive pathology, the median number of positive LNs was 2 (IQR: 1-4).

Complications

One intraoperative complication occurred in our study population which consisted of a small cavatomy in the inferior vena cava. This was closed laparoscopically with a figure-of-eight prolene stitch using LAPRA-TY clips with no further sequelae.

Five patients (26%) experienced a complication in the 30 day postoperative period, Table 3. Two patients developed scrotal pain which was managed conservatively with sitz baths, NSAIDs, and scrotal elevation (Clavien grade I). One patient developed a self-limiting brachial plexus neuropathy secondary to positioning which persisted for two months postoperatively (Clavien grade I). One patient developed shingles on his back treated with oral acyclovir and pain medication (Clavien grade II). The last patient developed a fungal rash in his groin unrelated to his surgical site treated with topical nystatin (Clavien grade II). No patients in our series had a lymphatic leak leading to chylous ascites within 30 days after surgery.

TABLE 3. **Postoperative complications**

Clavien grading	Complication	MI-PC-RPLND n = 19
I		
	Scrotal pain	2 (11)
	Brachial plexus neuropathy	1 (6)
II		
	Shingles	1 (5)
	Fungal rash	1 (5)

MI-PC-RPLND = minimally-invasive post-chemotherapy retroperitoneal lymph node dissection

Oncological outcomes

Overall median follow up in our study population was 24 months (IQR: 5-76). In patients with residual teratoma on final pathology (n = 8), median follow up was 41 months (IQR: 14-72). No patient has experienced a tumor recurrence to date, and there have been no reported deaths in our study population.

Discussion

Patients with NSGCT and normalized tumor markers after systemic chemotherapy but who have residual radiological abnormalities in the retroperitoneum should undergo PC-RPLND. The intense desmoplastic reaction, however, makes PC-RPLND a challenging procedure. The overall complication rate with open PC-RPLND ranges from 20.7% to 35% in large-scale series, and the mortality rate is as low as 0.8%.[21,22] The risk and severity of intraoperative and postoperative complications with PC-RPLND is also higher than with primary RPLND.[23] In a recent study, Williams et al reported that PC-RPLND was associated with a significantly greater operative time, EBL, and LOS as compared to primary RPLND.[24] Mosharafa et al, however, concluded that the morbidity associated with PC-RPLND seems to decrease with increased surgeon experience.[25]

Laparoscopic MI-RPLND has proven to be an effective staging and therapeutic procedure in patients with low stage disease, but the use of MI-RPLND in the PC setting for low volume residual masses has been limited due to its technical difficulty. Even though reports of MI-PC-RPLND are few, they do indicate that the procedure is feasible.[15-18,26] Although initial series demonstrated high open conversion rates (29%-67%), later reports have shown a decrease in both overall conversion and complication rates due to better patient selection.[16,18,27,28]

The largest experience reported to date is by Steiner et al who performed laparoscopic PC-RPLND in 100 patients with low-volume, stage II NSGCT.[29] Unilateral templates were performed in 71 patients with a mean OR time of 241 minutes, and bilateral templates were performed in 29 patients with a mean OR time of 343 min. Mean EBL was 84 cc, and mean LOS was 3.9 days. The overall major complication rate was 2% (one case of symptomatic lymphocele and one case of chylous ascites), and no in-field retroperitoneal recurrences occurred at a mean follow up of 74 months. No cancer-specific deaths were also reported.

Calestroupat et al also presented their experience with laparoscopic PC-RPLND in 26 patients with NSGCT and residual disease in the retroperitoneum with a median size of 3.4 cm.[18] All patients underwent right or left-sided template dissections with three conversions to open surgery (11.5%). Median OR time was 183 minutes, and median EBL was 400 cc. Median number of LNs removed was 7 (range 4-13), and no recurrences were observed at mean follow up of 27 months with no patient lost to follow up.

In addition to favorable oncological outcomes, the morbidity of this procedure has approached more acceptable levels. Janetschek et al reported on 24 patients with stage IIB NSGCT who underwent successful laparoscopic PC-RPLND.[15] No patient required open conversion, and there were no intraoperative complications. Postoperatively, five patients developed chylous ascites, but all resolved with conservative management. Corvin et al also treated 16 patients with laparoscopic RPLND after chemotherapy for clinical stage IIA-III NSGCT.[17] There were no intraoperative or postoperative complications directly related to the surgical procedure though one patient developed a bleomycin-induced interstitial pneumonitis. Finally, Permpongkosol et al reported on their updated experience with 16 patients undergoing laparoscopic PC-RPLND.[16] Two patients required open conversion, but most postoperative complications observed were classified as minor. All intraoperative complications in this series were also vascular injuries that occurred during their initial experience.

In our study, the rate of conversion from minimally invasive to open approach was 10% (2/21 cases), and the overall complication rate was 26%. All of the postoperative complications were Clavien grade I or II, and one intraoperative vascular injury occurred, but it was managed laparoscopically. The median OR time of 370 minutes and median EBL of 300 mL is consistent with prior published reports, and LOS was comparable at 3 days. The median LN count of 12 (9 for unilateral, 15 for bilateral) is also similar to prior series' although the majority of prior studies do not comment on this outcome as a measure of the quality of the dissection.

MI-PC-RPLND, additionally, has been performed in increasingly complex scenarios with associated vascular involvement, pushing the limits of laparoscopy and minimally-invasive surgery. Aufderklamm et al performed bilateral laparoscopic PC-RPLND in 19 patients with stage II or III disease and intraoperative vascular invasion requiring reconstruction.[30] Mean size of residual mass was 3.87 cm, mean EBL was 310 cc, and mean hospital stay was 6 days with no perioperative complications seen exceeding grade II. No reported recurrences were reported in this study at mean follow up of 18 months.

The long term oncologic efficacy of this technique, however, is still in question since most studies are single-institutional with heavy patient selection bias

toward low-volume disease. Additionally, although in-field recurrences after MI-PC-RPLND are rare, they have been reported after both modified and bilateral template dissections.[31]

The anatomical extent of PC-RPLND has also been the subject of controversy for many years. Full bilateral template dissection is considered to be the gold standard for PC-RPLND in patients with NSGCT due to limitations of modified dissections, which include the risk of leaving behind unresected retroperitoneal disease outside of the template leading to a higher rate of disease recurrence. Investigators at Memorial Sloan-Kettering Cancer Center (MSKCC) reviewed 500 patients who underwent primary RPLND and identified that 3%-23% of patients with retroperitoneal metastases (teratoma or viable GCT) had extra-template disease if modified dissections were used.[32] Another study by the same group evaluated 269 patients with pathological evidence of teratoma or GCT after PC-RPLND and reported rates of extra-template disease of 7%-32% depending on the modified dissection used.[33] Based on these two studies, modified templates might leave unresected retroperitoneal disease in a greater proportion of patients with an increased risk of disease recurrence, subjecting them to a greater total treatment burden (i.e. chemotherapy, re-operative RPLND).

There is, however, no level one evidence or prospective studies reporting on an oncological advantage of one technique over another. A number of retrospective reports suggest that modified template dissections are safe in selected patients with low tumor burden in the PC setting. In a study by Heidenreich et al of 152 patients undergoing open PC-RPLND (98 modified template and 54 bilateral template), eight recurrences occurred in the retroperitoneum at mean follow up of 39 months.[34] Only one patient had an in-field relapse after modified PC-RPLND while seven patients had recurrences outside the boundaries following bilateral PC-RPLND. Rabbani et al also reported that in patients with normal tumor markers that have a residual post-chemotherapy mass, a modified-template dissection with resection of all residual masses is associated with no significant risk of leaving tumor behind in the retroperitoneum[35].

No patients in our study experienced a recurrence, but this is limited by short term follow up and selection bias for low-volume disease. There is data, however, to suggest that most disease recurrences in NSGCT occur within the first 2 years after surgery with late (≥ 2 years) relapses accounting for only 3.2% of recurrences in patients with nonseminoma.[36,37]

Our study has several other limitations. This was a retrospective, single institutional, observational case series with a small patient population. The results of this study are only applicable to a highly selected group of patients with no prior abdominal surgeries and low-volume residual disease. Utilization of frozen section to make intraoperative surgical decision making is also controversial, but Herr et al has reported on its safety with an 89% concordance rate between the frozen section of the PC mass and the permanent-section histological diagnosis of the entire lymphadenectomy specimen.[38] Additionally, the postoperative ejaculatory status of our study population was not known although all patients had non-nerve sparing procedures. Finally, long term oncological outcomes are not reported, so the oncological efficacy compared to standard open PC-RPLND is still in question. This is especially true since the LN yield with minimally-invasive techniques is significantly reduced compared to traditional open approaches with possible under-sampling. Carver et al has previously reported median LN counts for open PC-RPLND of 25 (IQR: 15-37) in 425 patients who underwent full bilateral or modified template dissections.[39] Additionally, on multivariate analysis, decreasing LN counts were significant independent predictors of disease recurrence (hazard ratio: 1.35; 95% confidence interval: 1.01-1.82; p = 0.039). The predicted 2 year relapse free probability was 90% for patients with 10 nodes removed, but it increased to 95% when 30 nodes were removed and 97% when 50 nodes were removed.

Conclusions

Despite these limitations, this study contributes to a growing body of evidence suggesting that MI-PC-RPLND is a feasible though challenging procedure for NSGCT patients with low-volume residual disease. Due to the steep learning curve, we recommend that this procedure should be performed only at tertiary referral centers with experienced minimally invasive urologic oncologists that treat advanced testicular cancer in high volumes. The case selection for MI-RPLND is also very important, and the majority of cases still require an open approach. Our study suggests that the initial oncological outcomes in this highly selected group of patients are favorable but longer follow up is required to make a true comparison against the traditional open approach. □

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