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ORIGINAL ARTICLE

Preoperative phlebography in anterior L4-L5 disc approach. Clinical experience about 63 cases

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KEYWORDS
Iliocava junction;
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Anterior approach lumbar spine

Summary
Introduction: The anterior approach of the L4-L5 disc requires a perfect knowledge of the venous anatomy. Some configurations make this approach hazardous. The purpose of this study is to classify configurations of the iliocava junction and the iliolumbar vein relative to L4-L5 and to analyze vascular complications.
Materials and methods: The preoperative phlebographies of 63 patients (30 men, 33 women, mean age 42 years) undergoing a L4-L5 disc replacement were reviewed. The height of the iliocava junction was calculated as a ratio of the distance between the discs L4-L5 and L5-S1. The position of the left iliac vein was classified into three thirds across the width of L5. The number of branches of the iliolumbar vein was noted. Surgical reports were reviewed for complications.
Results: The height of the iliocava junction was very high in six, high in 25, low in 26 and very low in six patients. The position of the left iliac vein was medial in 20, intermediate in 28 and lateral in 15 patients. The iliolumbar vein had one branch in 37, two in 20, three in three patients. It was not visualized in three cases. Variants of the venous anatomy included eight duplications of the left iliac vein, four wide diameters and one iliolumbar vein network pattern. Intraoperatively, three lacerations of iliolumbar veins occurred.
Conclusion: The iliocava anatomy is very variable: the safety of an anterior approach to the L4-L5 disc depends on it. The information of preoperative phlebography can help to plan a more accessible antero-lateral approach or to switch on a posterior fusion if the anatomical situation is deemed too dangerous, such as duplicated left iliac veins.
Level of evidence: Level IV. Diagnostic study.

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Introduction

The anterior retroperitoneal approach to the lumbar spine is widely used for total disc replacement or anterior lumbar interbody fusion (ALIF) [1—4]. Because of the vascular anatomy, anterior approaches to the caudal lumbar spine are associated with exposure-related complications rates ranging from 2% to 18% [3,5—8]. Particular attention must be paid to venous anatomy of the vena cava, the iliac vein and the iliolumbar vein, because venous injuries belong to the most serious complications during the retroperitoneal approach and exposure of the spine [9—11]. While the approach to the L5-S1 disc space in the window below the iliocava junction is well described and codified, less attention has been paid to the L4-L5 disc space and its relationship to the venous anatomy [12—15].

Dissection of the L4-L5 disc space can be very challenging, because a certain number of anatomical configurations and variants, including duplications of the left iliac vein, may be present [16]. For a direct anterior approach of L4-L5, the iliolumbar vein and its branches, which can also present many anatomical variants, have to be ligated in order to retract the vena cava and the left iliac vein medially [10,17]. In the case of an ALIF, an antero-lateral approach to the intersomatic space can be used which requires fewer manipulations of the vessels since the iliocava junction has not to be retracted as far laterally. A strictly anterior approach to the disc is however mandatory when a total disc replacement is performed. Techniques that allow an implantation of an artificial disc through an antero-lateral pathway and minimize vascular dissection are currently under study [18].

The purpose of this study was to retrospectively review the preoperative phlebography of patients who were indicated for a retroperitoneal approach to the L4-L5 disc space at our institution. The relationships between the disc, the height of the iliocava junction and the lateral position of the left iliac vein were determined. The occurrence of iliac duplications and the configuration of the iliolumbar vein were studied. The concordance between surgical complications such as venous injuries and anatomical variants were recorded.

Materials and methods

Institutional review board approval was obtained for this retrospective study. Sixty-three consecutive patients who were indicated for a total lumbar disc replacement of L4-L5 underwent a preoperative phlebography from January 2004 until March 2011 at our institution. There were 33 male and 30 female patients. Their average age at the time of surgery was 42 years and ranged from 29 to 57 years. These patients' clinical charts and phlebographies were reviewed by two independent spine surgeons in order to decrease the inter-observer variations.

The phlebographies were performed by senior radiologists. In brief, after puncture of the left femoral vein the catheter was advanced to the left iliac vein. Contrast medium was injected and the patient was asked to perform a Valsalva maneuver to obtain retrograde filling of the vena cava, the right iliac vein and the iliolumbar vein including its different branches if present (Fig. 1).

Figure 1 Phlebography representing the iliocava junction and the iliolumbar vein with regard to the L4-L5 disc space.

The surgical technique consisted of a left paramedian skin incision, identification of the external oblique fascia and incision of it. The rectus muscle was mobilized laterally to identify the posterior rectus sheath and the semilunar line of Douglas. From here, the retroperitoneal space could be developed down to the psoas muscle. The left iliac artery and vein were identified and, after ligation of the iliolumbar vein, the iliac vessels were retracted in order to expose the anterior longitudinal ligament and the L4-L5 disc from the left to the right antero-lateral border of the annulus.

All preoperative phlebographies were reviewed in order to determine the vertical position of the iliocava junction (JP). Therefore, a ratio of the distance between Dj (inferior border of the iliocava junction to center of the L5-S1 disc space) and Dd (distance between the centers of L4-L5 and L5-S1 disc spaces) was calculated: $JP = 100 - (Dj / Dd \times 100)$. This formula has already been validated [5,17] and is illustrated by Fig. 2. The heights of the iliocava junction were classified into four groups: very high JP inferior to −33,3%, high JP between −33,3 and 33,3%, low JP between 33.4 and 66.6%, and very low JP superior to 66.7% (Fig. 3).

For the position of the left iliac vein (VP) in the frontal plane, a ratio was calculated between Dw (width of the left half of the superior L5 endplate) and Dlm (lateral border of the left iliac vein to left lateral margin of the L5 vertebral body): $VP = 100 - (Dlm / Dw \times 100)$ as illustrated by Fig. 2. The position of the left iliac vein was classified as: medial VP inferior to 33.3%, intermediate VP between 33.4 and 66.6%, and lateral VP superior to 66.6% (Fig. 4).

Furthermore, the anatomical configuration of the iliolumbar vein was analyzed. It was classified into three degrees, according to its number of branches ranging from one to three. Configurations with more than three branches were not identified in the present cohort.

The medical records were screened for the following items: demographic characteristics of the patients, surgical indications, and possible contraindications related to the

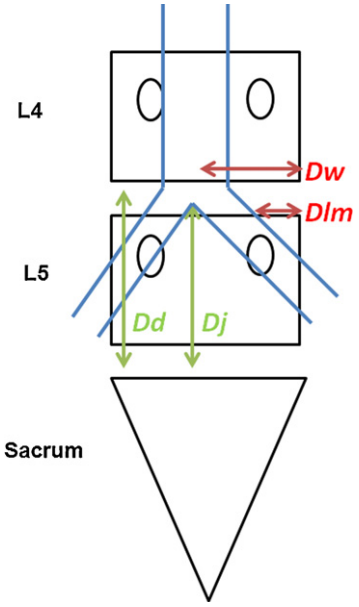

Figure 2 Height of the iliocava junction JP = 100 − (Dj / Dd × 100); Dj = inferior border of the iliocava junction to center of the L5-S1 disc space and Dd: distance between the centers of L4-L5 and L5-S1 disc spaces. Position of the left iliac vein VP = 100 − (Dlm / Dw × 100); Dw: width of the left half of the superior L5 endplate and Dlm: lateral border of the left iliac vein to left lateral margin of the L5 vertebral body.

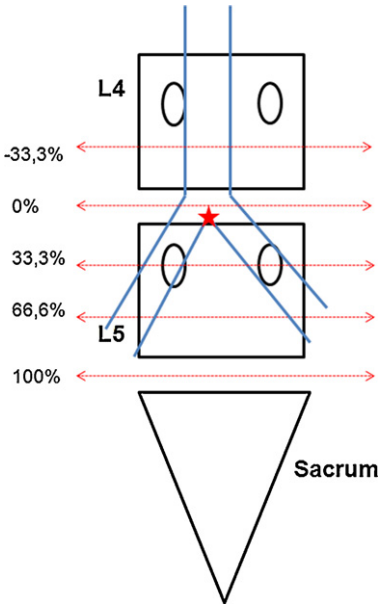

Figure 3 Classification of the height of the iliocava junction.

result of phlebography. Surgical reports were reviewed to collect data on adverse events or complications and particular difficulties related to the exposure of the L4-L5 disc.

Statistical evaluation was performed with SPSS software version 16.0 (SPSS Inc, Chicago, IL). Descriptive statistics were used to characterize the demographic characteristics of the patients. The distribution of the different positions

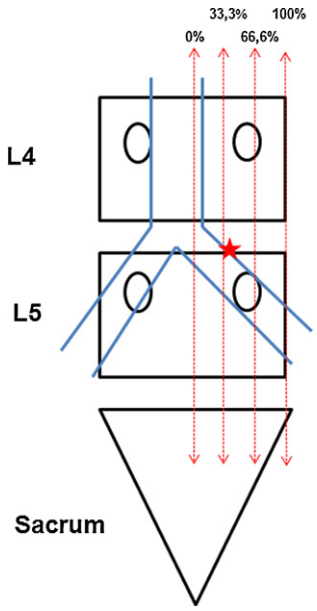

Figure 4 Classification of the position of the left iliac vein.

of the iliocava junction and the left iliac vein was analyzed with a Shapiro-Wilk normality test. The Fisher's exact test was used for the analysis of qualitative data in the evaluation of the relationship between anatomical variations and venous injuries. The significance level was set at $P < 0.05$.

Results

Out of 63 analyzed phlebographies, the vertical position of the iliocava junction was very high in six, high in 25, low in 26 and very low in six patients. This distribution, demonstrated in Fig. 5, did not follow a statistically normal distribution. However, it became apparent that the most frequent position of the iliocava junction was low ($P = 0.0035$). The calculated ratio JP was around 50% and mostly comprised between 20% and 80%. This corresponds to the projection of the anatomical area between the pedicles and the caudal endplate of L5 in the frontal plane.

The position of the left iliac vein was classified as medial in 20, intermediate in 28 and lateral in 15 patients. This distribution is shown in Fig. 6. It followed a statistically normal distribution which was, however, not significant ($P = 0.6828$). The calculated ratio VP was mostly in an intermediate position around 50%, which corresponds to the region between the three-quarter and the lateral left one-quarter of the vertebral body of L5 in the frontal plane. This area also corresponds to the projection of the medial border of the left L5 pedicle.

The anatomical configuration of the iliolumbar vein presented one branch in 37, two branches in 20 and three branches in three patients. On three phlebographies, the iliolumbar vein could not be visualized although a Valsalva maneuver was performed by all patients.

We identified 13 remarkable anatomical variations out of 63 phlebographies (21% of the cases), including eight duplications of the iliac veins (Fig. 7), four left iliac veins with a particularly important diameter (Fig. 8) and one case in

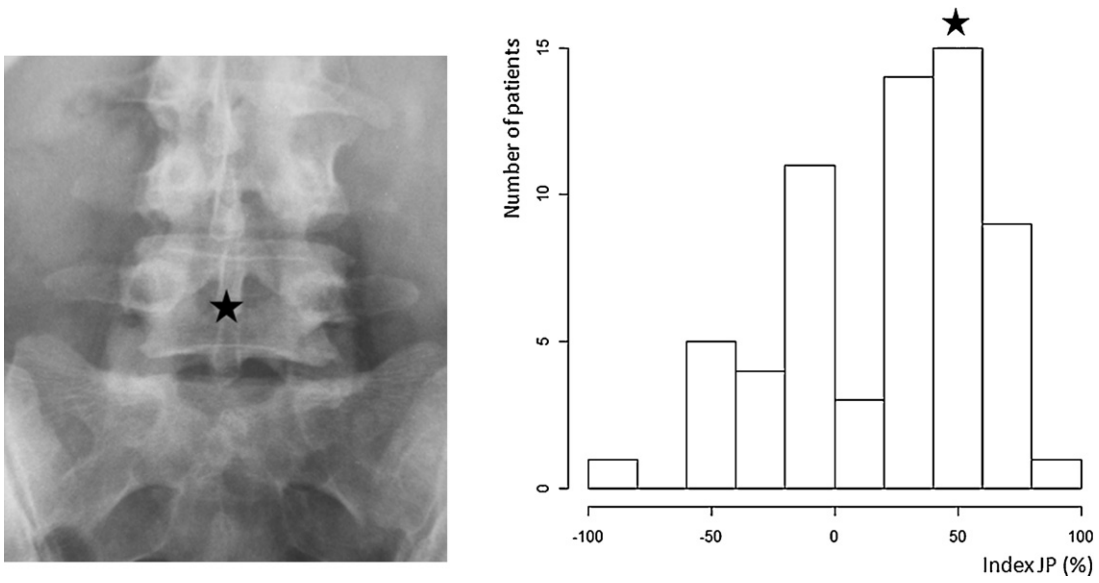

Figure 5 Distribution of the height of the iliocava junction, star indicating the most frequent localization.

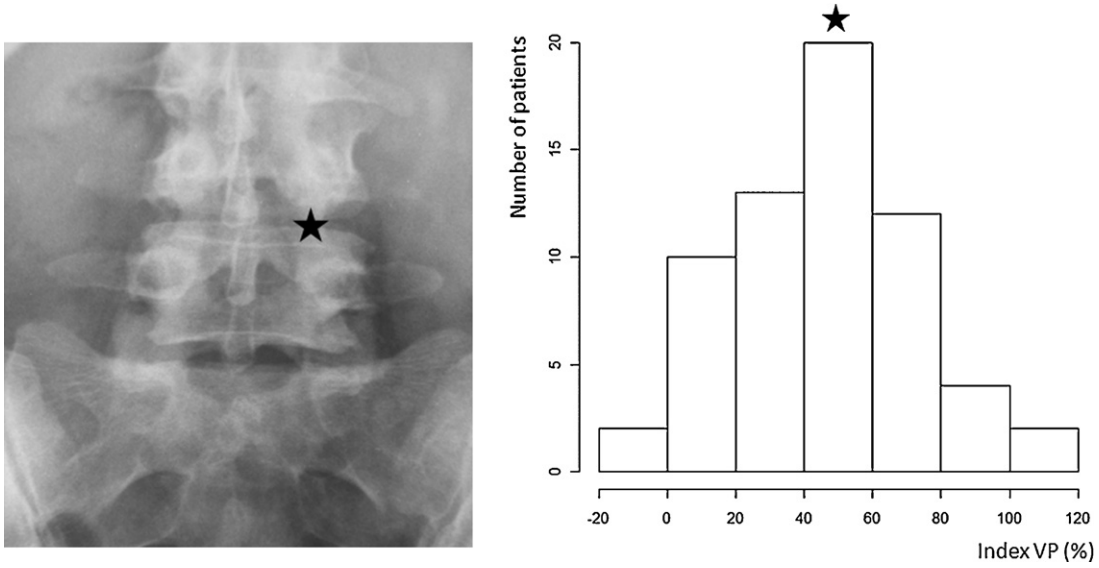

Figure 6 Distribution of the position of the left iliac vein, star indicating the most frequent localization.

which the iliolumbar vein confluence presented a network pattern on the height of the L4-L5 disc although two main branches were identified (Fig. 9).

Of the 63 patients, four refused to undergo the planned surgical intervention after informed consent and preferred the alternative of a posterior L4-L5 fusion. In eight patients, the anterior approach was deemed too dangerous by the surgeon with regard to the venous anatomy as evidenced by the phlebography. The remaining 51 patients were operated on for total lumbar disc replacement using a retroperitoneal anterior approach. According to the surgical reports, the approach was difficult in 12 patients because of a complex vascular anatomy and adhesive tissues. There occurred three venous vascular injuries (6% of the cases) which could be managed by a suture.

Discussion

The anatomical relationship of the iliocava junction of the lumbosacral spine and the aortic bifurcation, as well as possible variations in lumbosacral transitional vertebrae, have been well described [11,14,19]. Nevertheless, the anterior approach to the L4-L5 disc space can be very challenging and present a certain risk in terms of vascular complications. It is therefore mandatory to be aware or the individual vascular anatomy of each patient preoperatively since a certain number of anatomical variations may be present [10,13,17].

The height the iliocava junction has been studied by Pirró et al. [11] on 42 cadaver dissections. They found 12% of junctions at the level of the L4 vertebral body, 2% at the level of the L4-L5 disc, 64% at the level of L5, 12% at the level of the disc L5-S1 and 10% at the level of S1. Cho et al. [20]

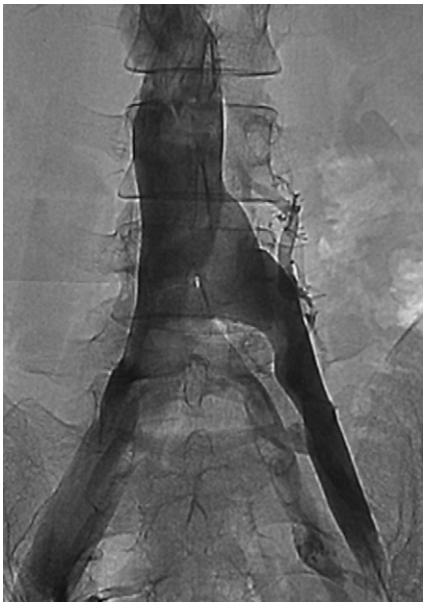

Figure 7 Duplication of the left common iliac vein.

Figure 8 Particular wide diameter of the left common iliac vein.

described similar relationships on 35 cadaver specimens, but focused on the anatomical area between the iliac vessels and the L5-S1 disc. Cappellades et al. [12] determined the height of the iliocava junction on a preoperative magnetic resonance angiography in 134 patients in order to describe the operative window delimited by the iliac veins at L5-S1. We used the same classification as these authors to assess the height of the iliocava junction. In their study, this point was very high in 4%, high in 60%, low in 26%, and very low in 10% of the patients. Madi et al. [16] applied a similar method on 35 magnetic resonance angiographies and demonstrated that 4% were very high, 56 were high, 29 were low, and 11% were low. Overall, the distribution found in our cohort seemed to be concordant with these previous results, although the

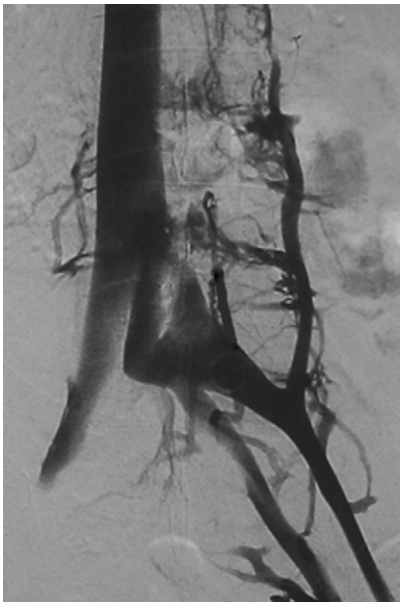

Figure 9 Iliolumbar vein confluence with a network pattern on the height of the L4-L5 disc.

height of the iliocava junction was slightly shifted caudally, with a peak of frequency at the level of the L5 vertebral body in our patients.

In the surgical approach to the L4-L5 disc space, the lateral position of the left iliac vein represents a major concern since this vessel needs to be mobilized and retracted to the right side in order to allow an anterior access to the disc. Cappellades et al. [12] have analyzed the position of the left iliac vein in relation to the L5-S1 disc using a similar method as we used for the L4-L5 disc. These authors found a medial position in 15%, an intermediate position in 18%, and a lateral position in 67% of their patients. Madi et al. [16] did also determine the lateral position of the left iliac vein with respect to the L5-S1 disc. The left iliac vein was in a medial position in 11%, intermediate in 28%, and lateral in 61%. These results are not strictly comparable to ours because the evaluated disc level was not the same. At L4-L5, the position of the left iliac vein was predominantly medial in 32% and intermediate in 44%, and only lateral in 24% of the patients. This is due to the more cranial localization in the transversal plane in relation to the iliocava junction. The knowledge of this position seems more important preoperatively when an access of the L4-L5 disc space is planned, because the position of the left iliac vein will represent the limiting factor. On the other hand, the height of the iliocava junction might be of a greater interest when operating the L5-S1 disc because its anterior approach is located in between both common iliac veins [21].

The ligation of the iliolumbar vein and its possible multiple branches is crucial for a safe mobilization of the left common iliac vein to the right and a sufficient exposure of the L4-L5 disc. Kiray et al. [17] have described five different drainage patterns between the iliolumbar vein and the lumbosacral major veins on 19 cadaver specimens: 44% presented two different branches of the iliolumbar vein and the ascending lumbar vein, 26% the veins presented a common trunk connected to the left iliac vein, and three other types

of venous confluences in 30% that were linked more distally to the external or internal iliac veins. Jasani and Jaffray [10] focused on the relationship between the left common iliac vein and the configurations of the iliolumbar vein and its tributaries on eight cadaver specimens. They described two main configurations with either a single iliolumbar vein or two distinct veins draining into the common iliac vein. This particular anatomical region is surgically more relevant for the dissection of the L4-L5 disc. These authors did also describe that in all specimens the iliolumbar vein tore on retracting the great vessels medially for exposure of the L4-L5 disc space. Unruh et al. [22] dissected 20 cadavers and described three different patterns: a common venous trunk combining ascending lumbar and iliolumbar venous systems with distal veins, a common venous trunk without distal veins, and two distinct venous systems. These studies evidence a great variability of iliolumbar venous anatomy. The preoperative phlebography in our study gave a representative indication of the present situation, and it allowed to avoid anterior surgery if a complex pattern with several proximal branches were present (Fig. 9).

Serious exposure-related complications rates are very variable. However, they are mainly due to venous lacerations. Ikard [23] emphasized that the mobilization and retraction of fragile veins represents a particular risk for intraoperative hemorrhage. Wood et al. [8] reviewed the literature and found that venous injuries could occur in up to 18%, particularly at the left iliac vein and the iliolumbar vein. Fantini et al. [6] reported an incidence of 2.9% at the level of the common iliac vein in 345 patients. Gumbs et al. [24] reported on 2% and Kleeman et al. [25] on 1.4% of venous injuries. In our cohort, venous injuries were related to adherent tissues and difficult ligation of the iliolumbar vein in 6% of the patients. Chiriano et al. [9] recommend the presence of a vascular access surgeon which might help diminishing the risk of vascular complications. A vascular surgeon was not systematically involved in our patients. It is therefore useful to determine the vascular anatomy using preoperative imaging, since variations of the normal anatomy may be present.

Lotz and Seeger [13] described normal variations in the iliac venous anatomy on 100 phlebographies. Two duplications, as well as two fenestrations of the left common iliac vein were found. Eight duplications were also determined on the phlebographies in our 63 patients (Fig. 7) which may represent a major difficulty for the exposure of the entire L4-L5 disc and prevent the proper positioning of a disc prosthesis. These cases advocate the use of preoperative imaging, which allows ruling out difficult situations for the anterior approach. Phlebography represents a valuable method to determine which patient could present a dangerous vascular anatomy at the level L4-L5 and where a posterior fusion might be safer.

The alternatives to phlebography are CT-angiography and magnetic resonance imaging (MRI), as described by Cappellades et al. [12] and Madi et al. [16], which is far less invasive and may be chosen instead of phlebography in actual clinical practice. Contraindications to MRI are claustrophobia and the presence of ferromagnetic implants, which can be present in patients already operated on. Barrey et al. [26] and Datta et al. [27] have described three-dimensional (3D) computed tomography (CT) reconstructions of the iliac vessels using contrast media. This procedure seems very seducing, since the anatomical relationship between the spine and the vessels may be clearly visualized, providing the surgeon with a better understanding of the anatomy. These authors stress the advantage of angio-CT which enables to automatically assess the 3D anatomical relationships compared to axial CT, but also mention that recalculation of 3D images can lead to underestimation of the size of vessels, in part because of manual reconstruction and parallax effects in 3D reconstruction. Compared to CT and MRI, phlebography offers the advantage of retrograde filling of the iliolumbar vein and visualization of a possible confluence through a simple Valsalva maneuver. However, a comparative study would be necessary to determine the accuracy of each of these imaging methods with regard to the iliolumbar vein. MRI has an advantage over angio-CT with regard to radiation, but this procedure requires an immobile patient during the exam to avoid motion artifacts. Although 3D reconstructions may be valuable, the patient receives a relatively high radiation dose during angio-CT with an average of 34,1 mSv for the abdomen [28].

The venous anatomy of the iliocava system and the iliolumbar vein demonstrates certain variability. Variants of the so-called ''normal anatomy'' were rated at 21%. It is therefore useful to determine the individual iliocava and iliolumbar anatomy of each patient preoperatively in order to avoid dangerous intraoperative venous lacerations. Preoperative phlebography represents a valuable indicator for preoperative planning of the approach to the L4-L5 disc space, which might help to reduce the risk of exposure-related complications.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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