Original article

Particularities of anterior fusion in L4-L5 isthmic spondylolisthesis


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A B S T R A C T

Purpose: L4-L5 isthmic spondylolisthesis may be associated with lumbosacral transitional vertebrae (LSTV) and altered venous vascular anatomy. The objectives of this study were to describe the anatomical characteristics of L4-L5 ISPL and the intraoperative difficulties encountered during the approach for anterior lumbar interbody fusion (ALIF).

Methods: This is a retrospective review of 20 ALIFs for L4-L5 ISPL. The anatomy of the common iliac veins confluence and the position of L4-L5 with respect to the projection of the iliac crest were analysed on CT-scan. Intraoperative difficulties were noted.

Results: A LSTV was present in 60% of cases, associated with abnormally distal positioning of L4-L5 below the projection of the iliac crest. The common iliac veins confluence was abnormally proximal compared to L4-L5. No complication was noted, even if the approach was unusually difficult in 11 cases.

Discussion: Anterior lumbotomies are difficult because the left common iliac vein courses transversely across the left anterolateral aspect of the L4-L5 disc and L5 vertebral body, increasing the risk of vascular injury. Those difficulties have led us to abandon lumbotomies to treat L4-L5 ISPL to favour a pure anterior approach (midline) or an exclusive posterior approach.

Level of evidence: IV (retrospective study).

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1. Introduction

Anterior approach to the lumbar spine has become an increasingly popular procedure due to the use of anterior lumbar interbody fusion (ALIF) to treat degenerative disc disease, degenerative spondylolisthesis [1] or scoliosis and isthmic spondylolisthesis (ISPL).

There is no ideal surgical procedure to treat ISPL in adults, based on published data [2]. In a systematic review, Jacobs et al. [3] reported good or excellent clinical outcome from 85 to 94% after ALIF for ISPL. The majority of ISPL is located at L5-S1, and only 10% are located at L4-L5 [4]. L4-L5 ISPL are rare and poorly studied. They may be associated with lumbosacral transitional vertebrae (LSTV), which are common congenital anomalies of the human spine, resulting in numerous abnormalities of the lumbar and sacral segments [5]. Altered venous vascular anatomy is often found anterior to the functional lumbosacral disc in the presence of a LSTV [6]. This may be problematic during anterior surgical approach of the lumbar spine since the most feared complications are vascular in nature, primarily venous injuries [6].

Our objectives were to describe the anatomical (radiological) characteristics of L4-L5 ISPL, then, to describe the intraoperative difficulties encountered during the approach for ALIF.

2. Materials methods

2.1. The series

We conducted a single-centre retrospective study of a series of 20 consecutive patients, 11 women (55%) and 9 men (45%), who underwent ALIF for L4-L5 ISPL between 2005 and 2013. The mean age at the time of surgery was 51 years (range: 29–71 years). The mean body mass index was 26.8 kg/m² (range: 21–31 kg/m²). All patients were either graded 1 or 2 according to ASA score.
2.2. Preoperative planning and radiological analysis

Preoperative radiological assessment included a computed tomography (CT) scan with 3D reconstruction of the lumbar spine and major vessels. Imaging studies were evaluated by blinded independent single review.

CT-scan with multiplanar reconstructions of the spine and the lumbosacral anterior great vessels were analysed using Kodak Carestream Picture Archiving and Communication System (PACS) software 11.0 (Eastman Kodak/Carestream Health, Rochester, NY, USA). A CT-based classification by Stenning et al. [7] was used to describe the type of LSTV (Fig. 1). The following parameters were measured to define the anatomy of the confluence of the common iliac veins and its relationship to the L4-L5 intervertebral disc: the confluence angle of the common iliac veins, and the distances between the confluence and the inferior boundary of L4 and L5 endplates (Fig. 2). The position of L4-L5 with respect to the projection of the iliac crest was noted (Fig. 3).

2.3. Surgical technique

An in situ ALIF was performed in all cases, through a retroperitoneal prepsoatic approach, as described previously [1,2]. After access to the retroperitoneal space, the posterior parietal peritoneum, to which the ureter is attached, was lifted off with a cotton-tipped applicator and mobilized medially. Depending on the local anatomy, to access L4-L5 disc, we either mobilized the iliac vein beyond the midline, then held with Steinman pins that were inserted into the L4 and L5 vertebral bodies, or we pushed back the vena cava confluence upwards and laterally with Steinman pins that were also inserted into the L4 and L5 vertebral bodies. The iliolumbar vein and the metamerism of the lumbar blood vessels above and below the olisthetic level were ligated or clipped, then cut.

In all cases, after extensive discectomy, endplate cartilage was removed. Instrumentation consisted in an anterior lumbar plate (n = 4) or a standalone cage (n = 16). Grafting was either autologous

<table>
<thead>
<tr>
<th>Type of lumbosacral transitional vertebrae (LSTV)</th>
<th>n = 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 0 (normal anatomy)</td>
<td>8/20  (40%)</td>
</tr>
<tr>
<td>Type 1</td>
<td>2/20  (10%)</td>
</tr>
<tr>
<td>Asymmetrical L5 TP with asymmetrical shortening of the iliolumbar ligament</td>
<td></td>
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<tr>
<td>Type 2</td>
<td>3/20  (15%)</td>
</tr>
<tr>
<td>L5 TP located within 2 mm of the sacrum but not forming a joint</td>
<td></td>
</tr>
<tr>
<td>Type 3 (A or B)</td>
<td>6/20  (30%)</td>
</tr>
<tr>
<td>L5 TP has formed an abnormal joint with the sacrum (B = degenerative aspect)</td>
<td></td>
</tr>
<tr>
<td>Type 4</td>
<td>1/20  (5%)</td>
</tr>
<tr>
<td>Fusion between L5 TP and sacrum</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1. Classification for lumbosacral segment abnormalities by Stenning et al. [7]. n: indicates number of cases; TP: transverse process.
bone graft harvested from the ipsilateral iliac crest \((n = 10)\), or 4 mg (1/3 of a sponge) of rhBMP-2 (Inductos®, MEDTRONIC WYETH PHARMACEUTICALS, Maidenhead, Berkshire, UK) \((n = 10)\).

3. Results

3.1. Preoperative planning of the anatomy of the iliac veins confluence and localisation of L4-L5 level

A LSTV (uni- or bilateral sacralization of L5) was present in 60% of cases of L4-L5 ISPL \((12/20\) (Fig. 1). The disc L4-L5 was below the projection of the iliac crest in 45% of cases \((9/20\) (Fig. 3), and in each of these cases, CT-scan showed the presence of a LSTV. In case of LSTV, L4-L5 was below the projection of the iliac crest in 92% of cases. Patients with a LSTV had a confluence of the common iliac veins significantly more proximal to the inferior boundary of the L5 endplate than patients without LSTV (Table 1). The mean confluence angle of the common iliac veins was also steeper in this group, but this did not reach statistical significance.

3.2. Intraoperative difficulties

Anterior approach of the lumbar spine was performed by laparotomy in the supine position \((n = 3)\), or through a minimally invasive lumbotomy \((n = 17)\) with left \((n = 13)\) or right \((n = 4)\) preposaotic retroperitoneal approach. Left- or right-sided approach was performed depending on the position of the left iliac vein on the preoperative planning. An attempt to mobilize the iliac vein medially, beyond the midline, was tried in all cases except one, where preoperative planning showed enough room to approach the L4-L5 disc between the 2 common iliac veins. In 11 cases \((58\%)\), mobilization of the vein was reported to be difficult and in 2 cases, it turned out to be impossible and approach of the L4-L5 disc was performed pushing back the confluence upwards and laterally. In most cases \((n = 17)\), approach could be performed laterally to the iliac vein. Despite the fact that the approach was reported to be difficult in more than half of the cases, no vascular injury was observed. No other intraoperative complications were reported.

The mean operative time was 172 min \((range: 110–200\) min). The average estimated blood loss \((EBL)\) was 261 mL \((range: 0–700\) mL). Due to the size of the series, we could not find any differences in EBL or operative time according to the presence of a LSTV or depending on the approach.
4. Discussion

Surgical treatment of ISPL is based on anterior, posterior or combined procedures [2,3,8]. Results of these procedures have been widely reported, but, to our knowledge, no studies targeting specifically L4-L5 ISPL have been published so far. L4-L5 ISPL represents numerous specificities, especially anatomical, that are not encountered in ALIFs for L4-L5 degenerative spondylolisthesis, and that might raise issues during their surgical management [4].

A LSTV (sacralisation of L5) was found in 60% of the patients in our series, whereas the prevalence of this anomaly is estimated between 4% and 35% in the general population [5,9,10]. This association can be explained by two phenomena. First, the lack of lordosis at L5-S1, in case of sacralisation of L5, causes a reaction hyperlordosis at L4-L5 to maintain a satisfactory sagittal balance, which is a known cause of pars defect. Second, the lack of mobility at L5-S1, in case of sacralisation of L5, logically leads to mechanical overuse at L4-L5 in early childhood, which favours the occurrence of pars defect at L4. However, it should be noted that epidemiological studies on LSTV do not show an increased risk of ISPL [11,12].

We have demonstrated that in case of L4-L5 ISPL, the olisthetic disc was below the projection of the iliac crest in about half of the cases (92% in case of LSTV). Therefore, in these cases, direct lateral pre- or trans-pectoral approaches, which must always go above the iliac crest, are impossible (Fig. 3). Lateral lumbar interbody fusions (LII) are therefore contraindicated in this pathology. If the surgeon chooses to perform an anterior approach of the lumbar spine, as a standalone procedure or combined to a posterior fusion, the approach must be more anterior, either a classic lumbotomy, or even a midline incision, as one would perform for L5-S1 ALIF or L4-L5 total disc replacement. However, these solutions run into another difficulty: the abnormally proximal iliac veins confluence in case of L4-L5 ISPL, especially if associated with LSTV, responsible for a far more lateral positioning of the left common iliac vein. The left common iliac vein courses transversely across the left anterolateral aspect of the L4-L5 disc and L5 vertebral body, preventing access. It is therefore necessary to mobilize the left common iliac vein more aggressively than usual to get a good exposure of the surgical site. The close proximity of the vein during exposure, dissectionary and instrumentation increases the risk of intraoperative vascular injury. The difficulties have been reported by Weiner et al., who identified 11 approach-related difficulties in a cohort of 107 patients with LSTV undergoing ALIF at the last mobile level. In addition to abnormally proximal positioning of the iliac veins confluence, Weiner et al. described abnormally proximal insertion of the ascending iliolumbar vein into the left common iliac vein, complicating the procedure [6]. Chithiriki et al. confirm our findings in their study on the relationship of the aortic bifurcation to the lumbar spine [13]. The aortic bifurcation was located at L3 in 59% of cases in patients with sacralisation of L5 and at L4 in 67% for the rest of the patients.

5. Conclusions

The high incidence of associated LSTV, responsible for placing the L4-L5 disc below the iliac crest, prohibits the use of LLIF techniques for L4-L5 ISPL. Approaches performed more anteriorly are rendered also much more difficult than in the degenerative pathology at L4-L5, because the left common iliac vein courses transversely across the left anterolateral aspect of the L4-L5 disc and L5 vertebral body, preventing access and increasing the risk of intraoperative vascular injury. Difficulties in approaching the spine have led us to abandon lumbotomies for L4-L5 ISPL to favour either a pure anterior approach (midline) or an exclusive posterior approach.

Disclosure of interest

The authors declare that they have no competing interest.

References