Safety and the Anatomy of the Retroperitoneal Lateral Corridor with Respect to the Minimally Invasive Lateral Lumbar Intervertebral Fusion Approach

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KEYWORDS

• LLIF • Transpsoas approach • Retroperitoneal anatomy

KEY POINTS

- Limited visualization of the surgical field during the lateral lumbar intervertebral fusion (LLIF) procedure exposes surgeons to difficulties and dangers that do not exist when performing similar procedures in an open technique.
- Anatomic understanding of the different structures in the abdominal wall and in the retroperitoneal space and their relationship to the LLIF approach is crucial for minimizing the risk for complications.
- Conscientious evaluation of the preoperative imaging studies, proper patient position, generous use of intraoperative imaging, and a systematic approach to surgical techniques are imperative to assure safe and successful outcome.

INTRODUCTION

The lateral transpsoas approach for lumbar interbody arthrodesis is a relatively novel method for performing minimally invasive LLIFs.[1] This approach allows for a large graft to be placed at the apophyseal ring where the bone is strongest, enabling disk height restoration and deformity correction.[2–4] In addition to the advantage of avoiding manipulation of the large retroperitoneal vessels, this technique uses a small incision that avoids significant abdominal wall muscle injury.[5,6] The limited visualization of the surgical field during this procedure, however, exposes surgeons to difficulties and dangers that do not exist when doing similar procedures in an open technique. Surgeons, therefore, must rely on intraoperative fluoroscopic images and neuromonitoring guidance during certain stages of the procedure to avoid neurologic complications.[7,8]

Although LLIF gained fast and wide popularity among spine surgeons as a safe and reproducible technique for anterior spine arthrodesis, several studies challenged the safety of this procedure, reporting complication rates ranging from 6.2% to 52%.[6,9–11]

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Anatomic understanding of the different structures in the abdominal wall and in the retroperitoneal space and their relationship to the LLIF approach is crucial for minimizing the risk for these complications. Several studies have been published in the literature regarding the morphometric measurements of these structures. Some of these studies used cadaveric specimens whereas others relied on morphometric measurements acquired by MRI studies.[12–20]

This review aims to describe the different important anatomic considerations when performing LLIF and offer technical notes that may help increase the safety of this procedure.

In order to simplify this review, the authors have divided the LLIF procedure into 5 stages; each is preformed in a distinct anatomic compartment that may cause location complications:

1. Patient positioning
2. Abdominal wall dissection
3. Retroperitoneal space dissection and anterior displacement of the peritoneum and abdominal organs
4. Transpsoas dissection and deployment of the surgical retractors
5. Diskectomy and penetration of the contralateral annulus

PATIENT POSITIONING

The importance of correct patient positioning cannot be overemphasized for the success and safety of the LLIF procedure.[12] In order to compensate for the lack of direct visualization of the operated field, the authors strongly recommend that this stage be performed by a senior surgeon or by a surgeon who is skillful and experienced in performing the procedure, because it requires multiple subtle adjustments of the surgical table under fluoroscopic guidance to achieve near-perfect anteroposterior and lateral visualization of the operated disk space and bordering vertebrae.

Among many other technical difficulties, malpositioning of patients may result in the misplacement of the surgical retractors inside the psoas muscle, which greatly increases the risk of injury to the dural sac, retroperitoneal vessels, lumbar plexus, and the psoas muscle.[12,21–26]

The retractor blades positioned inside the psoas muscle produce compression of the muscle fiber and of the adjacent nerves. This compression coupled with excessive positional stretching of the psoas and abdominal muscles can increase the intramuscular tension and may contribute to the risk of nerve injury.[27,28] Therefore, it is imperative to relax the muscle as much as possible by ensuring that the hip joint on the operated side is flexed as much as possible and that the lateral bending of the trunk is not exaggerated over what is needed to deflect the iliac wing away from the surgical corridor to the disk space.

ABDOMINAL WALL DISSECTION

The lateral abdominal wall musculature consists of 3 muscular layers: the external oblique, the internal oblique, and the transverse abdominis. Posterior to them is situated the quadratus lomborum muscle.[29,30]

Four nerves of the lumbar plexus—the subcostal, the iliohypogastric, the ilioinguinal, and the lateral femoral cutaneous nerves—travel outside the psoas in the retroperitoneum and inside the abdominal wall (**Fig. 1**). These nerves are vulnerable to injury during the early stages of the LLIF approach while accessing and dissecting the abdominal wall and retroperitoneum.[31] Injury to these nerves during laparoscopic abdominal surgery is a well-known complication that results in a full spectrum of sensory deficits (analgesia, paresthesias, and dysesthesia) at the corresponding dermatome and paresis of the abdominal wall. This may lead to an abdomen wall hernia or even a direct inguinal hernia.[32] Of the 4 nerves, the lateral femoral cutaneous nerve is the only one reported in the literature to be injured during an LLIF procedure, although nondocumented injury to the other 3 nerves have been reported by surgeons.[33]

Subcostal Nerve

The subcostal nerve originates from the T12 root and accompanies the subcostal vessels along the inferior border of the 12th rib. The nerve has a motor and a sensory component. It supplies the muscles of the anterior abdominal wall, especially the external oblique, and provides sensation to the anterior gluteal skin. If the dorsal cutaneous branch becomes injured or entrapped, this produces a posterior area of numbness with painful paresthesias, known as *nostalgia paresthetica*. When the anterior cutaneous branch is involved, this leads to an anterior area of numbness with painful paresthesias on the abdomen, known as *rectus abdominis syndrome*. Injury to the motor portion of the nerve paralyzes the muscle fibers supplied by it, thereby weakening the anterior abdominal wall.[29,34]

Iliohypogastric Nerve

The iliohypogastric nerve originates from the L1 root. It emerges from the upper lateral border of the psoas major muscle and runs obliquely

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