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Obturator Nerve Injury in Robotic Pelvic Surgery: Scenarios and Management Strategies

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Abstract

Background: Obturator nerve injury (ONI) is an uncommon complication of pelvic surgery, usually reported in 0.2–5.7% of cases undergoing surgical treatment of urological and gynecological malignancies involving pelvic lymph node dissection (PLND).
Objective: To describe how an ONI may occur during robotic pelvic surgery and the corresponding management strategies.
Design, setting, and participants: We retrospectively analyzed video content on intraoperative ONI provided by robotic surgeons from high-volume centers.
Surgical procedure: ONI was identified during PLND and managed according to the type of nerve injury.
Results and limitations: The management approach varies with the type of injury. Crush injury frequently occurs at an advanced stage of PLND. For a crush injury to the obturator nerve caused by a clip, management only requires its safe removal. Three situations can occur if the nerve is transected: (1) transection with feasible approximation and tension-free nerve anastomosis; (2) transection with challenging approximation requiring certain strategies for proper nerve anastomosis; and (3) transection with a hidden proximal nerve ending that may initially appear intact, but is clearly injured when revealed by further dissection. Each case has different management strategies with a common aim of prompt repair of the anatomic disruption to restore proper nerve conduction.
Conclusions: ONI is a preventable complication that requires proper identification of the anatomy and high-risk areas when performing pelvic lymph node dissection. Prompt intraoperative recognition and repair using the management strategies described offer patients the best chance of recovery without sequelae.
Patient summary: We describe the different ways in which the obturator nerve in the pelvic area can be damaged during urological or gynecological surgeries. This is a preventable complication and we describe how it can be avoided and different management options, depending on the type of nerve injury.

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1. Introduction

Obturator nerve injury (ONI) is an uncommon complication of pelvic surgery, usually reported in 0.2–5.7% of cases undergoing surgical treatment of urological and gynecological malignancies involving the pelvic lymph node packet [1]. Despite advances in the surgical approach using robotic platforms, pelvic lymph node dissection (PLND) during robot-assisted laparoscopic prostatectomy (RALP) may be related to ONI in 0.4% of cases [2,3]. The obturator nerve is at risk as it runs posterior to the pelvic lymph node packet and is not properly identified before dissection and excision. In addition, excessive medial traction during dissection could momentarily distort the anatomic location of the nerve, leading to its injury. The proximal section of the obturator nerve is frequently involved (80% of cases) [4,5]. More important is early ONI recognition, as immediate intraoperative repair has excellent prognosis and most patients experience complete recovery at 6 months, which may not be the case if recognition is in the early postoperative period [5–7].

The obturator nerve arises from the L2, L3, and L4 spinal nerves of the lumbar plexus. It carries sensory innervation to the inner thigh and motor innervation to the medial compartment of the thigh, which is responsible for leg adduction [6]. ONI may have a significant impact on the wellbeing of patients, as these muscles are routinely used in many activities of daily life.

A series of scenarios have been collected worldwide on how an ONI may occur during robotic pelvic surgery and what the management strategies are. It is essential to emphasize that proper anatomic knowledge is critical in preventing these injuries. However, when they occur, there are still options to offer patients the best chance of recovery without sequelae.

2. Patients and methods

Robotic surgeons from high-volume centers were asked to contribute video content on intraoperative ONI. Videos were anonymized, centers were deidentified, and the date and time of surgery were removed. Surgeons gave consent for use of their video material in the study and the video accompanying this article. Patients consented to video recording of their surgical procedure for education and publication purposes.

3. Results

3.1. ONIs according to type of injury

ONI can be classified as a crush injury or a transection injury, which can be either partial or complete. The management strategy varies according to the type of injury. The common aim is prompt repair of the anatomic disruption to restore proper nerve conduction.

3.1.1. Crush injury with a clip

The first scenario consists of a patient undergoing RALP with a right distal ONI crush injury caused by a clip placed during right PLND.

A crush injury caused by a clip or Hem-o-lok (Weck Closure Systems, Research Triangle Park, NC, USA) device frequently occurs when the dissection is advanced towards the iliac fossa during PLND. The clip may wrongly be placed in the trajectory of an obturator nerve that has been covered with lymphatic tissue, as demonstrated in Figure 1. These lesions may be evident intraoperatively, as locking of the clip will cause sudden movement of the ipsilateral leg as part of the motor reflex appreciable on the monitor. This motor reflex should immediately prompt further dissection to reveal the entire nerve trajectory and the exact location of the clip. Once an ONI crush injury caused by a clip is identified, management only requires its safe removal, which can be cumbersome if a Hem-o-lok removal tool (McKesson Medical-Surgical Inc.) is unavailable. However, if this is the case, one needle holder can be used to hold the clip firmly near the tip, as this will aid in prying the clip open, and another needle driver can be used to try to open the locking system. A less recommended option is to melt the clip with energy, but this may pose a greater risk of future neural dysfunction. Therefore, this should be left as a last resort and only in experienced hands. To prevent this type of injury, direct visualization of the obturator nerve before placing clips and proceeding with the dissection is recommended. Of note, clips should always be positioned parallel and not perpendicular to the nerve trajectory; this maneuver will lower the chance of causing an obturator nerve crush injury with a clip during PLND.

3.1.2. Transection injury

Transection injuries can be caused by either energy or cold cutting during dissection and excision of the pelvic lymph node packets. As the nerve is being transected, subtle movement of the ipsilateral leg may be appreciable on the monitor and at the bedside. This should immediately prompt a pause in the dissection to avoid going from a partial to a complete transection injury, followed by complete skeletonization of the nerve for injury identification and stratification. However, this may happen very rapidly and is not always apparent. In general, three situations can occur if the nerve is transected: transection with feasible approximation and tension-free nerve anastomosis; transection with challenging approximation that requires certain strategies for proper nerve anastomosis; and transection with a hidden proximal nerve ending that initially may appear intact, but is clearly injured when revealed by further dissection. Each case has different management strategies that we discuss in detail.

3.1.3. Partial or complete transection with feasible approximation

The second scenario consists of a patient undergoing RALP who had complete transection of the left proximal obturator nerve caused by cold scissors during left PLND. Reapproximation was feasible without tension for adequate anastomosis.

Once the injury is suspected, full obturator nerve skeletonization and detailed inspection should be performed to

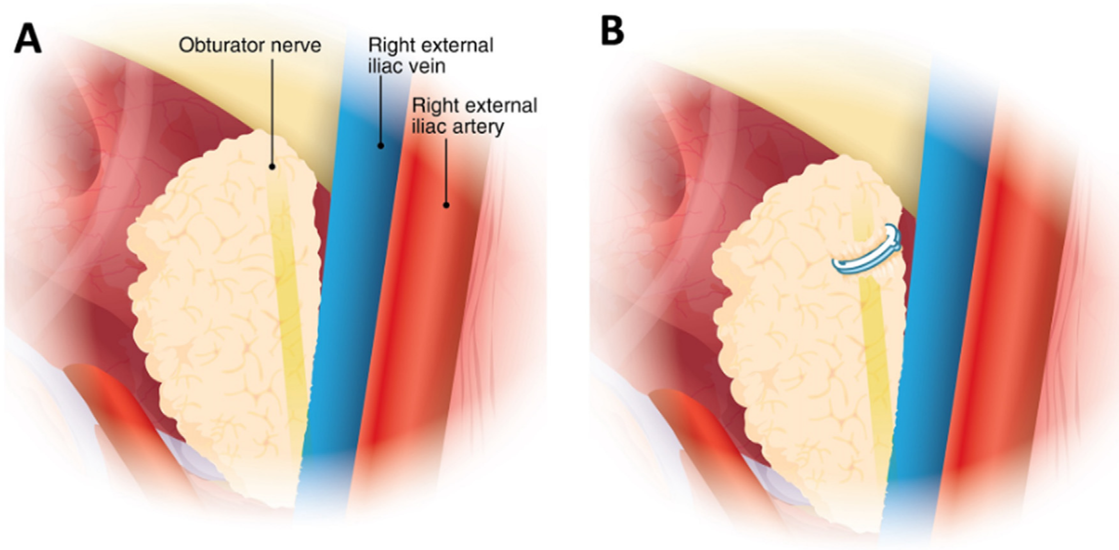

Fig. 1 – Crush injury with a clip. (A) Normal anatomy showing the right external iliac vessels to the right of the obturator nerve and the obturator nerve obscured by and embedded within the pelvic lymph node packets. (B) Obturator nerve crush injury with a clip placed transversely over the pelvic lymph node packets.

assess the injury. If the transection injury is partial, do not separate the remaining attached nerve endings, as this will help during the approximation. To repair the nerve, perform an epineural simple interrupted end-to-end anastomosis with 7-0 polypropylene (Prolene; Ethicon Inc., Cornelia, GA, USA) sutures for the injured border. If the transection is complete, there may still be some attachments to the surrounding tissue, but not to the nerve, that should be released to attempt approximation between the two nerve endings. If tension-free approximation is feasible, perform a simple interrupted epineural end-to-end anastomosis with 7-0 polypropylene (Prolene; Ethicon Inc.) sutures along the periphery of the nerve, as demonstrated in Figure 2.

3.1.4. *Complete transection with challenging approximation*

The third scenario consists of a patient undergoing radical cystectomy with complete transection of the right proximal obturator nerve caused by an EndoWrist (Intuitive Surgical, Sunnyvale, CA, USA) stapler during right lateral dissection of the bladder pedicle. An intraoperative hip flexion maneuver was performed to achieve tension-free approximation for adequate anastomosis.

For repair of a transection injury with challenging approximation of the nerve endings, two management strategies can be attempted in order. First, an intraoperative hip flexion maneuver may release tension in the spinal nerves for easier nerve approximation [7]. The maneuver consists of flexing the legs out of the extended lithotomy Trendelenburg position. This may allow approximation of the two nerve endings for adequate anastomosis, as demonstrated in Figure 3. Of note, if the transection is caused by a stapler, both nerve endings should be trimmed and debrided before simple interrupted epineural end-to-end anastomosis with 7-0 polypropylene (Prolene; Ethicon Inc.) sutures is attempted, as the stapler load may be encrusted within the nerve.

The fourth scenario consists of a patient undergoing radical cystectomy with complete transection of the right distal obturator nerve caused by an EndoWrist (Intuitive Surgical) stapler during right lateral dissection of the bladder pedicle. Despite initial attempts to approximate the two nerve endings, the damage was too extensive for feasible tension-free approximation. A cadaver nerve graft was required.

In some cases, nerve approximation without tension may not be possible despite attempts using an intraoperative hip flexion maneuver. The last option in these cases is to use a cadaver nerve graft to fill the gap between the nerve endings [7]. This graft can be trimmed to the desired length, and two epineural end-to-end anastomoses with 7-0 polypropylene (Prolene; Ethicon Inc.) sutures should be performed, one for the proximal nerve ending and the other for the distal nerve ending.

3.1.5. *Complete transection injury with hidden proximal nerve ending*

The fifth scenario consists of a patient undergoing RALP with complete transection of the right proximal obturator nerve with a hidden proximal nerve ending caused by electrocautery during right PLND.

Once ONI was suspected, initial visualization suggested that the nerve seemed to be intact, with the surrounding tissue attached to the nerve retaining its normal anatomic trajectory. However, further investigation was necessary as a leg movement occurred when advancing the dissection over the pelvic lymph node packets. Medial positioning of the external iliac vessels revealed a longer proximal nerve course, and a complete transection was observed. Repair with simple interrupted epineural end-to-end anastomosis using 7-0 polypropylene (Prolene; Ethicon Inc.) sutures should follow, as demonstrated in Figure 4.

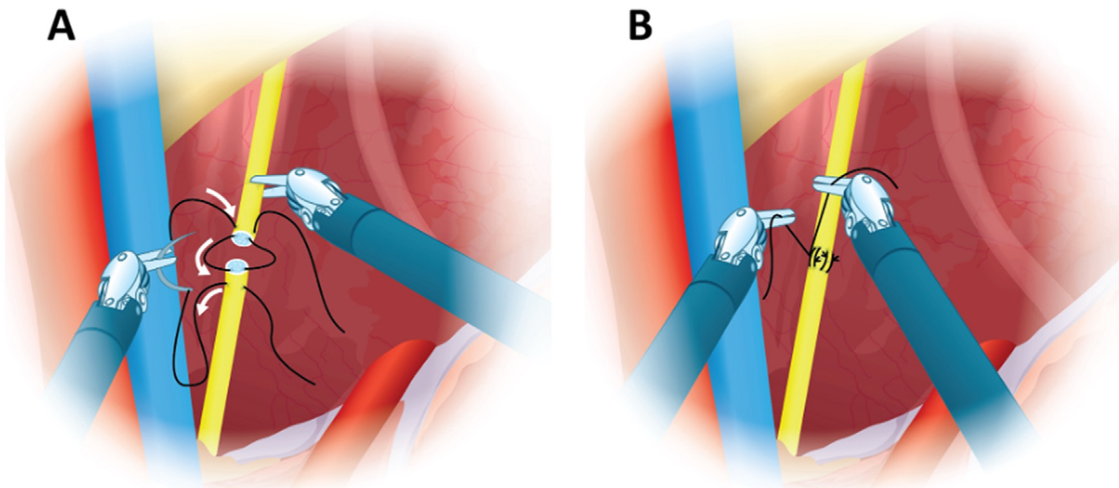

Fig. 2 – Complete transection injury with feasible approximation. (A) Tension-free approximation of the obturator nerve endings is feasible. (B) Simple interrupted epineural end-to-end anastomosis with a 7-0 polypropylene suture.

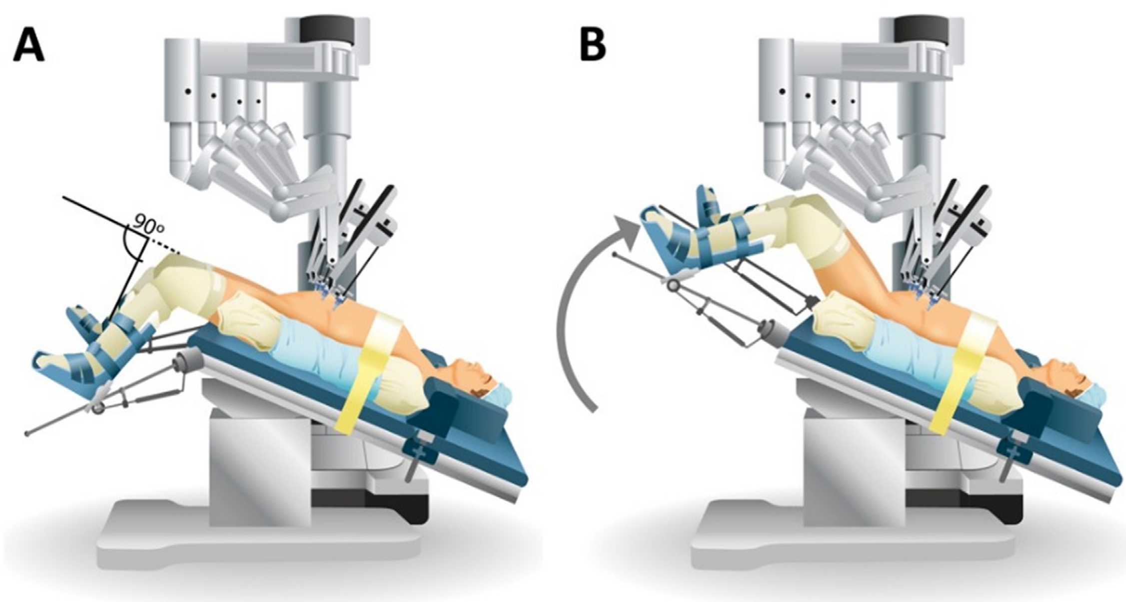

Fig. 3 – Intraoperative hip flexion maneuver. (A) Patient in the extended lithotomy position. (B) Flexing of the legs out of the extended lithotomy position.

ONI scenarios and management strategies are summarized in Figure 5.

3.2. *Neurological history and physical examination*

Patients with ONI may present with sensory and motor-strength abnormalities as the obturator nerve is a mixed nerve that carries a cutaneous branch to the medial thigh and anterior and posterior branches that provide innervation to the adductor muscles of the lower limb: the external obturator, adductor longus, adductor brevis, adductor magnus, and gracilis muscles, as shown in Figure 6. ONI will manifest as lower sensation over the proximal medial aspect of the thigh, weak leg adduction, and/or a decrease in muscle strength ipsilateral to the affected nerve, manifesting as a wide-based gait, weakness when crossing the legs, or difficulties in switching from the gas to the brake pedal when driving; ONI can even affect posture and deambulation. These represent a great spectrum of symptoms that can compromise a patient's quality of life; therefore, prevention, rapid assessment, and correct management are paramount for the patient's overall health [4,8].

4. Discussion

The obturator nerve arises from the anterior portion of the L2–L4 spinal nerves of the lumbar plexus [4,6]. The nerve runs along the iliopectineal line and descends through the psoas major muscle near the pelvic brim. It descends

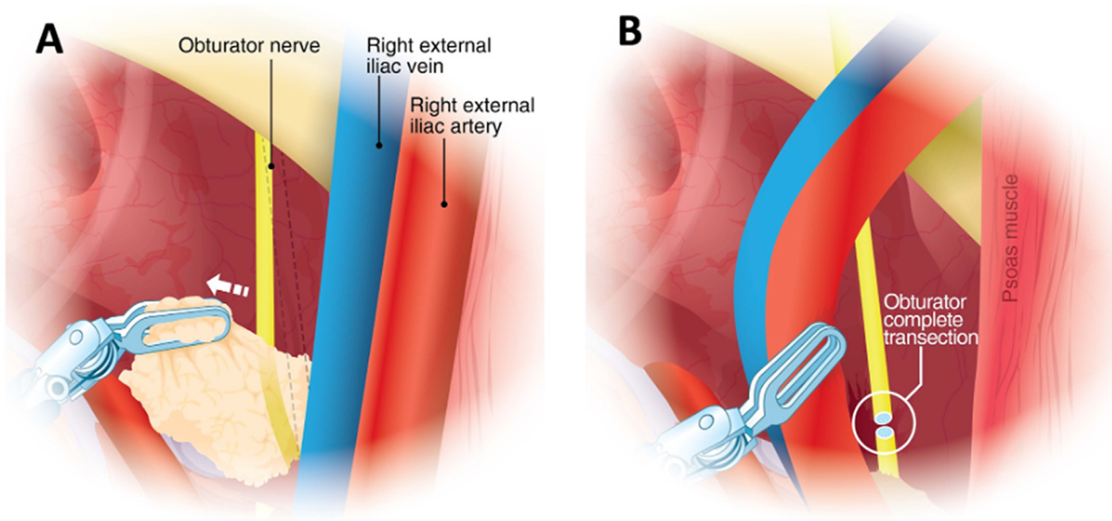

Fig. 4 – Complete transection injury with a hidden proximal nerve ending. (A) Traction in the node packet displaces the normal anatomic position of the obturator nerve, making it prone to injury. (B) Medial positioning of the external iliac vessels reveals complete transection.

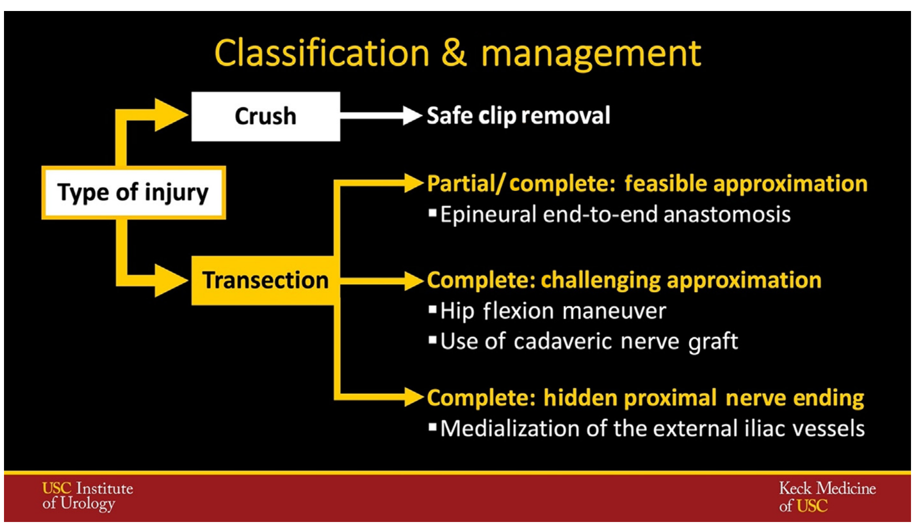

Fig. 5 – Possible obturator nerve injury scenarios and management options.

towards the obturator canal to the lower pelvis. Next, it divides into anterior and posterior branches. The anterior branch runs between the adductor longus and adductor brevis. This branch accounts provides sensory innervation to the skin of the medial aspect of the mid-thigh and hip joint, and motor innervation of the obturator externus muscle, adductor muscles of the lower leg (adductor brevis, adductor longus, adductor magnus), and gracillis muscle (Fig. 6), responsible for leg adduction (ie, crossing the legs, switching from the gas to the brake pedal). The posterior branch travels between the adductor brevis and adductor magnus. Both divisions provide skeletal muscle innervation, but only the anterior division ends as the cutaneous branch of the nerve [6].

ONI is a rare neuropathy that occurs most frequently after gynecological and urological procedures involving the pelvic node packet or after prolonged lithotomy positioning [4,5,7,9–11]. ONI is the direct result of crushing, stretching, partial or complete transection, electrocoagulation, or nerve ligation.

Understanding the mechanism of intraoperative adverse events and injury is key to determining the best approach for prompt management [12–15]. A peripheral nerve injury can be classified as neurapraxia, axonotmesis, or neurotmesis. Neurapraxia is a demyelinating lesion that affects normal conduction of the nerve impulse without any anatomic disruption. It has good prognosis, with full recovery after 6–8 wk. Axonotmesis is a lesion in which the axon is disrupted, but supporting tissue, such as the perineurium and epineurium, is intact. Recovery of this lesion depends on the length that the axon needs to grow to reinnervate the target structure, which can take from 6 months to 1 yr, as the growth rate on a peripheral axon is approximately 1 inch per month. Finally, neurotmesis is complete transec-

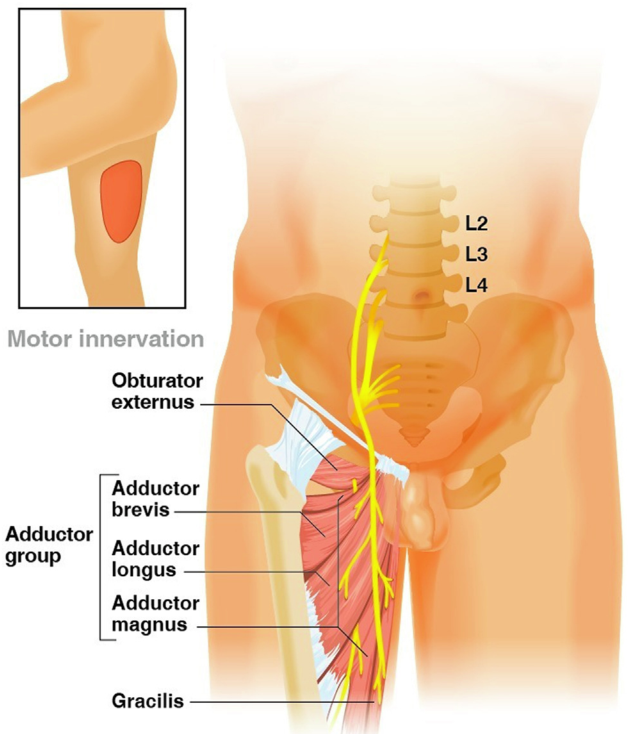

Fig. 6 – Motor and cutaneous innervation of the obturator nerve. (A) Muscles innervated by the obturator nerve. (B) Area of skin innervated by the obturator nerve.

tion of both the axon and the supporting structures. This type of lesion has poor prognosis, but surgical management increases the chance of regaining partial or complete neuronal function [16].

Knowledge and a high degree of awareness of the nerve anatomy and the multiple ways in which the nerve can be injured are crucial in preventing such injuries. Likewise, proper exposure of the nerve and vessels and careful dissection are the primary cornerstones for ONI prevention [3,11]. The obturator nerve should be skeletonized and well identified from its surrounding structures, as it is covered by fatty tissue and lymph nodes [11] (Fig. 7).

The nodal packet should be pulled medially and not anteriorly to visualize the nerve. Hem-o-lok clips (Weck Closure Systems, Research Triangle Park, NC, USA) must be placed parallel to the nerve, not perpendicular to it, and only after complete visualization [3] (Fig. 7). We recommend the use of Hem-o-lok (Weck Closure Systems) rather than titanium clips, which are wider and challenging to remove, causing more injury in cases in which the nerve becomes entrapped. In addition, use of a harmonic scalpel has been described as a safe option for removing a clip, decreasing the risk of further damage to the tissue that is being crushed [17].

Electrocautery must be used carefully and focally rather than grabbing tissue blindly in the location where a bleeding vessel is suspected [3]. Bipolar cautery is preferred, as it prevents the electrofulguration seen with monopolar energy [5]. Monopolar scissors are widely used in robotic surgery. Therefore, special care is required when dissecting near the obturator nerve. ONI does not appear to be associated with any particular instrument [7]. Bedside surgeons should be also aware of the possibility of such injuries, so any repair can be performed immediately once an injury is recognized. This will promote the neurological healing process, with excellent results [11].

Another critical parameter for successful management of ONI is time. An immediate nerve repair allows for prompt nerve regeneration, decreasing the possibility and degree of subsequent permanent sequelae. Nerve degeneration follows a sequence of events both proximal to and distal from the trauma zone that can lead to a point at which no nerve regeneration is feasible [18]. There is no recommended follow-up or safe period for delay of repair, as regeneration can vary on an individual basis [8]. Intraoperative repair of ONI has an excellent prognosis. Most cases experience complete recovery up to 6 mo postoperatively [1,5,9].

Another important factor in ONI repair is a tension-free end-to-end re-anastomosis. If this not possible, a nerve graft interposition (autograft, allograft, or artificial graft) is an attractive alternative for restoration of function (fourth scenario). Common donor nerves for graft interposition include the sural, lateral femoral cutaneous, and superficial radial sensory nerves [8]. Previous studies have reported successful ONI reconstruction using a sural nerve graft and an artificial nerve conduit [19–22]. A recent systematic review reported that 86% of patients who underwent nerve grafting for ONI achieved a full recovery over follow-up of up to 6 mo [8].

In all the ONI scenarios presented in this study, urologists performed the nerve repair. Therefore, urologists could be considered as an option in addition to other specialties when encountering ONI. However, surgeons must consider consulting a neurosurgeon or another specialist in peripheral nerve repair to assess the injury and decide on an appropriate course of treatment [8].

Determining prognosis is challenging, as the degree of the lesion is influenced by multiple factors, including the type of injury, its mechanism, location, and extent, and how it was managed. Electrophysiology studies can be used to assess the severity of the lesion and better predict its progression to guide the physician on the best next steps to follow after surgery [23].

During the early postoperative course, management after nerve injury is based on pain control and rehabilitation to stimulate the healing process and regain control of the muscle groups innervated by the affected nerve. However, there is no consensus regarding the duration of any physiotherapy [1]. Rehabilitation also targets complementary muscle groups to stabilize posture and allow safe ambulation. If not possible, correct use of walking aids may be required to maintain daily activities of living [16].

Electrical nerve stimulation is currently being investigated in preclinical studies, and a few clinical studies have shown promising results as a combined therapy for the management of peripheral nerve injury. It has been demonstrated that early electrical nerve stimulation after an injury enhances nerve regeneration by promoting nerve survival and sprout formation [24]. There have also been several efforts to develop new imaging techniques capable of iden-

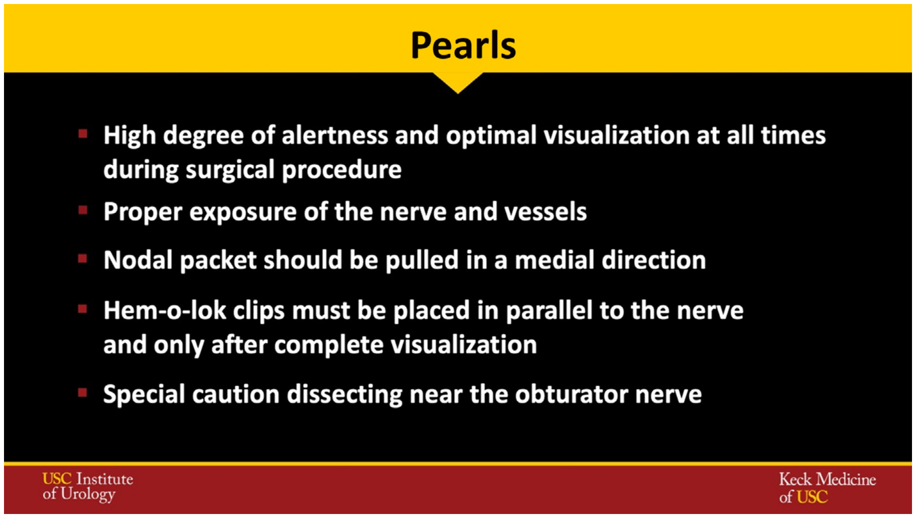

Fig. 7 – Pearls: tips and tricks to avoid obturator nerve injury.

tifying and clearly displaying peripheral nerves in real time during surgery [25], which could be promising for the training of new robotic surgeons. Nevertheless, further investigation is required to establish a consensus for its safe and optimal application [24].

5. Conclusions

ONI is a preventable complication that requires proper identification of the anatomy and high-risk areas when performing PLND for the treatment of urological and gynecological malignancies. An abnormal leg movement when dissecting the pelvic lymph node packets raises a high index of suspicion. Prompt intraoperative recognition and repair using the management strategies described offer patients the best chance of recovery without sequelae.

Author contributions: Rene Sotelo had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: La Riva, Sayegh, Perez, Medina, Adamic, Gill, Sotelo.
Acquisition of data: Poncel, Medina, Adamic, Powers.
Analysis and interpretation of data: La Riva, Sayegh, Perez, Poncel, Medina, Adamic, Cacciamani, Gill, Sotelo.
Drafting of the manuscript: La Riva, Sayegh, Perez, Poncel, Medina, Adamic, Cacciamani, Gill, Sotelo.
Critical revision of the manuscript for important intellectual content: Cacciamani, Aron, Gill, Sotelo.
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Peer Review Summary and supplementary data

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