# Chapter 4
# Complications of Inguinal Lymphadenectomy

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## Abbreviations

| | |
|---|---|
| DVT | Deep vein thrombosis |
| ILND | Inguinal lymph node dissection |
| LND | Lymph node dissection |
| PE | Pulmonary embolism, endoscopic inguinal lymphadenectomy |

## Introduction

Penile squamous cell carcinoma is a rare entity with an incidence of less than 1 per 100,000 males [1]. At initial presentation, 50% of patients with penile squamous cell carcinoma have inguinal lymphadenopathy, but only half of them have metastatic lymph node involvement [2]. It is one of the few urologic malignancies potentially curable by regional lymphadenectomy. The presence and severity of these nodal metastases have been shown to be the single most important predictor of cancer-specific survival [3]. In addition to refining pathologic staging, inguinal

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lymph node dissection (ILND) remains the most effective means of eradicating minimal metastatic disease in invasive penile cancer patients. Over time, the strategies concerning the indication of ILND as well as surgical technique have changed dramatically. Thus, different template extensions and perioperative management—as well as inconsistent methodology of complication definition, grading, and reporting—have contributed to a great variability of ILND complication rates reported in the literature.

Traditional groin dissection has been associated with a high complication rate [4–7] (Table 4.1). Radical ILND involves a 10-cm length skin incision with extensive dissection field involving the superficial and deep inguinal nodes with complete exposition of the femoral vessels, division of the great saphenous vein, and transposition of the sartorius muscle. The boundaries of the dissection are as follows: proximally, the inguinal ligament; distally, the entrance of Hunter's canal where the femoral vessels go under the muscles of the leg, medially is the adductor muscle, and laterally is the sartorius muscle. The floor of the dissection consists of the fascia lata, the femoral vessels, and the pectineus muscle. Morbidity with this template includes phlebitis, wound infection, pulmonary embolism, wound dehiscence, flap necrosis, and lymphedema. Due to the frequency and severity of complications, many physicians have been reluctant to offer ILND to patients with penile cancer particularly in the absence of palpable inguinal lymphadenopathy.

Over time, significant advances in the surgical approach to penile cancer have been made. It is now realized that not all patients require radical surgery to stage or even treat the inguinal region. The improved pre- and postoperative care, modification of the extent of the dissection, advances in surgical technique, plastic surgery consultation for myocutaneous flap coverage, and preservation of the dermis, Scarpa's fascia, and saphenous vein have decreased the incidence of ILND complications [8, 10–12]. Contemporary surgical series report decreased ILND complication rates during the last two decades and have been lower for patients undergoing modified ILND [16–18, 20, 23–26].

In this chapter, we review common complications of ILND, modifications of surgical technique and its effect on surgical morbidity, and potential preventative and management strategies of these problems.

## Modified Dissections

Both superficial inguinal and modified complete dissections have been proposed as staging tools for the patient without palpable inguinal lymphadenopathy. Superficial node dissection involves removal of those nodes superficial to the fascia lata. The rationale for the superficial dissection is based on some series, which haven't shown positive nodes deep to the fascia lata unless superficial nodes were also positive [21, 27].

Coblentz et al. proposed a modified ILND to reduce the morbidity and to preserve oncologic control [25]. It involves a smaller skin incision (6–7 cm), preservation of the saphenous vein, and thicker skin flaps. It also narrows the field of inguinal

**Table 4.1** Incidence of common complications after inguinal lymph node dissection for penile cancer

| Series | Year | Patients (*n*) | Overall complication rate (%) | Wound infection (%) | Wound dehiscence + necrosis (%) | Lymphocele (%) | Lymphedema (%) |
|---|---|---|---|---|---|---|---|
| Johnston et al. [8] | 1984 | 67 | 82 | 14 | 50 | 9 | 50 |
| Darai et al. [9] | 1988 | 85 | – | 12 | 14 | 3 | 32 |
| Ornellas et al. [10] | 1991 | 200 | – | 15 | 45 | – | 23 |
| Ravi et al. [11] | 1993 | 112 | – | – | 25 | 9 | 16 |
| Kamat et al. [12] | 1993 | 31 | 87 | – | – | – | – |
| Bouchot et al. [13] | 1993 | 32 | – | 29 | 44 | – | 44 |
| Ayyappan et al. [14] | 1994 | 78 | – | 70 | 36 | 87 | 57 |
| Lopes et al. [15] | 1996 | 145 | – | – | 18 | – | 30 |
| Bevan-Thomas et al. [16] | 2002 | 53 | 57 | 10 | 8 | – | 23 |
| Coblentz et al. [17] | 2002 | 22 | 45 | 9 | 9 | 27.2 | 0 |
| Bouchot et al. [18] | 2004 | 88 | 42 | 3 | 12 | – | 22 |
| Nelson et al. [19] | 2004 | 22 | – | 8 | 10 | 15 | 15 |
| Spiess et al. [20] | 2009 | 43 | 49 | 9 | 11 | 2 | 17 |
| Gopman et al. [21] | 2015 | 327 | 55 | 32 | – | 8 | 22 |
| Koifman et al. [22] | 2013 | 170 | 10 | 1 | 2 | 2 | 4 |

dissection excluding the area lateral to the femoral artery and caudal to the fossa ovalis [23, 25]. This technique also avoids transposition of the sartorius muscle to cover exposed femoral vessels. Unlike in superficial dissection, deep nodes within the fossa ovalis are also removed in a modified ILND. These maneuvers result in less severe disruption of the lymphatic collaterals and less vascular damage compared to a radical ILND. A long-term follow-up in two series showed that this method was reliable with less morbidity than standard ILND [16, 18]. The incidence of flap necrosis (2.5%), lymphedema (3.4%), and deep venous thrombosis (none) in a group of patients with modified lymphadenectomy was remarkably decreased in comparison with a historical control group of radical lymphadenectomy (skin necrosis 8.6%, lymphedema 22.4%, and deep vein thrombosis (DVT) 12%) [18]. Of note, cases with greater metastatic disease are more likely to be associated with increased morbidity. Although increasing the number of lymph nodes removed increases the likelihood of complications, surgical excision of suspected lymph nodes is necessary for staging as well as therapeutic treatment of the disease [8, 19, 22, 28].

## Wound Infection

Wound infection after ILND tends to be one of the most prevalent complications. Historical series [8, 10, 11, 29–31] have reported wound infection rates following ILND between 12 and 29% with one series showing a 70% wound infection rate [32]. The skin is a dynamic home to a large number of bacteria. Microorganisms isolated from groin wounds have included gram-negative rods, *Staphylococcus* species, diphtheroids, and *Peptostreptococcus* [32]. With improved operative technique, timely administration of preoperative antibiotics, and a variety of measures aimed at neutralizing the threat of contamination, infection rates have decreased in contemporary series [20, 27].

Preoperative skin sterilization with an antiseptic is important to remove transient organisms from the skin and decrease wound colonization prior to proceeding with surgical intervention. Additionally, patients should undergo clipping of the surgical site as needed as studies have shown that shaving the skin as compared with clipping results in a statistically significant increase in the rate of surgical site infection [32, 33]. Shaving results in microscopic cuts and abrasions, thus acting as a disruption of the skin's barrier, whereas clippers should not cut into the patient's skin potentially explaining the differences in infection rates.

Even though no comparative studies have been done on the use of prophylactic antibiotics, the potential benefit of decreased wound infection from antimicrobial prophylaxis (broad-spectrum antibiotics, e.g., ampicillin/gentamicin or ampicillin/ciprofloxacin) prior to skin incision is advisable. This type of surgery should be considered a contaminated procedure because of the often coexisting inflammatory reactions in the lymph nodes. Furthermore, in patients with active infection of the groin, bacterial cultures should be obtained and culture-specific antibiotics should

be given preoperatively. If the primary tumor is infected, a staged procedure is recommended. Antibiotic therapy for 4–6 weeks has been advised after treatment of the primary penile tumor, to remove the infected source and allow resolution of septic lymphadenitis before ILND [6, 13, 15]. After the groin dissection, it has been suggested that antibiotics should be continued for 1 week or until the wound drains have been removed as migration of bacteria along the drain can increase the risk of infection [6, 9].

Patient characteristics may also guide duration of antibiotic therapy post ILND. Diabetes, cigarette smoking, obesity, and coincident remote site infections or colonization have each shown significant independent association for surgical site infection prediction [14]. It is hypothesized that increased susceptibility to surgical site infections in obese patients results from tissue hypoperfusion, which in turn may lead to greater risk of ischemia or necrosis and suboptimal neutrophil-oxidative killing [34]. Nonetheless, no clear guidelines exist for duration of antibiotics after ILND. Additionally, postoperatively, it is imperative to keep the wound site clean and dry, especially in obese patients as the groin provides a moist environment that may predispose to fungal overgrowth [20].

Intraoperatively, meticulous atraumatic tissue handling should be performed to reduce the risk of wound-related problems such as a lymphocele or hematoma, which could potentially become infected [20]. Excess skin should be excised as well in order to reduce dead space and prevent fluid collections, which similarly could get infected. Additionally, the subcutaneous tissue superficial to the fibrous layer of Camper's fascia should be preserved as devitalized skin flaps are at an increased risk of ischemia, necrosis, infection, and wound dehiscence [4, 18, 20, 23].

## Wound Dehiscence and Skin Necrosis

Historically, ILND has been associated with a high rate (25–50%) of wound dehiscence and skin necrosis [8, 10, 11, 13, 14]. A decreased wound complication rate depends on preservation of the blood supply to the skin along with maintenance of collateral lymphatics, which is why knowledge of the vascular surgical anatomy of the groin is imperative. The blood vessels supplying the skin of the inguinal region arise from the superficial branches of the inferior epigastric, external pudendal, and circumflex iliac arteries. All three of these vessels are transected and ligated during the course of an ILND, and the flaps must rely on anastomotic branches and microcirculation for viability. These vessels run parallel to the inguinal ligament and lie in the fat of the superficial layer of the superficial fascia (Camper's fascia) [35, 36]. Consequently, the most physiological incision is parallel to the natural skin folds transecting as few anastomotic vessels in Camper's fascia as possible and maximizing the likelihood of primary wound healing without flap necrosis.

A variety of incisions have been described in the literature including but not limited to horizontal, vertical, T-shaped, S-shaped, and Gibson. Incisions that interrupt the anastomotic vessels in Camper's fascia are vertical incisions, S-shaped

incisions, or T-shaped incisions. Postoperative edema leads to excessive traction and tension along the line of the incision resulting in increased incidence of skin necrosis. Ravi and colleagues reported the incidence of flap necrosis was greatest using a T-shaped incision compared with a horizontal or vertical incision [11]. Tonouchi and colleagues compared the operative morbidity of an S-shaped incision versus a straight incision, and the authors noted the incidence of wound infections was significantly higher after S-shaped incisions [37]. Ornellas and colleagues found skin-edge necrosis in 82% of patients with bi-iliac incision, 72% with an S-shaped incision, and only 5% with a Gibson incision [10]. In a 170 patients series by Koifman and colleagues, a Gibson incision was used with a 1.5% rate of wound dehiscence or skin necrosis [22].

The length of the hospital stay as a function of wound morbidity has also been correlated with incision types, and the highest likelihood of primary wound healing occurred with oblique straight-line incisions [38, 39]. If enlarged nodes are present extending superficially toward the skin and subcutaneous tissues, an oblique skin incision can easily be modified to circumscribe and excise the skin en bloc with the nodal packet [40]. Additionally, the oblique incision allows access for simultaneous pelvic lymph node dissection if warranted [40]. For the most part, para-inguinal horizontal incisions that avoid the groin crease have been preferred due to their preservation of the blood supply [6, 20, 22, 41].

The key to minimal morbidity after lymphadenectomy is proper skin handling and meticulous dissection of the skin flaps [42]. A 2 mm thickness of fat is recommended to be left on the undersurface of the skin to accommodate the microcirculation of the skin flaps. Thin skin flaps are at an increased risk of ischemia, skin necrosis, and subsequent wound dehiscence. After dissection, the wound edges should be inspected, and any areas with doubtful vascularization should be removed. Some have suggested use of intravenous fluorescein to better detect the viability of the skin edges [8, 43, 44]. However, extensive experience has not been reported, and this surgical adjunct has not gained wide acceptance. In order to eliminate dead space and prevent fluid collection, the subcutaneous tissue should be anchored to the underlying muscles with interrupted absorbable sutures [6, 37]. Sartorius muscle transposition, previously recommended to protect the femoral vessels during ILND, has recently shown to increase the risk of complications postoperatively [21, 22, 45, 46]. A prospective randomized controlled trial examining the effect of transposition of the sartorius muscle on morbidity after ILND in vulvar cancer patients showed no favorable effects and a possible negative impact on seroma formation [40].

Whenever the skin has been sacrificed by the removal of a portion of the groin dissection flap, primary closure is rarely possible except under tension. Tension frequently tents the flaps up. This leads to underlying dead space permitting the formation of fluid collections, delayed healing, with the resultant increased risk of surgical site infection. Inguinal reconstruction with myocutaneous flaps can avoid wound dehiscence related to excessive tension [20]. Myocutaneous flaps used include gracilis, tensor fascia lata, rectus abdominis muscle, and internal oblique flaps [6, 47]. Ravi reported a 0% incidence of skin flap necrosis in a latter cohort of 30 patients undergoing therapeutic dissection with myocutaneous flap reconstruction

compared with an earlier cohort of patients undergoing lymphadenectomy without flap reconstruction (skin-edge necrosis was 61–78%) [11]. Additionally, split-thickness skin grafts can be used to cover skin edges that cannot be reapproximated [47]. The prompt assistance of a plastic surgeon may be necessary for tissue transposition or skin grafts in anticipation of large defects. If a myocutaneous flap is used, mobilization should be avoided for 48–72 h to avoid compromising the blood supply to the flap [20].

## Lymphedema and Lymphocele

After radical inguinal lymphadenectomy, lymphedema has the potential for causing difficulty ambulating and standing for prolonged periods. During a groin dissection, numerous major afferent lymphatics are transected and large segments of lymphatics are resected. Historically, lymphedema was a frequent complication following ILND. Kamat et al. described a total incidence of lymphedema of approximately 50% with a severe lymphedema occurring in 35% of dissections [8]. The rate of lymphedema has decreased in recent years due to more prophylactic dissection as well as other modifications in surgical technique [16–22]. Contemporary series have included a higher ratio of early prophylactic dissections of nonpalpable microscopic disease, which remove less lymphatic tissue. ILND in this setting may be less likely to produce complications than node dissection in the presence of bulky nodal metastases as alternative drainage of the limb is potentially maintained. For example, Bevan-Thomas and colleagues observed an incidence of scrotal and leg edema of 23% with only 13% severity. Notably, this rate increased to 33% when the authors excluded prophylactic dissections in clinically node-negative patients [16].

With preservation of the saphenous vein during a modified ILND for penile cancer, the risk of lymphedema has also shown to be reduced [20, 24, 26]. Zhang and colleagues showed rates of short-term lower extremity lymphedema occurring in 67% of patients who underwent saphenous vein excision versus 44% of patients who underwent saphenous vein sparing in vulvar cancer patients [46]. Four studies have reported results of lymphedema from saphenous vein sparing, and meta-analysis of these studies showed significant reduction in the rates of lymphedema in those who had preservation of the saphenous vein [48]. Transposition of the sartorius muscle, which is also not done during a modified ILND, has been associated with higher incidence of persisting lymphedema [49]. Some have also investigated the use of an omental flap after groin dissection to cover the defect of the dissected area of iliac lymph nodes with reduction of lymphedema [50–52]. The omentum is thought to facilitate absorption of any lymphatic fluid, provide good coverage for the femoral blood vessels, afford additional blood supply, and enhance wound healing. Another interesting concept in reducing lymphedema rates in ILND is preservation of the muscle fascia, which was reported by some centers with relatively low reported lymphedema rates of 14% in both studies [53, 54]. It is thought that fascia-preserving techniques cause less scarring and subsequently less lymphatic vessel

occlusion. Orefice et al. performed lymphovenous anastomoses immediately after completion of ilioinguinal lymphadenectomy in 30 patients and noted reduced incidence of lymphedema (30% vs. 75%) [55].

Meticulous control of lymphatics throughout the surgical dissection and careful ligation using absorbable sutures or titanium clips has been suggested in preventing lymphedema [20, 50]. The use of an electrothermal bipolar tissue sealing system (LigaSure™, Minneapolis, MN: Covidien) during a groin dissection has also been shown to reduce lymphedema in addition to reducing operative time [56]. Fibrin glue has been used to seal capillaries and obliterate dead space. A randomized prospective trial using suture closure with or without the addition of fibrin sealant following groin dissection was evaluated in vulvar cancer patients [57]. Unfortunately, rates of lymphedema based on the use of fibrin sealant were not effective. Bouchot and colleagues utilized a vaporized tissue sealant when closing the groins and did not use suction drains leading to three seromas of 118 procedures [18]. A review of randomized controlled trials in breast cancer literature concluded that fibrin sealant did not reduce the rate of postoperative seroma, the drainage volume, or the length of hospital stay [58].

Before closing the wound, suction drains are recommended to prevent the initial formation of lymphocele and increase the chances of primary wound healing [46]. There are no reported guidelines for duration of drainage with most recommending removal when the drain output is less than 25–50 mL/day, which is typically 3–17 days postoperatively [6, 37, 46, 47]. Of note, a prospective randomized study, evaluating women undergoing axillary lymph node dissection (LND) for breast cancer, showed no significant benefit in using high versus low vacuum drainage and indicated drains did not prevent seroma formation [9].

Early ambulation, physical therapy, elastic stockings, and/or pneumatic stockings have been suggested to be used postoperatively to reduce the chance of a lower extremity lymphedema [19, 20, 59]. A stepwise approach to the management of chronic lymphedema was developed and advocated by the International Society of Lymphology [60]. It consists of initial skin care, light manual massage, elevation of the affected limb, range-of-motion exercises, and intermittent compression with low-stretch elastic stockings or multilayered bandage wrapping. With compression garments, gradient pressure is applied to the limb, in which the pressure exerted distally is greater than that exerted proximally allowing movement of lymphatic fluid proximally [61]. Elastic stockings are recommended to be used for at least 6 months after surgery. However, prospective randomized studies on these interventions are currently lacking in penile cancer patients who underwent ILND. Randomized clinical trials in breast cancer literature have evaluated the role of early postoperative physiotherapy to prevent the development of lymphedema [62, 63]. Box et al. randomized 65 women to a treatment group consisting of early physiotherapy versus a control without intervention, and at 24 months, the incidence of lymphedema in the control group was 30% versus 11% in the treatment group [64]. Another study randomized 116 women to early physiotherapy (manual lymph drainage, massage of scar tissue, exercise, and educational strategy) or to a control group (educational strategy alone) [65]. Of the 116 patients, 18 developed

secondary lymphedema: 14 were in the control group and 4 were in the intervention group. Plastic surgery literature has also shown the benefit of elastic compression garments and lymphatic massage in minimizing the incidence, severity, and sequelae of lymphedema [66, 67].

## DVT/PE

Venous thromboembolism is a serious complication that should be aggressively prevented when possible. Its incidence in series has ranged from 0 to 7% [8, 11, 16, 18, 20–22, 27, 28]. In terms of risk of a deep vein thrombosis (DVT)/pulmonary embolism (PE), ILND for penile cancer should be considered a high-risk procedure as it meets all three criteria of Virchow's triad: (1) endothelial injury during dissection of the femoral vessels, (2) venous stasis during immobilization, and (3) a hypercoagulable state secondary to malignancy [20, 68].

Early ambulation decreases the risk of deep vein thrombosis formation and also assists in moving the patient to a status that is consistent with the level of ambulation required for discharge [19]. Prior to anesthesia induction, antiembolic stockings or intermittent compression devices have also been recommended to prevent DVT [6, 20, 37]. Strict leg elevation may also be maintained in the hospital when the patient is not ambulating.

In regard to low-dose heparin, no comparative studies have been done on its use to reduce the incidence of DVT for penile cancer patients after ILND [6, 20, 46]. Most centers recommend low molecular weight heparin while on bed rest postoperatively, but some centers have indicated that the perioperative use of low-dose heparin may be associated with an increased risk of wound hematoma and lymph drainage without reducing the incidence of DVT [6, 19, 38]. However, in patients with a remote history of DVT/PE low dose, low molecular weight heparin must be administered perioperatively until postoperative day 28, in accordance with results from a meta-analysis of randomized trials [69]. With a history of a DVT/PE 6 months prior to ILND, therapeutic dose of heparin should be restarted when the risk of postoperative hemorrhage is minimal with subsequent conversion to oral warfarin [20, 70].

## Vascular Injury and Hematoma

Vascular injury is a rarely reported complication after ILND. Although infrequent, vascular injury can have serious consequences including the need for emergent surgical exploration to prevent exsanguination or delayed interventions to drain an infected hematoma. In 106 dissections, Bevan-Thomas and colleagues reported a 4% incidence rate of vascular injuries or postoperative hemorrhage [16]. Similarly, Spiess and colleagues reported a 2% incidence rate of this complication [20].

A contemporary series of 340 procedures by Koifman and colleagues noted one case of an intraoperative femoral vein lesion that was promptly corrected [22]. Additionally, Gopman and colleagues noted 4 patients out of 327 required surgical re-exploration for hematomas [21]. The split-and-roll technique is commonly used in lymph node dissection for removal of the tumor and lymphatic tissues surrounding large vessels. Care must be taken in patients with bulky tumors surrounding the femoral vessels or palliative groin dissections in postchemotherapy patients that are deemed resectable.

To avoid vascular complications when performing an ILND, it is essential that the operating surgeon be familiar with the vascular anatomy. During the procedure, vessel ligation should be performed in a systematic fashion using sutures, surgical clips, or a vascular sealing device. At the completion of resection, the operative field should be aggressively irrigated with water or saline to uncover any potential unrecognized bleeding sources [20]. Postoperatively, any patients with suspected active bleeding should be re-explored to prevent exsanguination and minimize complications that potentially may lead to wound fibrosis obstructing lymph drainage [20].

## Neurapraxia and Nerve Injury

Neurapraxia or nerve injury is rarely mentioned in the ILND for penile cancer literature. Spiess and colleagues reported a 2% incidence in their series [20]. During an ILND, the femoral nerve is the most significant nerve to the surgeon. The femoral nerve originates in the lumbar plexus from branches of the posterior division of the L2, L3, and L4 roots. Injury to the femoral nerve creates considerable morbidity because it innervates the quadriceps, sartorius, and pectineus muscles and supplies sensation to a large part of the skin of the anterior and medial portions of the thigh [47]. Injury to the femoral nerve usually produces weakness of knee extension secondary to quadriceps paresis.

There are three general categories of nerve injury: neurapraxia, axonotmesis, and neurotmesis [64]. Neurapraxia, which is a nerve contusion, is a functional injury that is caused by nerve compression or traction resulting in a conduction block without overt axonal degeneration. Recovery from neurapraxia is expected to occur within 6 weeks. Axonotmesis is a more severe injury caused by prolonged compression or excessive traction. The supporting neuronal structures allow for nerve regeneration, and function recovers slowly in 6 months to 1 year. The most severe nerve injury, neurotmesis, denotes complete division of the nerve. In this case, both neural elements and supporting structures are disrupted, and recovery is not expected.

To avoid nerve injury when performing an ILND, it is essential again that the operating surgeon be familiar with the anatomy of neurovascular structures in the groin. The femoral nerve lies lateral to the artery as these structures pass beneath the inguinal ligament and enter the thigh; the nerve divides into its many branches and immediately passes beneath the sartorius muscle out of the field of dissection. Most

cases of femoral neuropathy following ILND result from direct compression injury from the placement of self-retaining retractors [6, 20]. The severity of the injury is usually related to the duration of retraction and positioning of the patient. If femoral nerve transection occurs, the nerve should be repaired immediately with the help of neurosurgery or plastic surgery [20].

If nerve injury is suspected postoperatively, prompt examination is required to determine the etiology. It is critical the clinician rule out nerve compression syndromes that require decompressive procedures [20]. Most femoral neuropathy is managed by physical therapy to prevent muscle wasting, and chronic neurogenic pain may be treated with nonnarcotic analgesics, carbamazepine, and amitriptyline [71]. Even though femoral neurapraxia almost invariably resolves spontaneously, the time to resolution remains variable [65].

## Video Endoscopy and Robotic-Assisted Techniques

Minimally invasive approaches—video endoscopic and robotic assisted—have been undertaken, and recent series demonstrate that these approaches can limit surgical morbidity with inguinal lymphadenectomy. The Tobias-Machado group reported 20% of complications in 20 dissections [72]. Master et al. reported on their incidence of complications in a series of 41 groin dissections performed in 29 patients [73]. A total of 11 (27%) minor complications (3% superficial wound infection, 12% seroma/lymphocele, 5% mild–moderate lymphedema) and 6 (15%) major complications (3% flap necrosis, 5% secondary procedure, 0% venous thromboembolism, 0% severe lymphedema) were reported in their series [73]. These series as well as other small series have concluded that a minimally invasive approach produces fewer complications in comparison to historical open surgery [3, 71, 74, 75]. The reduced complication rate is thought to be due to less mechanical trauma produced by retraction, minimal use of electrocautery, smaller incisions that allow a better conservation of blood flow and lymphatic drainage of the skin, absence of flap rotation of the sartorius muscle, and easy identification of lymphatic vessels by optical magnification [76].

Recently, the incorporation of robotic assistance as an enabling tool for performing endoscopic ILND has been described [77]. Matin and colleagues reported a series of eight patients who underwent bilateral robotic-assisted surgery [78]. Of the eight patients, two were readmitted to the hospital for cellulitis, with one patient requiring incision and drainage of an abscess. Two additional patients were treated as outpatients, one for an area of wound breakdown and the other for an area of skin necrosis. There were no intraoperative vascular or neurological injuries. Further studies are needed to evaluate the incidence and type of complications as well as oncological efficacy of minimally invasive techniques. Based on these initial series, there appears to be a trend toward improved outcomes in regard to surgical morbidity.

## Conclusion

Lymphadenectomy plays a paramount role in treating various malignancies, especially penile cancer. Historically, radical ILND is associated with high complication rate secondary to infections, wound healing, and lymphedema. The morbidity of ILND has declined over the past 20 years from a multitude of factors including surgical technique modifications (dissection templates, saphenous vein sparing, and thicker skin flaps), perioperative management strategies, patient selection, and surgical approach.

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