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TOPIC PAPER

Complications of laparoscopic retroperitoneal lymph node dissection in testicular cancer

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Abstract
Objectives A proposed benefit of laparoscopic retroperitoneal lymph node dissection (LRPLND) is more favorable morbidity in comparison to open retroperitoneal lymph node dissection (RPLND). The objective of this review is to examine and summarize the literature regarding complications in both primary and post-chemotherapy LRPLND (PC-LRPLND) and, where appropriate, we include the opinions of the senior author regarding management.
Methods A MEDLINE search was performed using the terms "laparoscopy" or "laparoscopic," "retroperitoneal lymph node dissection" or "RPLND," and "testicular neoplasms." Articles were included on the basis of study design and content. For series updated over time, an effort was made to include only the most recent data to avoid duplicate reporting of patients.
Results In primary LRPLND, vascular injury is the most common complication, occurring in 2.2–20% of reported cases. Bowel injury is rarely reported but potentially catastrophic. Rates of retrograde ejaculation are less than 5%. Chylous ascites and lymphocele are delayed post-operative complications. Rarely reported complications include nerve injury, retroperitoneal hematoma, and ureteral injury requiring internal stent placement.

PC-LRPLND is challenging, with high rates of conversion and complications. Hemorrhage is common. Retrograde ejaculation is several-fold more common in PC-LRPLND than in primary LRPLND. No peri-operative mortality has been reported for either LRPLND or PC-LRPLND.

Conclusions LRPLND and PC-LRPLND are technically demanding. Hemorrhage and vascular injury are the most commonly reported complications. Prospective studies will help clarify the proposed benefits of LRPLND.

Keywords Laparoscopy · Lymph node dissection · Post-operative complications · Retroperitoneal space · Testicular neoplasms

Introduction

Since the first report of laparoscopic retroperitoneal lymph node dissection (LRPLND) in 1992, extensive efforts have been undertaken to define the role of LRPLND in the staging and treatment of testicular cancer [1]. Proposed benefits of the laparoscopic approach include decreased morbidity, and improved intraoperative visualization, cosmesis and post-operative quality of life [2–4].

While the oncologic efficacy of LRPLND is subject to vigorous debate, the morbidity of LRPLND has generally been accepted to be less than the open approach [5, 6]. There is a paucity of comparative data to support this conclusion. Other than several case control studies, no prospective trials comparing the laparoscopic to open approach have been conducted [7, 8]. The purpose of this review is to examine and summarize the literature regarding LRPLND complications and, where appropriate, we include the opinions of the senior author regarding management.

Methods

A MEDLINE search was performed using the terms "laparoscopy" or "laparoscopic," "retroperitoneal lymph node

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dissection" (RPLND) or "RPLND," and "testicular neoplasms." Articles were included on the basis of study design and content. For series updated over time, an effort was made to include only the most recent data to avoid duplicate reporting of patients.

Results

Primary LRPLND for low-stage disease

Operative parameters and intraoperative complications (Table 1)

In the reviewed studies of LRPLND in low stage testicular cancers, mean operative time ranged from 230 to 313 min [4, 5, 7–12]. Mean estimated blood loss (EBL) varied from 50 to 389 mL, with two groups reporting EBL up to 3 L [4, 5]. One group, which reported a conversion due to bleeding from an aortic branch, did not report EBL [12]. Mean length of stay (LOS) ranged from 1.2 to 6 days. No perioperative deaths were reported.

Vascular injury Vascular injury is both the most common intraoperative complication in LRPLND and the most cited reason for converting to laparotomy [4, 5, 7, 10, 13]. In an early series, 11.8% of LRPLNDs were converted to open, with some contemporary series reporting no conversion [8, 9, 11, 12].

In a recent update of a large series, Neyer et al. from Innsbruck, Austria reported the occurrence but not the frequency of several "minor" intraoperative vascular complications, including injury to lumbar veins, renal veins and the vena cava [4]. An earlier publication from Linz, Austria, which includes some of the same patients as the Innsbruck series, related a 2.5% rate of these minor vascular complications, in which hemostasis was obtained laparoscopically with clips, fibrin glue or laparoscopic suturing [2].

The Innsbruck group reported a "major" intraoperative complication rate of 2.2%, described as injuries of the renal artery and colon [4]. Neyer et al. also noted that seven patients (5.1%) required conversion and all but one were due to vascular complications (four hemorrhages, two renal artery injuries). The four patients with hemorrhage prompting laparotomy were not included in the 2.2% rate of major complications. Neyer reported a 1.5% rate of transfusion ($n = 2$). In an earlier report of the same series of clinical stage 1 patients, Steiner disclosed a slightly higher number of transfusions ($n = 3$) [14].

The group from Baltimore, MD reported a 6.9% rate of conversion due to hemorrhage [5, 13]. Their index laparoscopic case had avulsion of the gonadal vein and a subsequent patient had a lumbar vein injury. These patients were the only in their series to receive blood transfusions.

A recent report of hand-assisted LRPLND described a 20% rate of "relatively severe" intraoperative bleeding, and a 10% rate of re-operation for post-operative hemorrhage [10]. Other series reported less EBL, no transfusion, and no conversion to open surgery [8, 9, 11].

Surgeons undertaking LRPLND must be well versed in laparoscopic management of vascular injury. Most vascular injury can be managed with clips or hemostatic agents, such as Fibrin glue [2]. In the senior author's experience, minor venous bleeding responds well to direct application of pressure and increased pneumoperitoneum. Large vessel injury may require more complex maneuvers using vascular clamps (e.g., Satinsky clamp) and laparoscopic suturing with 3-0 Prolene (Ethicon Inc., Piscataway, New Jersey) or similar suture. However, if bleeding cannot be managed safely with minimally invasive techniques, one should make a controlled conversion to laparotomy. The most advantageous technique is to maintain pneumoperitoneum and initiate an expeditious but deliberate layer-by-layer midline incision while compressing the bleeding site under laparoscopic vision. The goal is to preserve pneumoperitoneum to maximally control bleeding until it can be managed definitively in an open manner.

In summary, vascular injury is the most commonly reported complication of LRPLND. Vascular complications and severe bleeding occur in 2.2–20% of reported cases. Published series report injuries to an "aortic branch," the vena cava, renal arteries and veins, as well as lumbar and gonadal veins. Though not reported specifically in the LRPLND literature, injuries to the aorta and lumbar arteries are possible. Most vascular complications can be managed laparoscopically, though they are the most common reason for converting to laparotomy, which happens in 5.1–11.8% of cases.

Bowel injury In primary LRPLND, bowel injury is rarely reported. The Innsbruck group reports a colon injury, but it is not described [4]. In the series from Hungary, Holman et al. [10] relate 1 (10%) colon injury that was repaired laparoscopically. Bowel injury in LPRLND is a rare complication which, if not recognized intraoperatively, may have a characteristic post-operative presentation of severe pain at a trocar site associated with diarrhea, abdominal distention, and leukopenia [15]. One must be vigilant to recognize this infrequent but potentially catastrophic complication.

Solid organ injury Injury to the liver, pancreas, spleen and kidneys are not reported in the LRPLND literature, but are a known complication of urologic laparoscopy in general [16]. In a retrospective review of 2,775 laparoscopic

Table 1 Operative parameters: primary LRPLND for low-stage disease

Author, location publication year	Years enrolled	Clinical stage (CS): *n*	Path stage ≥IIa (%)	Mean/median operative time (min)	Conversion or abandonment (%)	Mean/median EBL (mL)	Mean/median LOS (days)	Mean/median follow-up (months)
Neyer et al., Austria 2007 [4]	1992-2005	CS I: 136	25 (18)	261 (115–570)	7 (5.1)	50 (20–3,000)	4.1	68 (8–151)
Bhayani et al., Baltimore, MD, USA 2003 [5]	1992–1998	CS I: 29	12/29 (41)	258 ± 10 min (157–380)	2/29 (6.9)	389 ± 114 mL (75–3,000)	2.6 ± 0.2 (1–5)	75 ± 25
Rassweiler et al., Heidelberg, Germany 2000 [12]	1992–1998	CSI: 34	6/34 (18)	271 (80–360)[a]	4/34 (11.8)	NR	6 (3–11)[b]	40 (4–72)
LeBlanc et al., France 2001 [11]	1996–1999	CS I: 20 CS IIa: 5	10/25 (40)	230 (180–300)	NR	<50	1.2 (1–3)	15 (3–35)
Corvin et al., Tubingen, Germany 2005 [9]	2002–2003	CS I: 18	7/18 (39)	232 ± 48 (115–365)[c]	NR	<100	NR	16.7 ± 5.8
Poulakis et al., Frankfurt, Germany 2006 [8]	2002–2005	CS I: 21	4/21 (19)	233 ± 17	0	270 ± 105	2 (1–3)	14 (6–20)
Abdel-Aziz et al., Dallas, TX, USA 2006 [7]	2000–2005	CS I: 22	7/22 (32)	313 ± 31.5	1/22 (4.5)	159 ± 220.9	1.2 ± 0.54 (1–3)	12 ± 10 (3–44)[d]
Holman et al., Hungary 2007 [10]	2002–2004	CS I: 8 CS IIa: 1 CS IIb: 1	7/10 (70)	258 (150–432)	0[e]	NR[f]	3.5 (3–10)	NR[g]

CS I American Joint Committee on Cancer (AJCC) Clinical stage 1, *CS IIa* American Joint Committee on Cancer (AJCC) Clinical stage IIa, *CS IIIb* American Joint Committee on Cancer (AJCC) Clinical stage IIb, *NR* not reported

[a] Recalculated from published data to include the entire cohort (i.e., all patients regardless of conversion to open surgery or presence of complications)

[b] Ibid

[c] This includes stage IIB and IIc patients who had a primary LRPLND

[d] Follow-up was reported only for the 19/22 patients for whom at least 3 months of follow-up was available. Three lost to follow-up

[e] There was one re-operation for bleeding

[f] Mean EBL was reported only for the eight patients without intraoperative vessel injury: mean 120 (80–150), not for the two patients with vessel injury. For these two patients, EBL was <300 mL

[g] The mean or median value was not reported. A range of 9–42 months was reported

urologic operations (of which approximately 3% were LRPLNDs), the incidences of injury to the spleen, liver and pancreas were 3.2, 1.1, and 0.36 per 1,000 cases, respectively [16].

Laparoscopic management of these injuries is similar to that described for vascular injury (e.g., increased pneumoperitoneum, direct compression, hemostatic agents, and laparoscopic suturing). Major injury may require splenectomy or conversion to laparotomy.

Post-operative complications (Table 2)

Retrograde ejaculation Retrograde ejaculation after RPLND is due to disruption of sympathetic nerve fibers. Reported rates of retrograde ejaculation after LRPLND range from 0 to 4.8%, similar to the open data [4, 5, 7–12, 17]. High rates of antegrade ejaculation are a result of adoption of prospective nerve sparing and modified templates. It is generally accepted that preservation of antegrade ejaculation should not be achieved at the expense of oncologic efficacy [6].

Chylous ascites Chyle leak due to lymphatic injury is one of the more common complications after RPLND and LRPLND. Chylous ascites is reported in up to 6.6% of patients following LRPLND [4]. In most series, this complication is either not reported or reported as non-existent [5, 8–12]. Since chylous ascites usually responds to conservative treatment, some investigators believe it is underreported [18].

Chylous ascites may be preventable. A prophylactic low-fat diet has been associated with reduction in incidence of chylous ascites. The Innsbruck group uses a low fat diet starting 2 weeks before surgery and continuing for 3 weeks following surgery. Chylous ascites, which was encountered in their first 30 patients, has not been diagnosed since introduction of the low fat diet [4, 14]. Though the surgical learning curve may have contributed to this reduction in chylous asictes, the association between prophylactic low-fat diet and reduced chylous ascites is intuitive and likely causal.

It is the belief of the senior author that clips should be used instead of bipolar coagulation in areas particularly prone to leakage from transected lymphatics, which include the region of the left renal hilum and right renal artery.

Patients with chylous ascites typically present days or weeks following surgery with abdominal distention and dyspnea [19]. Most can be managed conservatively with a low-fat, medium-chain triglyceride diet that reduces the flow of chyle into the lymphatics [18]. Should the chylous ascites not resolve with dietary intervention, additional conservative measures may be undertaken including total

Table 2 Post-operative complications of primary LRPLND for low-stage disease

Author, location publication year	Retrograde ejaculation	Chylous ascites	Lymphocele	Prolonged ileus	Nerve injury	Hematoma	Urinoma/ ureteral stent	Other
Neyer et al., Austria 2007 [4]	0%	9/136 (6.6%)	13.2% (18/136)	NR	NR[a]	NR[b]	NR	NR
Bhayani et al., Baltimore, MD, USA 2003 [5]	3.4% (1/29)	NR	3.4% (1/29)	NR	3.4% (1/29)	NR	NR	NR
Rassweiler et al., Heidelberg, Germany 2000 [12]	1/34 (2.9%)	NR	NR	NR	NR	2.9% (1/34)	8.8% (3/34)	2.9% (1/34) ureteral stenosis, 2.9% (1/34) PE
LeBlanc et al., France 2001 [11]	0%	NR	0%	NR	NR	NR	NR	NR
Corvin et al., Tubingen, Germany 2005 [9]	0%	0%	4% (1/25)	NR	NR	NR	NR	NR
Poulakis et al., Frankfurt, Germany 2006 [8]	1/21 (4.8%)	NR	NR	4.8% (1/21)	NR	4.8% (1/21)	4.8% (1/22)	NR
Abdel-Aziz et al., Dallas, TX, USA 2006 [7]	NR	1/22 (4.5%)	NR	4.5% (1/22)	4.5% (1/22)	NR	NR	4.5% (1/22) C. difficile colitis
Holman et al., Hungary 2007 [10]	0%	NR	NR	NR	NR	NR	NR	NR

NR not reported

[a] One case of peripheral nerve irritation was reported in the Linz series, which includes some of the same patients [2]

[b] One hematoma was reported in the Linz series, which includes some of the same patients [2]

parenteral nutrition and somatostatin, which is thought to reduce lymphatic flow [19, 20]. Conservative measures should be attempted for several months before embarking on surgical treatments, which include ligation of lymphatics or, rarely, peritoneovenous shunt. Minimally invasive surgical approaches have been reported [21].

Lymphocele Like chylous ascites, lymphocele is a delayed post-operative complication. The 2 largest series report lymphoceles in 3.4 and 13.2% of patients [4, 5]. A German group that utilized a water jet for LRPLND reported one lymphocele (4%), which resolved without intervention [9].

Asymptomatic lymphoceles most often can be managed expectantly [4]. In the Innsbruck series, all were asymptomatic and 94.4% of these were managed conservatively. The remainder was treated with laparoscopic incision [4]. The Baltimore group had one lymphocele (3.4%), which was treated with percutaneous drainage [5]. Our institution favors laparoscopic fenestration of lymphoceles over percutaneous drainage due to concerns regarding both recurrence and introduction of infection.

Retroperitoneal hematoma Three groups each report one case of retroperitoneal hematoma, with a corresponding prevalence up to 4.8% [2, 8, 12]. Two resolved spontaneously. The remaining hematoma was associated with ureteral stenosis which was managed with open ureterolysis [12].

Nerve injury There are isolated reports of peripheral nerve injuries in LRPLND. One patient in the Linz series (<1%) had transient irritation of the genitofemoral nerve [2]. Another group reported a patient (4.5%) with self-limiting lower extremity parasthesia [7]. Another patient (3.4%) was diagnosed with a latissumus dorsi compartment syndrome, which was managed conservatively without residual neurologic deficits [5, 13].

Nerve injury due to intraoperative positioning is caused by stretch, ischemia or compression. Risk factors include thin body habitus, diabetes mellitus, existing neuropathy, peripheral vascular disease, malnutrition, and intraoperative hypothermia or hypotension [22]. Particular care should be taken, especially in high-risk patients, to properly pad and position [22].

Other Two groups each report a case of prolonged ileus, with a corresponding prevalence of 4.5 and 4.8% [7, 8]. Two groups report use of ureteral stents in 4.8 and 8.8% of cases [8, 12]. One stent was for a urinoma, the indication for the other stents was not reported. Other reported complications include one pulmonary embolism (PE) (2.9%) and Clostridium Difficile colitis (4.5%) [7, 12].

While small bowel obstruction is a complication of 1–2% of open RPLND, none are reported in the laparoscopic literature [23]. No wound infections were reported, despite the fact that this is among the most common complications following urologic laparoscopic surgery [16].

Post-chemotherapy LRPLND

Operative parameters and intraoperative complications (Table 3)

Post-chemotherapy LRPLND (PC-LRPLND) is a technically demanding procedure with contemporary overall complication rates as high as 43.8% [24]. The authors of an early report of PC-LRPLND had a conversion rate of 77.8% attributed to severe desmoplasia. They concluded that PC-LRPLND was inadvisable due to a low success rate and unacceptable risk of inadequate dissection [25]. Subsequent series report lower rates of conversion [2, 9, 24, 26].

In the opinion of the senior author, proper patient selection is crucial to avoid unnecessary morbidity to the patient and to maximize oncologic outcome. Due to the technical complexities associated with PC-LRPLND, only surgeons extremely familiar with advanced laparoscopic techniques should perform PC-LRPLND [27].

In the reviewed series, mean operative times ranged from 232 to 364 min and median EBL was 50–903 mL. Mean LOS ranged from 2 to 7.8 days, increased with complications, and was not always reported [2, 9, 24–26].

Vascular injury As in primary LRPLND, vascular injury and hemorrhage were the most commonly reported complications of PC-LRPLND [2, 14, 24, 27]. The Baltimore group [24, 27] reported intraoperative vascular injuries in three patients (18.8%), two of which necessitated conversion to laparotomy. One patient underwent an aortorenal bypass graft for a renal artery mural hematoma, and the second had an iliac bypass graft for transection of the left external iliac artery. This patient subsequently developed a PE. The third intraoperative complication was a cavotomy that was repaired laparoscopically. One patient was transfused two units intraoperatively and another received 125 mL cell saver. In a fourth patient, a renal artery thrombus was discovered on the second post-operative day, with resultant nephrectomy for renal ischemia. This patient also had a major bowel injury as described below. In the Linz series, there were nine cases of intraoperative hemorrhage (15.3%), all of which were managed laparoscopically [2].

In summary, vascular injury is a common complication of PC-LRPLND and occurs in 15.3–18.8% of cases. In properly selected patients with an appropriately skilled surgeon, most vascular injuries in PC-LRPLND can be managed with the minimally invasive techniques described earlier.

Table 3 Operative parameters: PC-LRPLND

Author, location publication year	Years enrolled	*n*	Clinical stage (CS): *n*	Mean operative time (min)	Conversion or abandonment	Mean/median EBL (mL)	Mean/median LOS (days)	Mean/median follow-up (months)
Albqami and Janetschek, Austria 2005 [2]	1995–2004	59	CS IIb: 43 CS IIc: 16	234 (135–360)	0	165 (20–350)[a]	3.8 (3–10)	53 (10–89)
Permpongkosol et al., Baltimore, MD, USA 2007 [24]	1996–2005	16[b]	CS IIa: 3 CS IIb: 8 CS IIc: 2 CS IIIa: 2 CS IIIb: 1	327 (116–700)	2/16 (12.5%)	903 (100–2,800)	2 (1–68)	30.7 (4–108)
Rassweiler et al., Heidelberg, Germany 1996 [25]	NR	9	CS IIb: 2 CS IIc: 7	364[c]	7/9 (77.8%)	NR	7.8 (3–14)[d]	29 (6–40)
Corvin et al., Tubingen, Germany 2005 [9]	2002–2003	7	CS IIa: 1 CS IIb: 4 CS IIc: 2	232 ± 48 (115–365)[e]	0	<100 mL	NR	17.2 ± 8.2
Hara et al., Kobe, Japan 2004 [26]	NR	3[f]	CS IIb: 1 CS IIIa: 2	(255–310)	0	<50 mL	NR	NR

NR not reported

[a] In the Innsbruck series, which includes some of the same patients, Steiner noted EBL range 10–1,600 mL [14]

[b] Two patients had pure seminoma and one had epididymal small cell cancer

[c] Calculated from published data to include the patients who were converted to open RPLND

[d] Ibid

[e] This includes the operative data for the low stage patients as well as for those who underwent post-chemotherapy RLND

[f] One patient had seminoma

Bowel injury One of the first seven patients in the Baltimore series was found to have a duodenal injury during exploration on post-operative day 2 for an ischemic kidney [24]. The patient was treated with pyloric excision, hepaticojejunostomy, and multiple debridements for an intra-abdominal abscess with associated necrotizing fasciitis. The patient's course was complicated by cerebrovascular accident with durable neurologic deficits and extended hospital stay.

While no other bowel injuries are reported in the PC-LRPLND literature, the risk of bowel injury is in principal at least equivalent to primary LRPLND. In the case of significant residual tumor adherent to bowel or other organs, a higher risk of bowel complications must be anticipated.

Effect of chemotherapy The increased intraoperative complication rate in PC-LRPLND is attributed to chemotherapy-associated desmoplasia [24–27]. Dissecting adjacent organs away from a large residual mass can be arduous, and complete extirpation of tumor may necessitate resection of adjacent structures. In the open RPLND literature, resection of kidney, bowel and great vessels is well documented [28–30]. Laparoscopic nephrectomy has not been reported as an adjunct to PC-LRPLND, but is feasible.

Patients who undergo laparoscopic or open RPLND have a higher risk of post-operative morbidity following chemotherapy. Of particular importance is the marked pulmonary toxicity of bleomycin, necessitating restraint with supplemental oxygen and intravenous fluids [3, 27].

Post-operative complications

Rates of retrograde ejaculation up to 12.5% are reported in PC-LRPLND [24]. The Linz series reports chylous ascites and asymptomatic lymphoceles in 11.9 and 6.8% of patients, respectively [2]. In addition, the Baltimore group reports one case each of transient elevation in serum creatinine and chemical pneumonitis [24]. Ileus, wound infection, nerve injury, and SBO were not reported in any series.

Discussion

Summary

In primary LRPLND, vascular injury is the most common intraoperative complication and reason for converting to laparotomy. Most vascular injury, which occurs in 2.2–20% of reported cases, can be controlled with conservative measures including compression, clips and fibrin glue. Use of vascular clamps, laparoscopic suturing, or conversion to laparotomy may be required. Bowel injury is a rarely reported but potentially catastrophic complication. Knowledge of the unique post-operative presentation may aid in early recognition. Solid organ injury has not been reported, but is a potential complication. Rates of retrograde ejaculation in published primary LRPLND series are less than 5%. Chylous ascites and lymphocele, with reported rates of occurrence up to 6.6 and 13.2%, respectively, are most often treated conservatively. More rarely reported complications include nerve injury, retroperitoneal hematoma, and ureteral injury requiring internal stent placement. Complications are associated with increased LOS [16].

The desmoplastic reaction makes PC-LRPLND exceedingly challenging. In PC-RPLND, an early report disclosed a 77.8% rate of conversion to open surgery. A contemporary report cites a nearly 44% overall complication rate. As in primary LRPLND, hemorrhage and vascular injury are the most commonly reported complications in PC-LRPLND. Retrograde ejaculation is several-fold more common in PC-RPLND than in primary LRPLND. In one of the largest series, rates of chylous ascites and asymptomatic lymphoceles were 11.9 and 6.8%, respectively. No peri-operative mortality has been reported for either LRPLND or PC-LRPLND.

Limitations

There are several limitations to this review and to the current LRPLND literature. Complications are not consistently reported, as there is no universally accepted system of recording and reporting surgical morbidity [16]. In some series, EBL, LOS and duration of follow-up were not reported [9, 10, 12, 25, 26]. While the omissions may be minor, they support the notion that complications may not be comprehensively reported in the literature. Furthermore, delayed complications and their consequences (i.e., additional treatments and interventions, increased LOS, effect on quality of life) may not be captured in a retrospective review.

Fundamental differences among surgeons in LRPLND technique and intent may influence the morbidity of the procedure, and may thus render our comparison of these series unworkable. Some surgeons consider LRPLND in CS I disease a diagnostic tool rather than a therapeutic intervention, and thus limit the RPLND if grossly positive nodes are encountered [8]. Moreover, some surgeons remove lymphatic tissue posterior to the great vessels in order to duplicate the open technique, while others do not excise retrocaval nodes [2, 7, 8, 12, 24]. In the opinion of the senior author, dissection of the posterior caval nodes may be associated with a higher rate of vascular complications but is essential. One must be cognizant of the vital differences in technique when attempting to compare outcomes between series.

Table 4 Classification of surgical complications: the Clavien system (reprinted with permission) [32]

Grade	Definition
I	Any deviation from the normal post-operative course without the need for pharmacological treatment or surgical, endoscopic, and radiologic interventions. Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes and physiotherapy. This grade also includes wound infections opened at the bedside
II	Requiring pharmacological treatment with drugs other than such allowed from grade I complications. Blood transfusions and total parenteral nutrition are also included
III	Requiring surgical, endoscopic or radiological intervention
IIIa	Intervention not under general anesthesia
IIIb	Intervention under general anesthesia
IV	Life-threatening complication (including CNS complications) requiring intensive care unit management
IVa	Single organ dysfunction (including dialysis)
IVb	Multiorgan dysfunction
V	Death of a patient
Suffix "d"	If the patient suffers from a complication at the time of discharge, the suffix "d" (for "disability") is added to the respective grade of complication. This label indicates the need to follow-up to fully evaluate the complication

In addition, the patient populations are not uniform. For example, while several of the series are limited to non-seminomatous germ cell tumors, some reports include seminomas, which may have different complication profile due to severity of desmoplasia, especially in the post-chemotherapy setting [24, 26].

One must consider the complications of adjuvant chemotherapy when comparing the morbidity of LRPLND to open RPLND [3]. In the reviewed laparoscopic series, nodal disease was found on pathology in 5.9–41% of clinical stage I patients. While there are several reports of patients with positive nodes following LRPLND who did not have adjuvant chemotherapy [5, 7, 31], most studies report that patients with pathologic positive nodes following LRPLND receive adjuvant chemotherapy, regardless of volume of nodal disease [4, 8–11]. In open RPLND in the United States, adjuvant chemotherapy is usually limited to patients with high-volume disease in the lymph nodes (pN2-3) [6]. Complications of adjuvant chemotherapy, most commonly cysplatin, etoposide and bleomycin, are significant and include pulmonary fibrosis, cardiovascular disease, secondary cancers, peripheral neuropathy, infertility and renal toxicity [3]. None of the laparoscopic studies included in this review reported the complications associated with adjuvant chemotherapy. Since adjuvant chemotherapy is uniformly employed in LRPLND and only selectively employed in open RPLND, the complications associated with chemotherapy would be an important consideration if one were to compare the two techniques.

LRPLND and PC-LRPLND are exceedingly challenging procedures from a technical standpoint. The published complication rates may be difficult to extrapolate to urologists other than a few high-volume, laparoscopic specialists based at tertiary-care centers.

Future

Published series suggest that the short-term morbidity of LRPLND is less than open surgery. This should be confirmed with prospective trials. At present, comparing the morbidity of LRPLND to that of open RPLND may not be valid given the selection bias associated with retrospective study design, as well as fundamental differences in the extent of dissection between the open and laparoscopic approach. The morbidity of adjuvant chemotherapy given after LRPLND should be quantified and reported. Finally, the consequences of operative morbidity in terms of increased LOS, additional interventions, cost, and any effect on quality-of-life must be considered in a comparison of open and LRPLND.

Efforts must be made to systematically record and report complications to permit more rigorous evaluation and more reliable comparison of different series and different techniques. Several authors in the urology literature make use of a validated complication classification system that was developed for General Surgery [4, 16, 32] (Table 4). The Clavien system stratifies complications based on the therapeutic consequences of the complication. The system is validated, objective and reproducible, and may permit more meaningful comparison of outcomes between different surgeons and techniques.

These efforts will help clarify the proposed benefits of LRPLND.

Conflict of interest statement There is no conflict of interest.

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