Etiology and Management of Hernia-Related Chronic Pain: Implications of Robotics

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6.1 Background

Many techniques using open, laparoscopic, robotic, and hybrid procedures exist in the treatment of hernia with a broad variety of disease requiring many different options to address hernia type, location, patient factors, available tools, and technical expertise. The adoption of the routine use of mesh in ventral and inguinal hernia repair has improved recurrence rates. This is especially true for inguinal hernias, since tension-free, mesh-based repair has become the standard of care. High level evidence in ventral hernias supports the use of prosthetic reinforcement with significant reduction in recurrence rates [1, 2]. Postherniorrhaphy chronic pain, however, remains a prevalent complication representing a substantial burden of morbidity for patients after both ventral and inguinal hernia repair. Exact rates of postherniorrhaphy chronic pain depend on the definition used, but generally range widely in the literature from 0% to upwards of 60% [3, 4]. The Swedish Hernia Registry reports that severe or debilitating postherniorrhaphy chronic pain after inguinal hernia repair occurs at a rate of between 5% and 7% [5].

Development of postherniorrhaphy chronic pain may develop regardless of the repair technique [6–8], and as such must remain a consideration for any surgeon performing robotic-assisted ventral or inguinal hernia repair. A thorough understanding of the causes of pain, groin and abdominal wall neuroanatomy, and technical aspects of the initial operation are necessary to successfully manage this complication [8–10]. These factors determine the medical and operative interventions available to address chronic pain after hernia repair. In addition to the implications of robotic repairs on the development of chronic pain and hernia repair, the technical

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advantages of robotic assisted surgery including superior optics, range of motion, precision, and dexterity also play a role in the surgical treatment of this challenging problem. Effective management is crucial given the personal and societal consequences of postherniorrhaphy chronic pain on quality of life, disability, and healthcare utilization.

6.2 Pain Classification

Postherniorrhaphy pain may be divided into two broad categories: nociceptive pain and neuropathic pain. Nociceptive pain is the result of direct injury to tissue and the subsequent local inflammatory processes. Endogenous nociceptive molecules mediate the production of this pain by acting on nociceptors. Neuropathic pain, in contrast, results from nerve injury. After hernia repair, neuropathic pain symptoms may include pain with radiation (especially inguinodynia radiating to the scrotum or femoral triangle, in the case of inguinal hernia repair), hyperalgesia, hyperesthesia, hypoesthesia, paresthesia, allodynia, or hyperpathia. A positive Tinel sign may be present. Nerves may be injured by indirect or direct structural damage during the operation, or by entrapment by suture, contact with mesh (Fig. 6.1), folded mesh (Fig. 6.2), meshoma, or fixating devices. In the postherniorrhaphy patient, nociceptive and neuropathic pain exist on a spectrum with significant overlap between the categories. Somatic and visceral etiologies of pain including soft tissue and bony injury and inflammation as well as adhesions and obstruction add to the complexity of presentation, As is common in establishing the cause of any chronic pain, the diagnosis of postherniorrhaphy chronic pain is confounded by individual, social, genetic, and psychological factors.

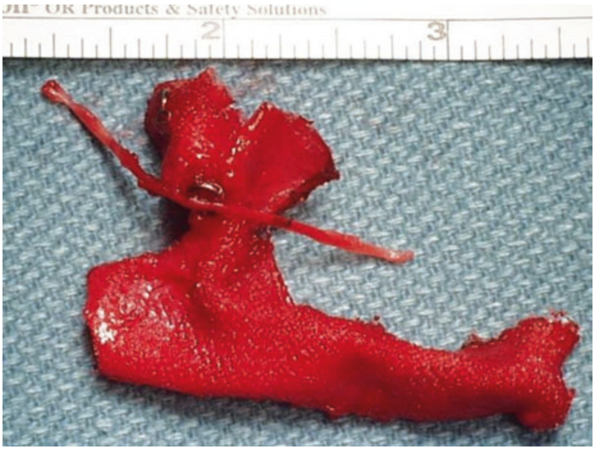

Fig. 6.1 Neuropathic pain is frequently related to nerve entrapment by suture, fixation devices, or mesh, as seen in this explanted mesh with associated injured nerve resected en bloc

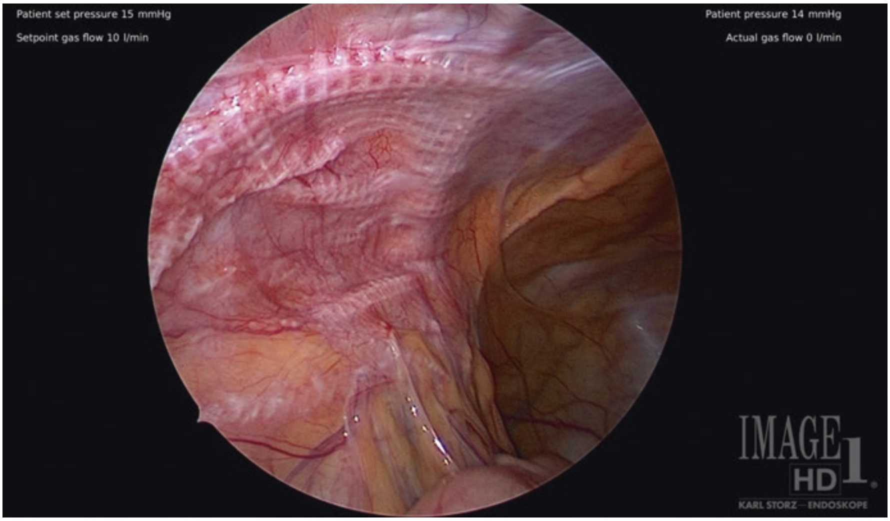

Fig. 6.2 Folded mesh (shown here), mesh migration, and meshoma may contribute to development of chronic pain.

6.3 Anatomic Considerations

Understanding the neuroanatomy of the abdominal wall and groin is crucial to preventing chronic pain, and to understanding the likely cause in the patient suffering from this complication. The anterior abdominal wall is innervated by the nerve roots from T7 at the subxiphoid position through L1 at the groin. These nerve branches travel from spinal cord to anterior midline, traveling initially along the inferior costal surface (for T7–T12), then traversing between muscle layers of the abdominal wall and giving off perforating superficial branches along the course of the nerve. Postherniorrhaphy neuropathic chronic pain in the abdominal wall above the groin is frequently caused by nerve entrapment or injury by suture, fixation devices, or by the mesh itself. While the nerves can be injured anywhere along their variable and redundant course, the proximal retroperitoneal trunks are most susceptible in flank hernia repairs while the coalescence of the perforating nerves at the semilunar line are at risk in ventral repairs. While the precision of robotic suturing may decrease the traditional risks associated with transfascial sutures and penetrating fixation with tacks or staples during intraperitoneal onlay mesh (IPOM) repair, robotic-assisted repair of ventral and flank hernias may risk nerve entrapment through other mechanisms. Robotic-assisted surgery facilitates visualization and placement of sutures with primary closure of ventral and flank defects. The use of suture through the abdominal wall especially in off-midline and flank hernias may predispose to pain related to nerve entrapment, though this is not currently well studied. During robotic-assisted ventral hernia repair, risk of nerve injury or entrapment may be minimized through careful suture placement, avoiding excessively deep suture bites, and sparing use of fixation devices, especially in the lateral areas of the abdominal wall and flank where the nerves course between the deeper muscle layers.

The neuroanatomy relevant to inguinal hernia repair extends from the retroperitoneal lumbar plexus to the terminal branches exiting through the inguinal canal. The anatomy of these nerves and nerve plexuses is complex and highly variable [11, 12]. However, meticulous identification of the relevant nerves and preventing their injury or direct contact with mesh has been demonstrated to reduce rates of post-operative chronic pain to less than 1% after open repair [7]. The three nerves most commonly contributing to chronic postherniorrhaphy inguinal pain (CPIP) are the ilioinguinal nerve, the genital branch of the genitofemoral nerve, and the iliohypogastric nerve.

The ilioinguinal nerve (IIN) originates from the L1 nerve root traversing anterior to the quadratus muscle before exiting through the transversus abdominis muscle above the level of the iliac crest. It then travels between the transversus abdominis and internal oblique muscles until it enters into the inguinal canal medial to the anterior superior iliac spine. The IIN then courses over the anterior surface of the spermatic cord, covered by the investing fascia of the internal oblique muscle. Care should be taken not to disrupt this protective fascia during open inguinal hernia repair. The iliohypogastric nerve (IHN) also originates from the L1 nerve root cephalad to the ilioinguinal nerve traversing anterior to the quadratus muscle before exiting through the transversus abdominis muscle above the level of the iliac crest. It then travels between the transversus abdominis and internal oblique muscles until it enters into the inguinal canal typically cephalad and medial to the ilioinguinal nerve. The IHN then travels between the internal and external oblique muscle layers in the medial inguinal canal exiting at the conjoined tendon. The investing fascia of the internal oblique protects the nerve from contacting an anteriorly placed mesh. Neither ilioinguinal nor iliohypogastric nerves are commonly visualized during robotic-assisted or laparoscopic inguinal hernia repair. The distal retroperitoneal course of the IIN and IHN above the iliac crest may be occasionally visualized with wide lateral dissection during an extended view total extraperitoneal (eTEP) inguinal approach or with lateral flank repairs. An understanding of their course is critical though, and care should be taken to avoid passing suture or fixation material through the anticipated course of these nerves, risking injury or entrapment of the underlying nerve.

The genitofemoral nerve typically originates from the L1 nerve root continuing its retroperitoneal course over the psoas muscle. In the preperitoneal space, the genital branch continues inferiorly and anteriorly to enter the deep inguinal ring, traversing the inguinal canal within the spermatic cord. While identification in the inguinal canal is difficult due to its diminutive size and location within the cremasteric sheath, the genital and femoral branches may be encountered with dissection lateral to the spermatic vessels. In the case of robotic-assisted or laparoscopic pre-peritoneal repair, one must additionally consider that the main trunk or femoral branch of the genitofemoral nerve, the anterior or lateral femoral cutaneous nerve, or even the femoral nerve may contribute to the development of chronic pain. During a pre-peritoneal repair, these structures typically lie within a predictable area in the surgical field, termed the "triangle of pain." The boundaries of this triangle are the iliopubic tract, the gonadal vessels, and the reflected border of peritoneum. After reflection of the peritoneum away from this area of the abdominal wall, dissection in this region should be minimized to avoid disrupting the transversalis fascia and connective tissue layer protecting these nerves from the overlying mesh. Suture and fixation material should be avoided in this area, as placement carries risk of nerve injury and resulting chronic pain. Avoidance of fixation or use of glue or self-gripping mesh in preperitoneal inguinal hernia repair is recommended to minimize the risk of developing chronic post-operative inguinal pain. Specific to robotic inguinal hernia repair is the recommendation to avoid direct suture closure of the direct and indirect hernia defect. This technique was abandoned from laparoscopic hernia surgery as it increased the risk of pain without benefit with regards to recurrence. While robotic suturing simplifies this task, it risks entrapment of the iliohypogastric nerve along the inguinal floor with direct defects. Damage to the spermatic cord, genital nerve, and ilioinguinal nerve from entrapment has also been seen from suturing. Alternative strategies such as imbrication of the transversalis fascia or suturing this to Cooper's ligament may obliterate the dead space without risking nerve entrapment.

6.4 Conservative Management of Neuropathic Pain

Most pain that develops after hernia repair is self-limited, though it may take upwards of a year to resolve. For this reason, pain is managed expectantly during this time period. Pharmacologic therapies including NSAIDs and agents for neuropathic pain, such as gabapentin and pregabalin, may be beneficial. Chronic use of narcotics should be avoided. Behavioral therapies including physical therapy, stretching, icing, and avoidance of exacerbating activities and positions should be encouraged. If pain persists for greater than 3 months, it is reasonable to consider procedural intervention. For pain that seems localized to one or more individual nerve distributions, nerve blocks using local anesthetic or steroids are a typical first step to establishing that pain is neuropathic in nature and related to injury or irritation of a particular nerve or nerves. If transient relief is gained from nerve block but symptoms remain severe, nerve ablation may be pursued for a more durable effect, or the patient may proceed to operative intervention. It is preferred that any nerve blocks and/or ablations should be performed by specialists with experience in management of neuropathic pain.

6.5 Surgical Management of Neuropathic Pain

Appropriate and effective management of postherniorrhaphy chronic pain requires a thoughtful and systematic approach. Proper identification of patients suited for operative intervention is imperative. Surgical intervention for chronic pain unresponsive to standard nonsurgical modalities should not be considered until 3 months (6 months with mesh based repairs) after the original hernia repair [3, 7]. Furthermore, surgery is not appropriate nor beneficial for all patients who fail conservative measures, and should only be sought for those patients determined to have discrete, neuroanatomic problems amenable to surgical correction. The patients most likely to benefit from operative neurectomy are those with neuropathic pain isolated to a defined distribution that was not present prior to the original operation, and that showed improvement with diagnostic and therapeutic nerve blocks. Identification of good operative candidates requires a comprehensive history characterizing symptoms, physical examination including dermatomal mapping/distribution and sensory testing, review of the prior operative report (with specific attention to the type of repair, mesh used, position of the mesh, fixation method, and nerve handling), imaging evidence of meshoma or other anatomic abnormalities, and effects of prior treatments [7, 13].

6.6 Risks of Surgery

Operative remediation of post herniorrhaphy chronic pain carries risk of complications including persistence or exacerbation of underlying pain, deafferentation hypersensitivity, abdominal wall laxity due to partial muscle denervation, and anticipated permanent numbness in the affected regions. For female patients undergoing inguinal neurectomy, the region of anticipated numbness includes the ipsilateral labia, which may contribute to sexual dysfunction. Reoperation in a field containing scar tissue carries risks of bleeding, vascular injury, disruption of the original hernia repair, hernia recurrence, vascular injury, and testicular loss. These risks should be disclosed to the patient and this discussion documented prior to the operation.

6.7 Chronic Pain After Ventral Hernia Repair

Chronic pain after ventral hernia repair is multifactorial and challenging to treat as many overlapping etiologies may exist and further intervention may not alleviate the subjective pain. Recurrence, infection, chronic inflammation, scarring and contraction, nerve entrapment, meshoma, and adhesions may all contribute to these symptoms. Neuropathic pain is typically related to nerve entrapment at site of defect closure or in the area of mesh placement. Surgical management of neuropathic pain related to ventral hernia repair has not been studied as extensively as it has in inguinal hernia repair. Unlike in inguinal hernia repair, neurectomy is not routinely performed nor recommended for chronic pain after ventral hernia repair due to the inaccessibility of the thoracic nerve roots and the unpredictable, overlapping, and redundant course of the peripheral branches. As suture and fixation devices are commonly implicated as the cause of nerve entrapment, surgical management of this pain is focused on removal of the offending suture or fixation material. While removing entrapping sutures or fixating devices may be effective, it is theorized to carry risk of persistent pain attributable to the injured nerves which are left in place [7]. Mesh-related pain caused by contraction, folding, disruption, extrusion, migration, adhesions, fistulization, hernia recurrence, and infection may lead to nociceptive pain and foreign body sensation. Use of robotic-assistance may facilitate removal of intraperitoneal or pre-peritoneal suture, fixation material, or mesh. Distribution and foci of pain should be carefully identified pre-operatively and marked in such a way that the site on the abdominal wall can be identified and confirmed intra-operatively, both internally and externally. As there is significant overlap of innervation throughout the abdominal wall sensory nerves, an attempt should be made to remove all foreign material in the area of pain in order to maximize expected relief of symptoms. In many instances, this may require completely dismantling a prior repair and performing a new repair of the hernia. This should be done again with careful attention to placement of suture and fixation material. Operative consideration for remedial surgery for ventral hernia-related pain has no specific operative algorithm and the decision to pursue intervention should be shared with the patient to establish realistic expectations. Optimally, a discrete pathology, anatomic target, and remediable problem should be present to maximize the likelihood of success. An experienced hernia specialist should consider reliable patients with severe pain that originated after surgical intervention with a reasonable mechanism of pain for operative intervention.

6.8 Chronic Pain After Inguinal Hernia Repair

For patients with neuropathic pain resulting from inguinal hernia repair that is refractory to conservative measures, neurectomy of the ilioinguinal nerve, iliohypogastric nerve, and/or genital branch of the genitofemoral nerve is a universally accepted treatment option. For patients with pain in the overlapping distribution of these three nerves in the lower groin, triple neurectomy remains the most definitive approach. This operation was pioneered in our institute in 1995, and currently remains arguably the most effective therapy available [7, 14]. Alternative but less effective options include removal of mesh and fixation material with or without revision of the prior repair, and selective neurolysis or neurectomy without triple neurectomy [7, 15–17]. The normal appearing nerves in place during single or double neurectomy often contain ultrastructural changes or microscopic neuromas, which may cause pain without overt changes to the appearance of the nerve. Furthermore, the anatomic variation and overlapping distributions of innervation of the nerves in the groin make selective neurectomy less reliable [7]. Finally, further remedial surgery following selective neurectomy increases the technical challenge increasing the risk of morbidity and decreasing the likelihood of successful intervention.

Operative triple neurectomy in conjunction with removal of meshoma, when present, is a safe, effective, and well tolerated therapy for well selected patients with refractory neuropathic inguinodynia [7]. At the Lichtenstein Amid Hernia Clinic, our experience includes over 800 patients using an open approach with a success rate of over 85%, and 100 patients using a laparoscopic retroperitoneal approach with a 90% success rate. Our current management strategy involves a tailored approach with open, laparoscopic, and hybrid techniques to address the anterior and posterior inguinal canal with tailored neurectomy, mesh removal, and subsequent hernia repair based on mechanism, anatomy, symptoms, and technical feasibility.

6.9 Technique: Neurectomy After Robotic-Assisted Preperitoneal Inguinal Hernia Repair

If no penetrating fixation was used in the original preperitoneal repair and dermatomal mapping demonstrates involvement of the genitofemoral or lateral femoral cutaneous distribution, neurectomy may be performed in the preperitoneal space or retroperitoneum via a laparoscopic approach avoiding the anterior canal and inguinal nerves. If all the ilioinguinal and iliohypogastric nerves are also involved by mechanism and dermatomal distribution, a triple neurectomy is more likely to successfully address this pain. Standard triple neurectomy after open inguinal hernia repair involves resecting segments of the ilioinguinal nerve, the iliohypogastric nerve, and the genital branch of the genitofemoral nerve. However, inguinal hernia repairs performed via a posterior approach (including robotic-assisted repairs) are most often associated with in neuropathic pain originating from the main trunk, femoral branch, and preperitoneal segment of the genital branch of the genitofemoral nerve. Neuropathic injuries of these nerves can be addressed by open extended triple neurectomy, which includes segmental resection of the main genitofemoral trunk in the retroperitoneum, or by robotic/laparoscopic preperitoneal or retroperitoneal neurectomy [18]. If all three nerves are implicated by dermatomal mapping, an open extended triple neurectomy, robotic/laparoscopic retroperitoneal triple neurectomy, or hybrid open ilioinguinal and iliohypogastric and laparoscopic preperitoneal genitofemoral neurectomy may be performed.

6.10 Open Extended Triple Neurectomy

Open Extended triple neurectomy is approached through the same incision in the case of a prior open repair, or through a standard inguinal incision in the case of a prior laparoscopic or robotic-assisted repair. The incision may be extended cephalad and lateral to facilitate exposure of the proximal portions of the ilioinguinal and iliohypogastric nerves. All nerves are resected as proximally as possible. It is our standard practice to ligate the proximal nerve stumps and place them into surrounding muscle, as intramuscular reimplantation is theorized to protect the nerve from post-operative inflammation and scarring.

The ilioinguinal nerve can be identified lateral to the deep inguinal ring and should be divided as proximally as the exposure will allow. The iliohypogastric nerve can be identified in the plane between the aponeuroses of the internal and external oblique. It should be traced proximally to the segment of the nerve that runs within the internal oblique muscle, and divided in this intramuscular segment, at a point outside the field of the original hernia repair and proximal to injury and scarring. Failure to resect the intramuscular segment may result in persistent pain due to an occult injury in this segment. Rarely, the iliohypogastric nerve runs deep to the internal oblique aponeurosis and traverses both internal and external oblique aponeuroses at a single point. If this is the case, the internal oblique aponeurosis should be split to allow division of the subaponeurotic nerve proximal to this point. Attention should be paid to any mesh or fixation material along the course of these nerves, and the nerves should be divided proximal to any such material. In respect to anterior inguinal nerve injury from a posterior preperitoneal repair, the potential sites of injury include the direct and indirect spaces from entrapment or penetrating fixation. Anterior neurectomy should be directed as proximal in the canal near the anterior superior iliac spine as possible as a posterior injury may not be as readily apparent.

The trunk of the genitofemoral nerve is exposed utilizing the same split made previously in the internal oblique muscle during resection of the iliohypogastric nerve. Extending this split exposes transversus abdominis muscle, which is similarly bluntly split along its fibers. The underlying parietal peritoneum is mobilized cephalad and medially to access the psoas muscle and main trunk of the genitofemoral nerve. Resection at this level addresses any neuropathic pain originating from the main trunk, femoral branch, or preperitoneal segment of the genital branch. Access for open extended triple neurectomy remains a challenge with preperitoneal mesh based repairs as the mesh will typically cover the entire myopectineal orifice. The genital nerve however, may still be identified as it travels between the mesh and parietal surface of the preperitoneal space.

6.11 Laparoscopic Retroperitoneal Triple Neurectomy

Laparoscopic retroperitoneal triple neurectomy involves accessing and resecting the main trunks of the ilioinguinal, iliohypogastric and genitofemoral nerves within the lumbar plexus [19]. Dividing the nerves at this site guarantees a resection proximal to the surgical field of the original hernia repair, and any associated cause of neuropathic pain. With the patient positioned in lateral decubitus position, the operating table is flexed to maximize the ipsilateral space between the costal margin and iliac crest. Initial access is achieved via a 12 mm transverse incision 4 cm above the iliac crest, in the midaxillary line. Access to the retroperitoneum is achieved by incision of the external oblique fascia and bluntly splitting the oblique muscles along their fibers. This potential space is expanded using an oval dissecting balloon placed through the incision and inflated under direct vision. After dissection, the cavity is insufflated to a pressure of 15 mm Hg. The operation typically only requires placement of one additional 5 mm port, placed 2 cm medial to the initial access port.

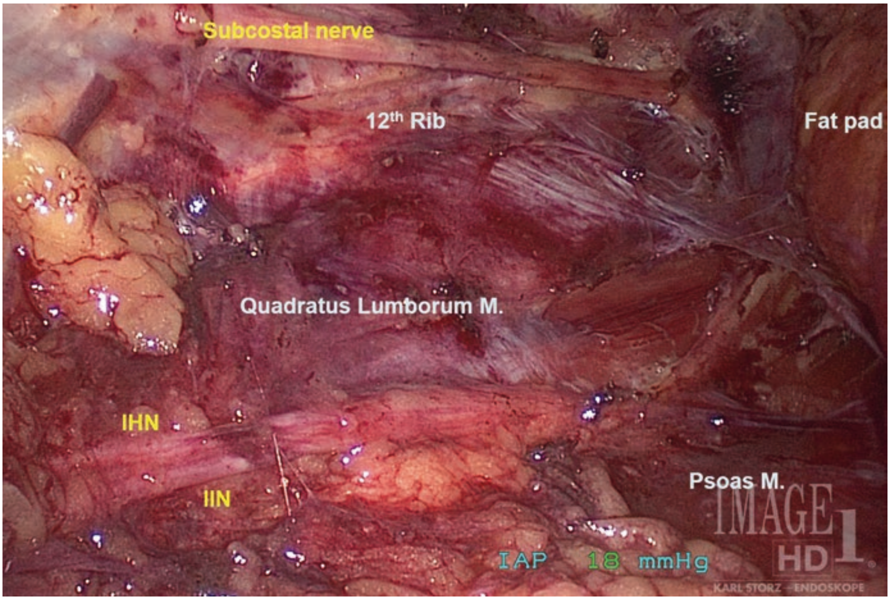

Fig. 6.3 Intraoperative identification of retroperitoneal nerve anatomy (cephalad view). Subcostal nerve at top easily identified by the 12th rib. Iliohypogastric nerve (IHN) and ilioinguinal nerve (IIN) shown here arising from a common trunk over quadratus and exiting behind psoas at L1. Retroperitoneal fat pad rotated over psoas medially

Medial dissection of the retroperitoneal fat pad provides exposure of the psoas and quadratus lumborum muscles. The iliohypogastric and ilioinguinal nerves can be identified overlying the quadratus muscle at L1 (Fig. 6.3). These nerves frequently share a common trunk.[11, 12] In order to aid identification of these nerves at L1, the T12 subcostal nerve may be identified at the T12 costal margin. Dissection is continued inferiorly to identify the genitofemoral nerve trunk running over the body of the psoas muscle (Fig. 6.4). This nerve may be a common trunk at this level, or may have already split into separate genital and femoral branches. The lateral femoral cutaneous nerve may be seen as it traverses over the iliacus muscle lateral to the psoas, below the iliac crest and may be addressed at this location if injured. The anatomy of the lumbar plexus and related structures should be clearly delineated prior to division of any nerve. The structures medial to the psoas include the ureter and iliac vessels, and should be identified and protected. Once the anatomy has been defined, the iliohypogastric and ilioinguinal nerves should be resected over the quadratus lumborum. The main trunk of the genitofemoral nerve should be resected over the psoas muscle. In rare cases of femoral nerve injury with motor deficits, removal of all offending foreign mesh, fixation material, sutures, and tacks should be performed lateral to the psoas overlying the femoral nerve ensuring that the nerve itself is preserved and the injury is not exacerbated. The primary limitation of retroperitoneal neurectomy is the wider distribution of numbness and the loss of motor innervation to the lower oblique muscles leading to bulging. While

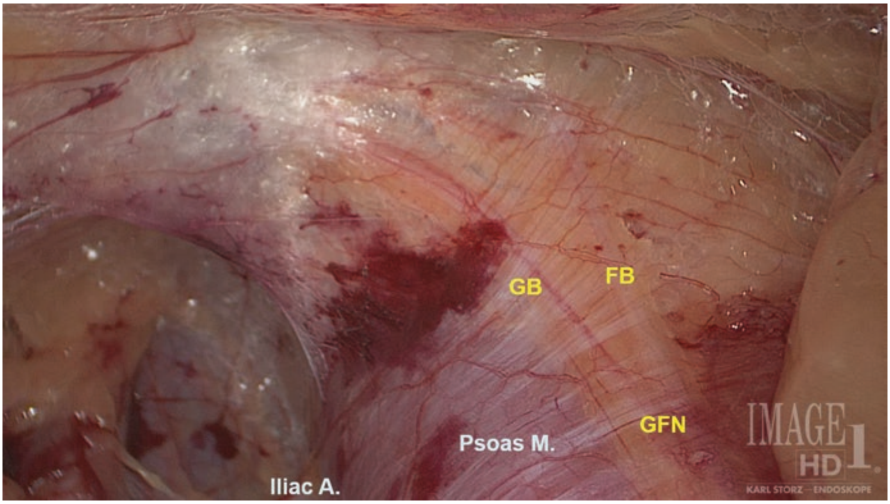

Fig. 6.4 Shown here on the patient's right side, the genitofemoral nerve (GFN) can be found in the retroperitoneum running along the psoas muscle. It splits into the genital branch (GB) and femoral branch (FB)

this has not been a significant consideration for patients in excruciating neuropathic pain, the proximal resection of the iliohypogastric and ilioinguinal nerves clearly carries more incidental morbidity and is used sparingly as needed in our experience.

For isolated genitofemoral or lateral femoral cutaneous nerve injuries, remedial surgery can be performed using a standard laparoscopic or robotic preperitoneal transabdominal (TAPP), total extraperitoneal (TEP), or extended view total extraperitoneal (eTEP) approach. These nerves may be traced cephalad and lateral to the prior repair and the likely mechanism of injury examined. Fixation material including tacks and sutures should be removed, mesh may be released or removed as indicated, and neurectomy or neurolysis may be performed depending on preoperative symptoms and intraoperative findings. This approach to the GFN and LFC nerve may be combined as a hybrid approach with an open ilioinguinal and iliohypogastric neurectomy avoiding the motor denervation and wide distribution of numbness experienced with retroperitoneal neurectomy.

6.12 Chronic Orchialgia

Orchialgia may result from open or laparoscopic inguinal hernia repair, and may be difficult to distinguish from the scrotal pain often associated with neuropathic genital inguinodynia. True orchialgia will not respond to triple neurectomy alone. Postherniorrhaphy orchialgia is thought result from injury to the paravasal and autonomic nerve fibers that accompany the cord structures. The paravasal nerves are found in the lamina propria of the vas deferens, and segmental resection of this structure has been shown to be of benefit in treating this symptom [18]. However, it

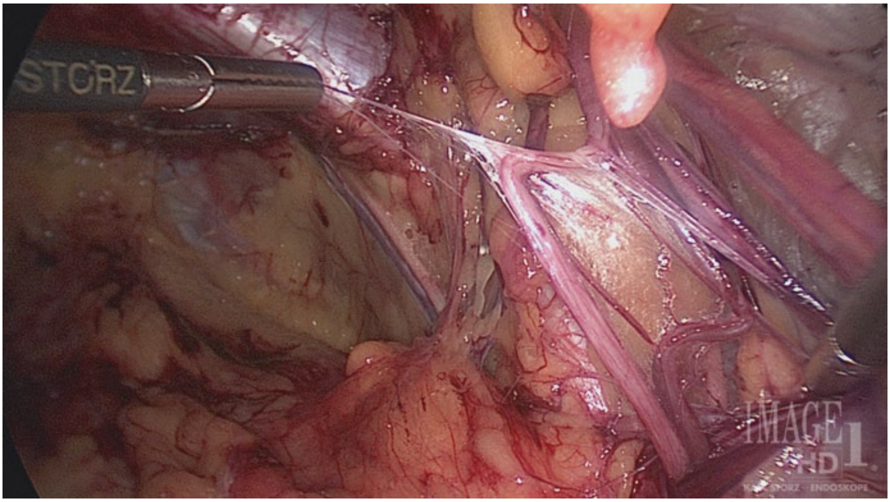

Fig. 6.5 Proximal vas deferens neurolysis

should be noted that orchialgia caused by preperitoneal mesh repair such as robotic-assisted repair is unlikely to respond to open vas neurolysis, as the affected area is commonly too proximal to be accessed via an open approach. For these patients, the autonomic nerve plexus may be accessed proximal to the mesh either laparoscopically or with robotic-assistance (Fig. 6.5).

6.13 Robotic-Assisted Surgery for Chronic Pain

There has been little study of the use of robotic-assistance for remedial surgery in cases of postherniorrhaphy chronic pain. At our institution, we have found the robot to be most useful in cases of difficult reoperative fields after posterior hernia repairs, especially in patients in whom folded mesh or meshoma seems to be the primary inciting factor causing pain. The robotic approach offers excellent visualization of the posterior groin and facilitates precise dissection of mesh that could be challenging or impossible laparoscopically (Fig. 6.6). The additional angles of traction and dissection that are possible allow the surgeon to limit the use of energy devices and associated thermal spread. Finally, use of the robot allows for suture repair of any vascular structures if necessary (Fig. 6.7). This operation may be approached with similar positioning and port placement to a robotic assisted transabdominal preperitoneal repair. The peritoneal flap is created in similar fashion and the mesh dissected from surrounding tissue. The peritoneal flap dissection may need to be widened to allow closure if any peritoneum is removed with the mesh. This approach allows for access to the genital branch of the genitofemoral nerve, and allows for paravasal neurolysis in cases of orchialgia. It does not offer easy access to the iliohypogastric

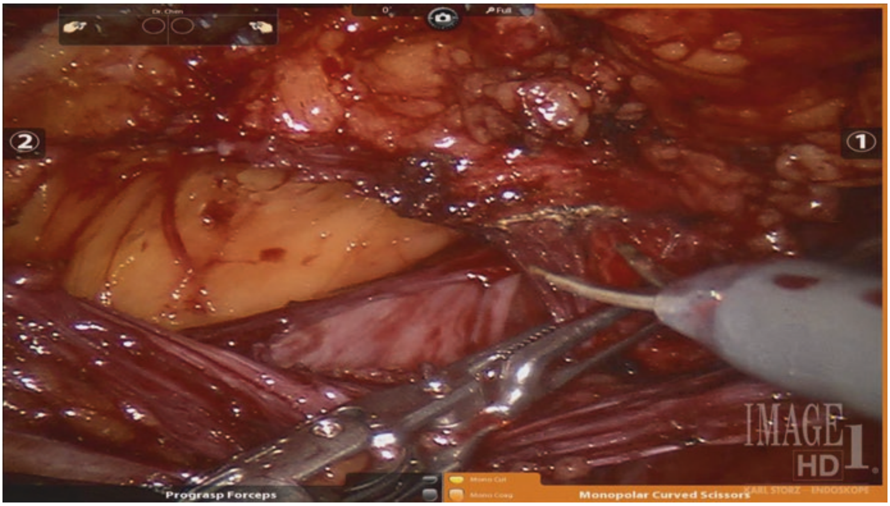

Fig. 6.6 Robotic-assisted removal of preperitoneal mesh. The robot facilitates precise dissection of the mesh from surrounding tissues

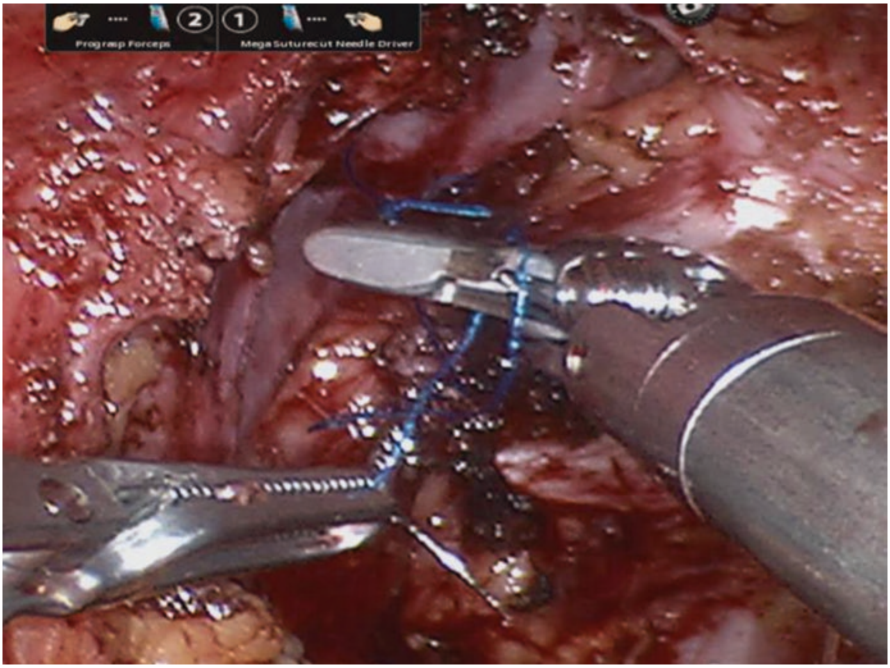

Fig. 6.7 Robotic-assisted repair of iliac vein after removal of preperitoneal split mesh

or ilioinguinal nerves, but may easily be combined as a hybrid procedure with an open inguinal neurectomy if indicated.

There is little literature regarding robotic-assisted triple neurectomy. Mahan et al. described performing this operation in 2014 [20], but no significant data exist to evaluate its the efficacy or safety. The operation is performed in the mid-lateral decubitus position via a transperitoneal approach. The posterior peritoneum is incised and medial visceral mobilization is performed to expose the retroperitoneum on the affected side. This provides exposure of the retroperitoneal structures similar to that gained during laparoscopic retroperitoneal triple neurectomy, as described above. Again, the anatomy should be carefully and completely defined prior to any resection. Clips or suture may be used to ligate the proximal and distal nerve stumps. The purported benefits of this approach, as described by Mahan et al., are technical simplicity and elegant anatomic visualization.

In our experience, any remedial operation that would be performed laparoscopically may be facilitated by robotic assistance. While we have performed posterior neurectomy, removal of plug and bilayer mesh, femoral nerve neurolysis, and subsequent hernia repair using robotic assistance, the true benefit has been in removing large, multiple, fixated, and split (encircling the cord) preperitoneal meshes that typically carry significantly more risk regarding compromise to cord and vascular structures. The robotic assisted method has allowed for precise and controlled venous and arterial repair, complete meshectomy, and preservation of entrapped cord structures. While no universal algorithm exists for management of these complex cases, robotic assistance has made these minimally invasive operations safer and more controlled in our experience, without vascular complication or cord loss.

6.14 Conclusion

There is no level 1 or 2 evidence regarding the operative management of neuropathic pain resulting from repair of ventral or inguinal hernia, by robotic-assisted or any other approach. Best practices are guided by case reports, case series, expert opinion, and expert consensus [7, 14]. At the Lichtenstein Amid Hernia Clinic, we have evaluated and treated thousands of patients with postherniorrhaphy chronic pain. Therapies have included conservative or nonoperative management, mesh removal, removal of suture and fixation material, revision of hernia repair, selective neurectomy, quadruple neurectomy and others. For pain related to ventral hernia repair, we advocate removal of meshoma, suture, and fixation material in the distribution of pain in reliable, highly symptomatic patients. For pain related to inguinal hernia repair we advocate selective neurectomy of all likely involved nerves- typically a triple neurectomy if all nerves are mechanistically and symptomatically at risk. In the case of laparoscopic or robotic-assisted repair with placement of a preperitoneal mesh, we specifically recommend open extended triple neurectomy, laparoscopic retroperitoneal triple neurectomy, or hybrid open and preperitoneal neurectomy including resection of the main trunk of the genitofemoral nerve. Patients with concurrent postherniorrhaphy orchialgia may benefit from combining paravasal neurectomy with inguinal neurectomy. We have performed over 800 open triple and open extended triple neurectomies, over 100 laparoscopic retroperitoneal triple neurectomies, and over 50 hybrid laparoscopic preperitoneal and open inguinal neurectomies making ours the largest single-institution experience. Overall success rates for open triple neurectomy are over 85% and increase to over 90% when the intramuscular segment of the iliohypogastric nerve is resected (as has been our practice since 2004) or when open extended triple neurectomy is performed. Laparoscopic triple neurectomy, performed in selected patients, has carried a similar success rate of over 90%. Our current practice does not follow a single algorithm but tailors the approach often with a hybrid minimally invasive laparoscopic or robotic and open technique to maximize the likelihood of success and minimize the morbidity of neurectomy and reoperative surgery. Acceptable outcomes are a product of careful patient selection and surgeon experience. A plan of care must reasoned for each patient based upon mechanism, symptoms, anatomy, and technical considerations. Careful attention to neuroanatomy and operative technique during initial hernia repair is the best means of preventing the development of postherniorrhaphy chronic pain and the need for remedial surgery.

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