Early complications of the minimally invasive lateral lumbar spine surgery: a 50-case series

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ABSTRACT

Introduction: Minimally invasive spine surgeries (MISS) are designed to improve postoperative morbidity in lumbar fusion procedures. Their limited surgical exposure and potentially poor visualization of the operative field are not without complications. The purpose of our study was to analyze our early postoperative complication rate in the first 50 patients that underwent a lateral MISS approach, evaluating these procedures in relation to our learning curve. **Materials and Methods:** We conducted a retrospective study in 50 patients that underwent lateral retroperitoneal interbody fusion using a MISS technique between September 2015 and April 2018. The assessed parameters were: demographic, radiological and surgical data, and all the early complications encountered. **Results:** A total of 76 cages were used: 5 at L1-L2 level; 33 at L2-L3 level; 34 at L3-L4 level; and 4 at L4-L5 level. Out of the 50 patients, 25 underwent fusion only at 1 level, 24 underwent fusion at 2 levels, and 1 underwent fusion at 3 levels. A total of 21 complications were encountered: 4 major complications, and 17 minor complications. The longest surgical time (90 minutes) and the highest complication rate were observed within cases 1-16 (12 patients). Thereafter, these parameters proportionately decreased until they reached a minimum of 3 complications within cases 34-50. **Conclusions:** The main complications occurred in the surgical access, and their incidence decreased as the surgeon's experience increased and as the surgical time shortened.
Key words: Lateral lumbar approach; XLIF; complications.
Level of Evidence: IV

Complicaciones tempranas en los primeros 50 casos de cirugía mínimamente invasiva lateral a la columna lumbar

RESUMEN

Introducción: Las técnicas mínimamente invasivas intentan mejorar la morbilidad posoperatoria en las fusiones lumbares. Esta limitación en el abordaje quirúrgico y la potencial falta de visión del campo operatorio no estarían exentas de complicaciones. El objetivo de este estudio fue analizar nuestra tasa de complicaciones tempranas posoperatorias, en pacientes sometidos a un abordaje mínimamente invasivo lateral, valorando las complicaciones en relación con nuestra curva de aprendizaje. **Materiales y Métodos:** Estudio retrospectivo de 50 pacientes operados con técnica de artrodesis intersomática por vía lateral retroperitoneal mínimamente invasiva, entre septiembre de 2015 y abril de 2018. Los parámetros incluidos fueron: demográficos, radiológicos, quirúrgicos y todas las complicaciones tempranas. **Resultados:** Se colocaron 76 cajas: 5 en L1-L2, 33 en L2-L3, 34 en L3-L4 y 4 en L4-L5. A 25 de los 50 pacientes se les realizó un solo nivel de fusión; a 24, dos niveles y a uno, tres niveles. Se detectaron 21 complicaciones (4 mayores y 17 menores). El tiempo quirúrgico más prolongado (90 min) y la tasa más alta de complicaciones correspondieron a los casos 1-16 (12 pacientes), luego estas cifras disminuyeron proporcionalmente en los siguientes casos hasta llegar a un mínimo de tres complicaciones en los casos 34-50. **Conclusiones:** Las mayores complicaciones ocurrieron en la vía de abordaje, pero disminuyeron progresivamente, a medida que crecía la experiencia del cirujano y se acortaba el tiempo quirúrgico.
Palabras clave: Abordaje lateral lumbar; técnica XLIF; complicaciones.
Nivel de Evidencia: IV

Received on 3-22-2019. Accepted after evaluation on 8-12-2019 • JUAN J. GOTTLIEB, MD • juangottlieb@hotmail.com
How to cite this paper: Gottlieb JJ, Resano H. Early complications of the minimally invasive lateral lumbar spine surgery: a 50-case series. *Rev Asoc Argent Ortop Traumatol* 2020;85(1):39-48. https://doi.org/10.15417/issn.1852-7434.2020.85.1.970

INTRODUCTION

Lumbar fusion has been described as a successful technique for the treatment of multiple spine pathologies (degenerative disc diseases, trauma, tumors, etc.) and is the standard indication for several of them.

Open posterolateral fusion remains the treatment of choice in spine surgery. However, the major blood loss, the postoperative lumbar pain and the surgical difficulties led to the development of new methods for interbody fixation that would reduce the disruption to the paraspinal muscle related to the spinal access and, therefore the postoperative pain and morbidity.

Numerous MISS techniques have been described in an effort to limit surgical exposure, reduce blood loss, shorten hospital stay and improve postoperative morbidity. Their limited surgical exposure and potentially poor visualization of the operative field are not without complications.

One of these MISS techniques that has become popular over the past years is the transpsoas approach to a lateral retroperitoneal interbody fusion, developed by the Brazilian neurosurgeon Luiz Pimenta,[1] his earliest articles being from 2006. This lateral approach allows for a discectomy where the anterior and posterior longitudinal ligaments remain intact, thus providing greater stability and a greater cage-bone contact ratio, which improves bone fusion. Another benefit of this method is that it allows performing sequential corrections in the coronal (and sometimes sagittal) plane of certain adult deformities. However, along with its great benefits, this method could pose risks that may involve structures adjacent to the vertebral body.

Although there is a growing, yet limited, international literature on the early complications of this technique, there is no Argentine publication addressing them.

The purpose of this retrospective study was to analyze our early postoperative complication rate in the first 50 patients that underwent a lateral MISS approach, evaluating these procedures in relation to our learning curve.

MATERIALS AND METHODS

We conducted a retrospective study using the clinical and radiological data collected from patients who underwent surgery between September 2015 and April 2018. The study population consisted of 50 patients who underwent a MISS using a lateral retroperitoneal interbody fusion, performed by the same surgeon.

The patients were evaluated by two members of the surgical team within 45 days after surgery, who filled out data lists for the retrospective review, which were separately compiled. The assessed parameters were: demographic (sex and age), radiological (number of levels, fusion levels, and whether a posterior fixation was performed) and surgical (preoperative diagnosis and system used). They also collected all the encountered complications, which were compiled, in another list, into categories devised by the surgical team according to the complication frequency observed in the international literature as to prevent any omission.

The cases were divided into 3 groups (case 1 to 16; case 17 to 33; and case 34 to 50) to study the learning curve and its relation with adverse events and the surgical time.

The surgical technique was performed following doctor Pimenta description but for one exception: a single lateral incision, which is the current global standard. The surgery included: general anesthesia, patient in lateral decubitus, identification and placement under fluoroscopic guidance, access and dissection according to the transpsoas approach, discectomy and insertion of a PEEK interbody cage (using different retractor systems: XLIF® [NuVasive®, San Diego, CA, USA] in 44 cases, DLIF® [Medtronic Sofamor Danek, Memphis, TN, USA] in 4 cases, and LLIF® [Globus Medical Inc. Audubon, PA, USA] in 2 cases), and direct intraoperative neurophysiological monitoring.

RESULTS

Thirty-seven women and 13 men, with an average age of 68 (range, 44-80) and 67 years (range, 45-78) respectively, underwent a MISS through a lateral approach.

A total of 76 cages were used: 5 at L1-L2 level; 33 at L2-L3 level; 34 at L3-L4 level; and 4 at L4-L5 level.

Out of the 50 patients, 25 underwent fusion only at 1 level (50%), 24 underwent fusion at 2 levels (48%), and 1 underwent fusion at 3 levels (2%).

Only 6 cases were left without fixation (stand-alone procedures), and the remaining 44 underwent posterior fixation (Table 1).

Table 1. Number of implanted cages, fusion levels y posterior fixations

Fusion level	76 cages	L1-L2 (5)	L2-L3 (33)	L3-L4 (34)	L4-L5 (4)
Number of levels	25 cases 1 level	24 cases 2 levels	1 case 3 levels		
Postoperative fixation	6 stand-alone	36 open	5 percutaneous	3 unilateral	

Degenerative disc diseases with or without spinal stenosis were this series most common indication, followed by adjacent segment diseases and adult scoliosi (Table 2).

Table 2. Preoperative diagnosis and used systems

Surgical			
Preop. Diag.	Scoliosis (12)	ASD (18)	DDD/canal stenosis (20)
Used system	Nuvasive (44)	Medtronic (4)	Globus (2)

ASD: adjacent segment disease; DDD: degenerative disc disease; PREP. DIAG.: preoperative diagnosis.

The longest surgical mean time (90 minutes) and the highest complication rate (12 cases; 24%) were observed in the first group; thereafter, these parameters proportionately decreased until they reached a minimum complication rate of 6% in the last group (Table 3). We registered a total of 21 complications (42%) in the 50 studied cases, of which 3 were major (8%) and 17 minor complications. *Major complications* were defined as the events that were chronic or functional limitations or that required revision surgery to be resolved. *Minor complications* were defined as those without any residual effects and those not requiring any follow-up surgery.

Table 3. Complications associated with the learning curve and the surgical time

Complications associated with the learning curve	Amount	Description	Surgical time
Cases 1-16	12	Sensory and pain (9 cases) Injury of the segmental artery (1 case) Anterior longitudinal ligament rupture (1 case) Pseudohernia (1 case)	90 min, average
Cases 17-33	6	Lateral migration (1 case) Subsidence (2 cases) Misplaced cage (3 cases)	40 min, average
Cases 34-50	3	Vertebral body fracture (1 case) Subsidence (2 cases)	25 min, average

Out of the 4 patients that sustained a major complication, two did not undergo any revision surgery. In one of them, the level L1-L2 procedure resulted in chronic intercostal neuropathic pain due to the need to remove part of the rib in order to access the disc space. The other one was a case of adult scoliosis, which procedure involved access to the disc spaces of L2-L3 and L3-L4 (curve apex) and resulted in dysesthesia in the frontal aspect of the thigh that persisted for at least one year after surgery. One of the patients who sustained a major complication and underwent surgery had an injury in the segmental artery in the L3-L4 space, which the surgical team was able to ligate with the assistance of a vascular surgeon through the same incision and a new one through a posterior approach, which altered the original surgical strategy. The other patient who sustained a major complication presented a longitudinal L3-body fracture in the immediate postoperative period, which resulted from the level L2-L3 cage being placed too anterior and the level L3-L4 cage (immediately caudal) being placed more dorsal, resulting in a weakness of both L3 vertebral endplates, where the fracture line occurred. The complication was resolved by performing a supplemental posterior fixation (Figure 1).

Figure 1. L3-body fracture.

The remaining 17 cases were minor complications: 7 cases of some sensory alteration or hip flexion weakness which subsided within 3 weeks after surgery; 1 case of abdominal muscles paresthesia (pseudohernia) that spontaneously subsided within 3 months after surgery; 1 case of unintentional rupture of the anterior longitudinal ligament, treated with a cage which was screwed immediately, resulting in a slightly anterior position to the vertebral body and a subsequent posterior fixation; 4 cases of interbody cage subsidence (3 in the inferior endplate, which were detected at the first control, 15 days after surgery, and 1 in the superior endplate, which was detected in the immediate postoperative period [Figure 2]); 2 cases of cage migration (1 lateral and 1 anterior migration which were detected in the first postoperative control [Figures 3A and 3B]); and 2 cases of misplaced cages (too lateral) with no signs or symptoms in the following controls.

Figure 2. Superior endplate subsidence (intraoperative and immediate postoperative controls).

Figure 3. Lateral and anterior migration. **A.** Lateral migration. **B.** Anterior migration.

There were no cases of motor or visceral complications, infections or retroperitoneal hematomas (Tables 4 and 5).

Table 4. Complications associated with the approach

Complications associated with the approach	Amount (%)	Description
Motor	0 (0%)	
Sensory	2 (4%)	Chronic intercostal pain (1 case) Long-term thigh dysesthesia (1 case)
Psoas pain/weakness	7 (14%)	Pain with hip flexion (5 cases) Weakness (2 cases)
Vascular	1 (2%)	Injury of the spinal segmental artery
Visceral	0 (0%)	
Infections	0 (0%)	
Abdominal hernia/pseudohernia	1 (2%)	Abdominal muscle paresthesia, 2-3 level
Retroperitoneal hematoma	0 (0%)	

Table 5. Complications associated with the surgical technique

Complications associated with the surgical technique	Amount (%)	Description
Anterior longitudinal ligament rupture	1 (2%)	Cage screwed in an anterior position
Vertebral body fracture/subsidence	5 (10%)	Longitudinal L3-body fracture (1 case) Subsidence (4 cases)
Misplaced cage/migration	4 (8%)	Laterally misplaced cage (2 cases) 1 anterior migration and 1 lateral migration (2 cases)

DISCUSSION

No medical or surgical intervention can be completely free of complications. Technological development seeks to minimize the potential adverse events that may be encountered during surgical procedures and after the intervention. MIS procedures aim at these outcomes, trying to lessen the damage inflicted on patients and their hospital stay while speeding their recovery.

Like any new procedure, it involves a learning curve. The surgeon's training began with corpses and later involved selected patients where to apply the newly acquired technique. Our analysis of the complications related to the surgeon's experience showed that most complications (12 cases, 24%) occurred in the first group. All complications were associated with surgical access and not with cage implantation, likely due to the new spinal access, different from traditional approaches. After the first group, complication incidence exponentially decreased until they reached a minimum of 6%; however, the complications encountered in the last patients were not associated with the surgical access, but with surgical technique errors.

In our 50-case series, the early surgical complication rate for MISS was 42%, which is much higher than the rate reported by Rodgers *et al.*[2] in their 600-XLIF surgeries (42% vs. 6.2%). However, since only 8% of our patients suffer complications involving chronic functional disorders (major complications), our results are not that different. In addition, Rodgers *et al*. did not consider psoas muscle weakness a complication, as they considered direct trauma to the psoas muscle a common feature of the approach. As we did consider it a complication, albeit minor, this factor also plays a role in the final rate difference.

In their 84-case series, Youssef *et al*.[3] reported a major complication rate ranging from 4% to 8.6% and a minor complication rate ranging from 1.3% to 13.3%, which coincides with our minor complication rate (2%-14%), where thigh weakness and pain represent the highest rate (7 cases, 14%).

Most publications that address the complications encountered with the lateral access include sensory symptoms, thigh weakness and pain, and report rates ranging from 5% to approximately 70%. Such is the case of the article of Tohmeh *et al*.,[4] who studied 102 patients that underwent a lateral interbody fusion using neurophysiological monitoring and found that 17.6% experienced a postoperative thigh sensory loss, with complete resolution within 6 months. Lee *et al*.[5] studied hip flexion strength following lateral lumbar interbody fusion in 33 patients, all of whom had motor weakness and a full recovery two weeks after surgery. Our statistical analysis of these complications shows that the patients (7 cases, 14%) improved within a month after surgery. These symptoms are closely associated with the spreading of the psoas muscle fibers and the approach direct injury to the ilioinguinal nerve or the iliohypogastric nerve (located in the abdominal wall) and, sometimes, to the genitofemoral nerve (located within the psoas muscle). The sensory monitoring of these nerves is challenging. To prevent or decrease this complication requires special attention in the incision management and direct visualization of the nerves during the abdominal wall stage of the approach, when visible, by gently separating the retroperitoneal space while accessing the cavity. To summarize, it is vital to have a full understanding of the peritoneum and the lumbar plexus anatomy.

Nerve injury to a motor branch of the lumbosacral plexus is described as one of the most devastating complications associated with this procedure. The L4-L5 level is considered to pose the highest risk, according to several authors, as the femoral nerve is close to the ideal site for cage implantation, in the posterior two-thirds of the disc, In their retrospective study, Cahill *et al*.[6] studied the incidence of the femoral nerve injury in 118 patients, and reported that the procedures involving the L4-L5 level had a 5% rate of femoral nerve injuries. Knight *et al*.[7] reported that 2 out of their 58 patients treated with lateral approach showed residual motor effects due to L4 nerve injury.

In our study, although we had no complications associated with motor nerve injuries, we had only four procedures involving the L4-L5 level, so no significant conclusion may be drawn. However, two major circumstances should be taken into consideration: 1) the thorough preoperative strategy planning and imaging examination, studying the MRIs and CTs (especially the transverse and frontal sections); 2) the retractor time never exceeded 20-30 minutes per level, as suggested by Bendersky *et al*.,[8] as it decreases the incidence of femoral nerve neuropraxia produced by the compression of the retractor blades, which may occur due to the close proximity to the discectomy site.

Another complex injury due to close proximity to the vertebral body is the vascular injury, as great vessels and segmental arteries may be injured. The slightest incision interferes with the repair of a potential vascular injury, which is associated with the great vessels, owing to its anterior location, thus being potentially fatal, as published by Assina *et al*.[9] in the first death report due to an inferior vena cava injury caused by split retractor blades.

In our case series, there was only one case of segmental artery injury, which the surgical team was able to ligate without modifying the original incision. Santillan *et al*.[10] reported a case of a segmental artery injury, with delayed diagnosis, which was treated with angiographic embolization.

Larger case series have reported low incidence rates for vascular injuries and lateral decubitus position moving the vessels away from the surgical field, thus helping in the prevention of potential injuries. This movement is very well described the MRI study on the abdominal structures movements associated with the change from a supine to a lateral decubitus position, conducted by Deukemedjian *et al*.[11] We believe and insist on the importance of a thorough preoperative imaging assessment, which aids in decreasing risks and evaluating if the procedure is feasible.

Cage subsidence is a common phenomenon in lumbar interbody fusion, and also happens with the lateral approach. Most studies consider patient bone quality, interbody cage size and failure to achieve bone fusion as associated factors.

Le *et al*.[12] reported a radiographical subsidence rate of 14.3% and a clinical subsidence rate of 2.1% in 140 patients and concluded that the use of 22-mm width cages would decrease the subsidence rate. Marchi *et al*.[13] suggested using wider cages (>22-26mm) and not particularly long cages (8-12 mm) to prevent this risk. In our study, all implanted cages were 22-mm width, and there were 4 subsidence cases (8%): 3 in the inferior endplate and 1 in the superior endplate, diagnosed in the immediate postoperative period. Although all these fusions were supplemented with posterior fixation, cages still sagged into the vertebral body, which was ascribed to an aggressive force applied on the vertebral endplates when preparing the intervertebral space. This factor may be included among the previously mentioned and could be prevented by a thoughtful preparation of the intervertebral space and avoiding the unintentional endplate breach, which usually sustains some damage. Although we do not dismiss that there could be more subsidence cases in late follow-ups, this study only assessed early complications.

Another rare complication is the vertebral body fracture. Brier-Jones *et al*.[14] reported four cases of patients with intraoperative vertebral body fractures, all caused by endplate breach. These authors considered that they were due to the attachment of lateral plates with screws too close to the endplate, which can alter the cancellous bone beneath it, weakening and overloading the endplate, thus resulting in the cage causing endplate breach. Other authors have also associated vertebral body fracture with the application of a lateral plate fixation, such as Kepler *et al*.[15] We had only one case of vertebral body fracture, which involved no lateral plate fixation but a supplemental posterior pedicle fixation. We believe the fracture resulted from a violation of the inferior endplate of the superior disc during the implantation of the first cage and the later weakening of the superior endplate of the disc distal to L3-body during the implantation of the second cage, thus causing the longitudinal fracture line. As we have mentioned above, these complications could be avoided by thorough management applied on endplate preparation, endeavored to prevent its weakening. Additionally, the implantation of interbody cages should involve using blades to prevent endplate damage and avoiding overdistraction caused by too large implants, especially in patients with significant osteoporosis.

Lateral cage migration is a rare complication associated with the lateral approach. We only found one case reported in the available literature of laterally migrated interbody cages, despite posterior fixation.[16] The patient was symptomatic and migration was resolved with revision surgery. Towers *et al*.[17] reported a case of lateral cage migration, however, the patient was asymptomatic, it involved a stand-alone fusion and it did not require a revision surgery. This case is similar to our only lateral migration in a L3-L4 lateral fusion, although with posterior fixation; the patient was asymptomatic and did not require a new surgical intervention.

We know that this technique includes releasing the lateral ligaments; however, due to the cage own stability achieved when restoring disc space height, it should not migrate. Towers *et al*.[17] suspected that migration may be due to two factors: 1) an uneven posterior compression of the pedicle screws during the supplemental posterior fixation; or 2) an inadequate release of the contralateral ligament. These factors may result in a slight coronal imbalance, asymmetrically overloading the cage, and thus contributing to its migration. Towers *et al*.[17] suggest the application of a lateral plate to act as a buttress in cases involving significant coronal plane deformity. We believe that the proper management of the contralateral ligament and the use of an adequate cage size should achieve stability without the need of a lateral plate.

One patient (2%) had pseudohernia (abdominal wall muscles paresis), a very rare complication, that spontaneously subsided within 3 months after surgery. Our findings coincide with those of Dakwar *et al*.,[18] who reported a 1.8 incidence and no sequelae.

Three nerves innervate the abdominal wall muscles (subcostal, iliohypogastric, and ilioinguinal) and are present in the first steps of the lateral approach (abdominal wall and retroperitoneal fat). We suggest to carry out a blunt and soft divulsion of the abdominal muscles and separation of the peritoneum (no electric scalpel), to prevent this rare complication.

CONCLUSION

The main complications occurred in the surgical access, and their incidence progressively decreased as the surgeon's experience increased and as the surgical time shortened, thus making this type of procedure safer and more reliable.

Conflict of interests: Authors claim they do not have any conflict of interest.

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