Review Article

Clinical presentation and surgical anatomy of sympathetic nerve injury during lumbar spine surgery: a narrative review

Bradley Brickman[1]^, Mina Tanios[1,2]^, Devon Patel[1]^, Hossein Elgafy[2]^

[1]The University of Toledo College of Medicine and Life Sciences, Toledo, OH, USA; [2]Department of Orthopedic Surgery, University of Toledo Medical Center, Toledo, OH, USA

Contributions: (I) Conception and design: M Tanios, B Brickman; (II) Administrative support: M Tanios, H Elgafy; (III) Provision of study materials or patients: B Brickman; (IV) Collection and assembly of data: B Brickman, D Patel; (V) Data analysis and interpretation: B Brickman, D Patel; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Bradley Brickman, BS. The University of Toledo College of Medicine and Life Sciences, OH 43614, USA.
Email: bradley.brickman@rockets.utoledo.edu.

Background and Objective: To highlight the surgical anatomy, procedural variations, presentation, and management of sympathetic nerve injury after surgery of the lumbar spine.

Methods: PubMed and Google Scholar were searched for publications that were completed between 1951 and 2021. Relevant full-text articles published in the English language were selected and critically reviewed.

Key Content and Findings: Sympathetic injury is a highly variable postsurgical complication with a greater incidence after an anterior or oblique approach to the lumbar spine compared to posterior and lateral approaches. The direct and extreme lateral approaches reduce the need to disturb sympathetic nerves thus reducing the risk of complications. It can present in multiple manners, including complex regional pain syndrome (CRPS) and retrograde ejaculation. These complications can be transient and resolve spontaneously or be treated with medications, physical therapy, and spinal blocks. The severity of the conditions and extent of recovery can vary drastically, with some patients never fully recovering.

Conclusions: To access the lumbar spine, there are operational approaches and techniques that should be used to decrease the risk of intraoperative injury. It is crucial to understand the advantages and risks to different approaches and take the necessary steps to minimize complications. Early identification of dysfunction and adequate management of symptoms are imperative to effectively manage patients with lumbar sympathetic trunk and sympathetic nerve fiber injuries.

Keywords: Sympathetic trunk; lumbar spine; retrograde ejaculation; complex regional pain syndrome (CRPS); hypogastric plexus

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Introduction

Surgical treatments for lumbar spine disorders are not without their complications (1). The development of different approaches and techniques to access the lumbar spine has impacted these complication rates. A thorough understanding of the complications that can occur and methods to avoid them are valuable to the surgeons to enable them to counsel their patients who are undergoing

^ ORCID: Bradley Brickman, 0000-0002-9426-2006; Mina Tanios, 0000-0002-6622-9399; Devon Patel, 0000-0002-0449-1199; Hossein Elgafy, 0000-0001-7518-9600.

Table 1 The search strategy summary

Items	Specification
Date of search	July 31, 2021
Databases and other sources searched	PubMed, Google Scholar
Search terms used (including MeSH and free text search terms and filters)	Lumbar sympathetic trunk, lumbar spine surgery, lumbar interbody fusion, superior hypogastric plexus, complex regional pain syndrome, and retrograde ejaculation
Timeframe	1951–2021
Inclusion and exclusion criteria (study type, language restrictions etc.)	Study type: N/A; language: English
Selection process (who conducted the selection, whether it was conducted independently, how consensus was obtained, etc.)	Authors conducted searches independently and ensured sources were not duplicated

these procedures. The purpose of this narrative review is to summarize the information regarding sympathetic nerve injury during lumbar spine surgery, the clinical presentations, and the recovery patterns. Pertinent surgical anatomy of the lumbar sympathetic trunk, the surgical approaches that are used to access the spine, and strategies to avoid adverse outcomes of an injury from surgery will be discussed. We present the following article in accordance with the Narrative Review reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-22-2/rc).

Methods

We performed a search within PubMed and Google Scholar for publications with terms including "lumbar sympathetic trunk", "lumbar spine surgery", "lumbar interbody fusion", "superior hypogastric plexus", "complex regional pain syndrome", and "retrograde ejaculation". Studies included were completed between 1951 and 2021. Relevant full-text articles published in the English language were selected and critically reviewed. *Table 1* summarizes our methods.

Surgical anatomy

It is imperative to have a thorough understanding of the surgical anatomy of the lumbar region involved to safely access the spine and minimize injury to the sympathetic trunk, which innervates organs and blood vessels in the lower extremities, abdominal cavity, and pelvic cavity (2). Although there are typically four ganglia per side, this number is variable (2-5). The lumbar sympathetic trunk is situated on the anterolateral aspect of lumbar vertebral bodies and anterior to the psoas major muscle (4,5). The right trunk is posterior to the lateral edge of the inferior vena cava and the left trunk lies along the lateral edge of the abdominal aorta (5).

Four cadaveric studies were completed to identify the location of the lumbar sympathetic trunk and the associated ganglia. The formation of ganglia was not symmetric on both the left and right side and the number of ganglia per side varied from 1 to 6 with 4 being the average, except for zero ganglion noted in one cadaver (3-5). Lowenberg and Morton (5) reported the first ganglion at the L1 or L2 vertebrae, or the L1/2 level, the second ganglion at the L2/3 level, L3/4 level, L3 vertebrae, or L4 vertebrae, the third ganglion at the L2/3 level, L3/4 level, L3 vertebrae, or L4 vertebrae, the fourth ganglion at the L3/4 level, L4/5 level, L3 vertebrae, or L4 vertebrae, and the last ganglion at the L4/5 level, L5/S1 level, or the L5 vertebrae. The distance between the sympathetic trunk to the transverse processes and the medial margin of the psoas major muscle was measured at three levels. At the L2/3 level, the distance from the sympathetic trunk to the transverse process was 30.6 (±1.1) mm and from the medial margin of the psoas major was 0.6 (±0.3) mm. At the L3/4 level, the distance from the transverse process was 33.9 (±1.0) and 3.1 (±0.8) mm from the psoas major. The final measurements were taken at the L4/5 level with the distance of the sympathetic trunk to the transverse process being 32.9 (±1.2) and 5.1 (±0.9) mm to the psoas major muscle. The mean lengths of the 1st rami connected to the lumbar spinal nerves were significantly longer than the 2nd–4th nerves, whereas the 5th was significantly shorter than them (4). Additionally, it is important to consider the effect of spondylophytes on the location of the lumbar sympathetic

trunk. In a study completed with 56 cadavers, of which 11 spines had spondylophytes on at least one side, the lumbar sympathetic trunk was shifted ventrolateral in 12 sides, dorsolateral in 6 sides, and ventromedial in one side due to the presence of spondylophytes (6).

The superior hypogastric plexus (SHP) is a retroperitoneal structure formed from the continuation of thoracic and lumbar splanchnic nerves coursing anteriorly to the lumbar vertebrae located close to the aortic bifurcation at L4-S1 (7,8). Specifically, it extends from the lower third of L5 to the upper third of S1 surrounded by loose connective tissue (9,10). The SHP is a continuation of the preaortic plexus and extends into the bilateral hypogastric nerves. The SHP has been described to have multiple anatomic and morphological variations (11). In terms of anatomic location, Ripperda *et al.* (12), which used female cadavers, reported most cases (82.4%) showed the SHP inferior to the aortic bifurcation with the remaining cases being superior. There was a greater range of distances between the SHP and aortic bifurcation with the SHP inferior to the aortic bifurcation (range, 9–40 mm; median: 21.3 mm) than superior (range, 20.5–30 mm; median: 25.3 mm). The SHP typically lies left of the midline. In 35 cadavers, Paraskevas *et al.* (13) noted four morphological variations of the SHP: one thin nerve (17.14% of cases), wide plexiform formation (28.57%), band-like nerve trunk (22.85%), and two distinct nerves (31.44%). Correia *et al.* (14) noted six morphological variations. There are also different characteristics between males and females. In adults, males were reported to have a greater height and width of the SHP (height: 5.06±0.38 cm; width: 0.93±0.11 cm) than females (height: 3.95±0.56 cm; width: 0.79±0.06 cm), which contrasts fetal findings. Along with the sympathetic fibers in the SHP, parasympathetic fibers could also be present (15). The common iliac arteries (CIA) are also present in the same region as the SHP. At the bifurcation of the CIAs, the SHP is closer to the left CIA than the right as measured from the inferior middle border of the SHP (14). The ureter is another structure that can be affected during lumbar spine surgery and needs to be mobilized away from the surgical site. The ureter travels anteromedially to the L2-5 transverse processes along the medial aspect of the psoas muscle and crosses over the CIA at its bifurcation before curving laterally in the pelvis (16).

Surgical approaches

Anterior approach

There are two different broad categories of anterior approaches to the lumbar spine that are used, an open lumbosacral method and a less commonly used endoscopic method. There are several options within the open approach, with the most prevalent one placing the patient in the supine position with a retroperitoneal exposure through a paramedian abdominal incision with a left-sided approach. This option allows retraction of the aorta, which is safer than the vena cava, and provides access to L2-S1. In order to access L1, a thoracolumbar incision is necessary (17). The anterior rectus sheath is cut, and the rectus muscles are retracted laterally, sparing splitting the abdominal muscles and preserving enervation. In contrast, retracting the abdominal muscles medially would result in denervation of segments of the rectus abdominus (18). The extraperitoneal plane is entered by incising the posterolateral corner of the posterior rectus sheath. Blunt dissection is used to separate the peritoneum from the transversalis fascia and then the abdominal contents are retracted medially to expose the great vessels, spine, and psoas (19,20). There have been other small anterior incisions used such as those described by Brau and Dewald *et al.*, but these have been limited to only three spinal levels (21,22).

The transperitoneal approach is an older and less often used technique due to injury to the peritoneum and SHP, and resulting secondary intestinal occlusion (23). The anterior peritoneum is opened, and the digestive tract is pushed back with the sigmoid and mesosigmoid pushed to the left. Saline is injected into the retroperitoneal space to separate the peritoneum from the prevertebral vessels and SHP, followed by a vertical incision. The remainder of the procedure is performed in the retroperitoneal approach.

There are also different anterior approaches within the endoscopic category, but the most commonly used techniques are the transabdominal endoscopic technique and the retroperitoneal endoscopic approach, with the latter used slightly less frequently (24). There are some variations in exposure techniques depending on the lumbar spine level desired to be reached, but the process is similar. Lieberman *et al.* (25) describes how the small bowel needs to be swept out of the way and how the sigmoid colon needs to be elevated and retracted prior to the longitudinal parietal peritoneum incision. Another structure that needs to be removed from the field is the ureter. Once the ipsilateral ureter is identified, it is moved with the peritoneum toward the midline (26). Depending on the level of exposure, various vessels will need to be dissected and retracted to gain clear access to the spine (25). The anterior approach does pose a risk for sympathetic chain injury in both the

open and endoscopic option (25,27).

Oblique approach

The oblique approach utilizes the anatomical window created from the anterior border of the psoas and the lateral extent of the great vessels; aorta, inferior vena cava or common iliac vessels depending on the level and side of dissection (28). Access may be limited by the rib cage at the L1-2 level and by the iliac crest and vessels at the L4-5 level (29). The patient should be placed in a lateral decubitus position, preferably to access the spine via the left side, and a transverse incision is made centered on the anterior margin of the disc space (30). Next, the abdominal muscles are dissected along the direction of their respective fibers. The retroperitoneal fat, including the peritoneum and ureter are pulled anteromedially to expose the psoas muscle, which is retracted posteriorly to reach the spine (31). The lumbar sympathetic chain is identifiable and may require anterior retraction during the operation (32).

Extreme lateral approach

The extreme lateral approach is a newer technique to access the lumbar spine. To begin, the patient should be placed in the right lateral decubitus position with the patient positioned to increase the distance between the iliac crest and the rib cage as well as the hips and knees flexed to relax the psoas muscle as much as possible (30). This can be done using a pad or roll underneath the patient's side on the table or by tilting the table (33). After proper aseptic treatment and draping, a k-wire is placed, and lateral fluoroscopic imaging is used to identify the lumbar disc's mid-position for L4-5 and posterior one-third of other discs levels which is then marked on the skin to be used as the location for an incision designated for tissue dilators and an expandable retractor. Posterior to the first mark and between the erector spinae muscles and abdominal obliques, a second mark is made that is used for a small incision for the surgeon's index finger to be inserted anterior to identify the retroperitoneal space using blunt dissection. Once in the retroperitoneal space, the psoas muscle should be identified and then the index finger should be swept up towards the initial mark on the skin. An incision is then made at the first mark and a dilator is inserted, being guided by the index finger already in the retroperitoneal space towards the psoas muscle directly overly the disc space of interest which is then confirmed by fluoroscopy. The psoas is separated using blunt dissection with electromyographic (EMG) monitoring between the middle and anterior third of the muscle to avoid injury to the lumbar plexus, located posteriorly, and the great vessels, located anteriorly. Dissection is continued until the surface of the disc is reached and then the muscle is gradually dilated and retracted to access the disc space.

Direct lateral approach

The direct lateral approach begins with placing the patient in the lateral decubitus position with the hip positioned over the break of the table to maximize the space between the twelfth rib and iliac crest and to open the disc space. The top leg should be flexed to relax the psoas muscle as much as possible. Antero-posterior (AP) and lateral images should be obtained, which will guide the 2.5–3 cm long incision over the desired disc space. However, if two adjacent levels are desired, an incision can be made midpoint between the two levels. Blunt dissection through the skin, subcutaneous fat, external and internal oblique muscles, and transversus abdominis muscle are made to ensure muscles are split in the direction of the fibers. Once the retroperitoneal fat is visualized, a posterior to anterior finger sweep should be performed to separate the fat and peritoneum from the psoas muscle. A triggered EMG probe is used and the anterior third to half of the psoas muscle is probed, aiming toward the anterior aspect of the disc space, adjusting the probe if a nerve is stimulated. Once the probe is passed through the muscle, a guidewire is passed and docked using radiographic guidance. Sequential retractors are then placed on the lateral aspect of the disc space while free-running EMG monitoring occurs for safe muscle-splitting dissection until the desired dilatator is placed and subsequent tubular retractor is stabilized.

The advantages of the direct lateral approach include access to the lumbar spine without requiring retraction of nerve roots or mobilization of the great vessels and the disadvantages include placing the lumbar plexus and genitofemoral nerve at risk during dissection through the psoas muscle (34,35). In the context of sympathetic nerve injury, the direct lateral approach avoids damage to the associated structures. Important to note, the L5-S1 disc space cannot be accessed with the direct lateral approach due to obstruction from the iliac crest and it may not be possible to access the L4-L5 disc space in males depending on the size of their iliac crest.

Prevention of sympathetic nerve injury

The two major methods of preventing sympathetic nerve injury can be broadly categorized into either the choice of surgical tools or the method of surgical approach. Starting with surgical tools, one way to minimize injury is avoid all cautery dissection when possible, and if needed, to use bipolar cautery (36). Vascular clips can be used as an alternative to control bleeding in the prelumbosacral fascia area (37). Surgeons should also avoid splitting structures in the presacral area to minimize injury. If necessary, splitting should be done longitudinally in direction of the fibers (36).

Selecting the method of approach plays a large part in the chances of perioperative sympathetic nerve injury. The rates of injury and clinical symptoms are highlighted in sections below, with the anterior and oblique approaches being more likely to cause injury while the extreme lateral and direct lateral approaches have minimal risk of injuring sympathetic nerves. The hypogastric plexus extends distally from the fourth lumbar vertebra, running anterior to the aorta before crossing the left common iliac vein towards the pelvis. Injury to this bundle is more of a concern in the transperitoneal anterior approach than in the retroperitoneal anterior approach because the plexus is retracted forward, swept left to right, and usually protected from injury in the retroperitoneal approach. In a study by Sasso *et al.* (38), six of the 146 men developed retrograde ejaculation, they found a ten times higher incidence in patients undergoing anterior lumbar interbody fusion (ALIF) with the transperitoneal approach versus the retroperitoneal approach. If a transperitoneal approach is used, a longitudinal division of the peritoneum followed by retraction of the hypogastric plexus underlying the peritoneum to the left is advised (24,37). Despite preventative measures, some authors claim that sympathetic nerve injury is an unavoidable complication of anterior approach to the lumbar spine (18,39). However, compared to the posterolateral approach, the anterior approach is associated with significantly less operative and perioperative morbidity after a single-level fusion. Depending on the surgical goal, the anterior approach could be favorable despite the risk of sympathetic nerve injury, especially given how subjective the decisions about surgical approach are (40). Another factor influencing the approach is the level of the fusion. The anterior approach is most commonly used for L5-S1 and the oblique and lateral approaches are used for L2-5.

Clinical presentations

Complex regional pain syndrome (CRPS) and retrograde ejaculation are a common presentation of sympathetic nerve injury after lumbar spine surgery (41,42). Patients will often complain of a cold limb contralateral to the surgery due to the loss of sympathetic vasoconstriction on the warmer, affected side. Along with the approach influencing the incidence of injury, the level at which the surgery is performed can also be a risk factor. Evidence suggests a trend that there are increased persistent neurologic deficits as the level moves more caudally (43). Overweight/obese patients and those who experience a longer operation are also more likely to have nerve injury complications (44).

CRPS

CRPS occurs following incidental trauma such as surgery, fractures, peripheral nerve damage, and infections (45-47). CRPS and the severity of associated symptoms are disproportionate to the causative event (47). It often presents with hyperalgesia, edema, abnormal skin temperature, skin blood flow abnormalities, along with dysfunction of the sympathetic nervous system such as abnormal sweating in the affected limb (47-49). Two diagnostic criteria for CRPS are the Budapest criteria and The International Association for the Study of Pain (IASP) criteria (50). It could be argued that sympathetic dysfunction such as a temporary sympathetic reaction, which can present as a warm leg after sympathetic injury in lumbar surgery, is on a spectrum with CRPS, with warm leg symptoms alone on the milder side and CRPS on the severe side. CRPS typically presents with warm, dry, erythematous skin in the acute setting, but as a colder limb with a sweaty and cyanotic appearance in the chronic setting (49). When treated early, permanent relief is possible but when left untreated, it can result in pain and swelling that extends beyond the original area of trauma with diffuse limb pain, muscle wasting, and joint immobility (46,47,51).

CRPS has been reported in several studies after lumbar spine surgery (45,52-58). In a study by Wolter *et al.* (45), five patients developed CRPS of the lower extremity following lumbar spine surgery. Two of these patients had total remission, two had partial remission, and one patient had no remission of CRPS. All five patients received medical treatment, physiotherapy, and lymphatic drainage. The one who had no remission also had a sympathetic

Table 2 Complication and recovery rates of different approaches to lumbar surgery

Surgical complications	Anterior (open)—retro and transperitoneal	Anterior (laparoscopic)	Oblique	Extreme lateral	Direct lateral
Sympathectomy effect/ CRPS	0.4–15% (1,39,60-62)	6.4% (26)	1.7–9% (41,60)	4% (62)	Case report of 1 patient (58)
Recovery from sympathectomy/CRPS	Transient: 66% (39)	Transient: 100% (26) (by 3 months)	–	–	100%, 8 weeks (58)
	Permanent: 17%	Permanent: 0%			
Retrograde ejaculation	0.5–22.5% (1,38,39,61,63-66)	2.7–45% (26,36,61,63,67-69)	0–6% (41,69)	0% (58,70)	0% (58)
Recovery from retrograde ejaculation[†]	Transient: 22–88% (38,39,61,64,66) (at 1–15 months)	Transient: 45–100% (26,61,68) (by 8 weeks–9 months)	–	–	–
	Permanent: 13–78%	Permanent: 0–25%			

[†], % of men with retrograde ejaculation, not total men in study. CRPS, complex regional pain syndrome.

block and spinal cord stimulation. Of the two patients who had partial remission, one of them had a sympathetic block. They found that one-third of all patients in their study experiencing CRPS of the lower extremities had spinal surgery prior to their onset of symptoms. There are proposed theories such as the mobilization or traction of the sympathetic trunk causes the reaction of CRPS, but the exact mechanism is unclear (45,52-57,59).

The rates of complications with the various approaches to the lumbar spine are highlighted in *Table 2*. Sympathetic dysfunction was found to occur with 0.4–15% of patients undergoing lumbar spine surgery with an anterior approach with open methods (1,39,60-62) and 6.4% when laparoscopic techniques were used (26). With the oblique approach, we found the rate of lower extremity sympathetic dysfunction to be between 1.7% and 9% (41,60). The extreme lateral and direct lateral approaches are not very susceptible to sympathetic nerve injury, but one study found 4% of patients undergoing extreme lateral interbody fusion (XLIF) had sympathectomy symptoms (62). A case report by Morr *et al.* (58), reported CRPS following a lumbar fusion using a lateral approach, but based on our search of the literature, the scarcity of this complication would indicate it should not be a source of worry in lateral approaches.

Retrograde ejaculation

Another complication of lumbar surgery that has been reported in several studies is retrograde ejaculation (26,36,38,63). Retrograde ejaculation is a dysfunction of the internal vesical sphincter to contract during ejaculation which normally prevents semen from travelling into the bladder. Injury of the internal vesicular sphincter limits the quantity of spermatozoa delivered to allow fertilization. Damage to sympathetic fibers, more specifically the SHP, can affect the innervation of this sphincter (28,38). Motility of the vas deferens and contractibility of the seminal vesicles are also under sympathetic control but appear to be less affected by sympathetic injury. Although injury occurs during the perioperative period, it may not be entirely evident to the patient until later as there is no immediate sign of retrograde ejaculation (71). Retrograde ejaculation can be a major complication for a male of reproductive age still hoping to reproduce and has been reported in a range of 0.5% to 22.5% in open anterior approaches (1,24,38,39,61,63-66) and 2.7% to 45% in endoscopic cases with an anterior approach (26,36,61,63,67-69). A recently published review found the overall incidence of retrograde ejaculation following open anterior lumbar surgery in 2,503 men to be 2.3% (72). That study also found higher risk of retrograde ejaculation with a transperitoneal approach of 8.6% compared to that of a retroperitoneal approach with 3.2%. This is consistent with the results of a study by Sasso *et al.* (38), where retrograde ejaculation incidence was found to be 1.7% (2/116) in patients with the retroperitoneal open approach and 13.3% (4/30) in the transperitoneal open approach. A study with the lowest incidence rate of 0.42% (37) that is referenced in many other publications was based on estimated total case numbers and does not exclude female patients, therefore we excluded this study when determining incidence rate ranges. Endoscopic methods appear to have higher incidences of retrograde ejaculation,

but this may be due to the use of a transperitoneal approach rather than the actual use of endoscopic methods (38). There are studies indicating laparoscopic surgery is an effective technique for lumbar fusion but, studies that directly compare laparoscopic with open or mini-open techniques have consistently shown higher complication rates in the laparoscopic method. The severity of sympathetic injury is hard to differentiate between approaches due to limited studies that follow patients long enough to determine recovery rates. In addition, there are complications beyond sympathetic injuries to consider when deciding between an open or laparoscopic approach (73).

The oblique approach has an incidence between 0% and 6.0% (41,69). The extreme lateral and direct lateral approaches avoid disturbing the SHP and therefore retrograde ejaculation is not a complication of these approaches. In a case series of 600 patients, Rodgers *et al.* (70), reported zero cases of retrograde ejaculation in the extreme lateral approach. There was a case study indicating sympathetic injury during a lateral lumbar approach (58), so it is theoretically possible but highly unlikely that retrograde ejaculation is a cause for concern in lateral approaches.

These patients are still able to have erections despite retrograde ejaculation because the inferior hypogastric plexus is often protected due to its location in the deep pelvis (37). Anatomically speaking, impotence in men should not be an issue with lumbar surgery as the parasympathetic plexus responsible for erection is within the pelvis. When impotence does occur, it is believed to be of psychogenic origin (39). It has been theorized that another possible explanation of impotence is that elderly men with advanced vascular disease and extensive sympathectomy can have an adverse effect on peripheral blood flow leading to erectile impotence (7,74). Priapism has also been postulated as an adverse effect of lumbar surgery due to unopposed parasympathetic input when sympathetic input is reduced, but studies supporting this claim have not been found (7,24,37).

Management and recovery

Early detection of CRPS is key as early treatment generally leads to quicker recovery (75). Symptoms often resolve on their own and thus, careful following is commonly first line (76). Recovery from sympathetic dysfunction occurs on a spectrum, ranging from no recovery to full recovery with individual rates depending on the surgical approaches. Data from one study showed full recovery in all three patients with the laparoscopic anterior approach (26). In contrast, another study of six patients reported four full recoveries, one permanent dysfunction, and one lost to follow-up with the open anterior approach (39). The laparoscopic approach is not commonly used and therefore data is limited. Studies that identified recovery rates of sympathetic dysfunction after lumbar surgery was limited as well. One study reported 100% recovery after three months (26), although we know this is not the case for everyone. A case report of a patient who experienced CRPS after a lateral approach to the lumbar spine recovered fully by the 8-week post-operative appointment (58). It is unclear what controls the regeneration of sympathetic nerves after lumbar sympathectomy but it been suggested by Navarro (77), that functional deficits of nerve injuries can be alleviated by reinnervation of denervated targets by either regenerating injured axons or collateral branching of undamaged axons.

For refractory cases, other treatment options include medications, physical therapy, occupational therapy, sympathetic blocks and spinal cord stimulation (45,78). Bisphosphonates, topical DMSO, systemic steroids, and spinal cord stimulation were also shown to improve symptoms associated with CRPS, while other options such as anticonvulsants were not as clinically useful (78).

Retrograde ejaculation

Retrograde ejaculation may not be entirely apparent in the immediate post-operative period, so management may not begin until weeks after surgery. The main goal of treatment is to improve fertility, although not all cases require treatment due to spontaneous recovery. Complete recovery rates vary between the open and laparoscopic anterior approaches, 33–88% and 45–100%, respectively. Permanent retrograde ejaculation in the open anterior approach had a wider range, between 13% and 78%, compared to between 0% and 25% for laparoscopic anterior approaches (26,38,39,61,64,66,68). A systematic review found the recovery rate to be 45.8% after final follow-up for open anterior lumbar surgery (72). In studies where patients did recover from retrograde ejaculation following anterior approaches, normal function was reported between one and 15 months following open surgery (38,39,61,64) and between 8 weeks to 9 months following laparoscopic surgery (26,61,68). Although very limited data, recovery from retrograde ejaculation seems less likely in patients that

underwent a transperitoneal anterior approach compared to a retroperitoneal anterior approach (38). No studies could be found regarding specific recovery rates of retrograde ejaculation after an oblique or lateral approach.

Retrograde ejaculation can possibly be alleviated through medical intervention, including medications, surgical intervention, or sperm retrieval from the urine for fertilization. A systematic analysis by Jefferys *et al.* (79), reviewed studies that evaluated the influence of sympathomimetic or anticholinergic medications, or a combination of the two, on antegrade ejaculation; 28% (11/40) of patients given sympathomimetic drugs achieved antegrade ejaculation compared to 22% (11/50) of patients given anticholinergic drugs; 38% (5/13) of patients who received a combination of drugs achieved antegrade ejaculation. Therefore, these medications can be used in patients with retrograde ejaculation, but efficacy is far from guaranteed.

Electroejaculation can also be used to achieve antegrade ejaculation. This method has been demonstrated in patients treated for testicular cancer. Three out of five patients with retrograde ejaculation who underwent transrectal electroejaculation were able to have sperm collected that resulted in pregnancy via in vitro fertilization (IVF). One of the five patients attempted fertilization via intracytoplasmic sperm injection (ICSI) but was unsuccessful (80).

Bladder neck reconstruction surgery can be used to convert patients from retrograde to antegrade ejaculation (81). Some patients were able to achieve antegrade ejaculation after undergoing either the Young-Dees operation or Y-V plasty (82,83).

Overall, there are different treatment options for retrograde ejaculation, depending on the underlying etiology. However, there have not been studies with large enough sample sizes for appropriate analysis of various interventions.

Limitations

There are several limitations in this review article. First, studies focusing on sympathetic injury during the oblique and lateral approaches are very limited. More research is needed in this area to determine complication rates and recovery times. The designation of what sympathetic dysfunction meant in some studies was unclear and therefore could not be further subcategorized. Studies that use newer diagnostic tools are needed to accurately categorize sympathetic injuries following lumbar surgery.

Conclusions

Consequences of sympathetic nerve injury during lumbar spine surgery, while not life-threatening, can have a significant impact in quality of life for patients. Although the effects, ranging from CRPS to retrograde ejaculation, may be temporary, many patients may never fully recover. Thus, sympathetic injury should be considered when deciding on the approach of lumbar surgery and the tools used perioperatively. The current study highlights the rates of injury with different lumbar approaches, and it is apparent that the anterior and oblique approaches put patients at a significantly higher risk to sympathetic injury than the extreme lateral and direct lateral approaches. When injury does occur, early detection is crucial to improve recovery and for better outcomes. Treatment varies depending on the complications present. A thorough understanding of sympathetic nerve injury from lumbar spine surgery, the clinical presentations, and recovery patterns benefits both the surgeon and patient, guiding the surgeon's decision-making process and preparing the patient for any potential morbidities that may result.

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Footnote

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-22-2/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-22-2/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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