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Original Article

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An Anatomical Clue for Minimizing Iliac Vein Injury During the Anterolateral Approach at L5–S1 Level: A Cadaveric Study

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Objective: The injury to the common iliac vein (CIV) seems to be the most important concern during the anterior approach to the spine at L5–S1 level. We investigated the anatomy of the L5–S1 vertebral structures related to the CIV through a cadaveric study to find an anatomical clue for safe dissection of CIV.
Methods: Ten cadavers were prepared for this study. After removing the peritoneum and the presacral fascia, the section from the lower part of the L5 to the upper part of the S1 vertebral body was removed with the CIV attached. After decalcification, 2 sections in the vertical and horizontal directions were made for histological study.
Results: An adipose tissue layer was present between the intervertebral disc and CIV. The adipose tissue layer in 6 cadavers was thin, and in 3 of these cadavers, the CIV was attached to the vertebral body and the disc. In the other 4 cadavers, the CIV was clearly separated from the vertebral body and the disc by the intervening adipose tissue layer (IATL). Under the microscope, a thin layer surrounding the anterior longitudinal ligament, periosteum, and disc was observed, and we named this structure the 'perivertebral membrane'. The perivertebral membrane was attached to the CIV when there was no IATL, but a potential space was detected under the membrane.
Conclusion: There was a thin membrane, perivertebral membrane, between the CIV and L5–S1 disc. In cases with CIV adhesion to the disc due to the absence of IATL, the CIV may be mobilized indirectly through the perivertebral membrane.

Keywords: Lumbosacral region, Iliac Vein, Anatomy, Spine, Anterior approach

INTRODUCTION

In the surgical treatment of degenerative lumbar disease, correction of lumbar lordosis is an important factor in maintaining sagittal balance and for a better postoperative clinical course.[1-4] In particular, the segmental angle of L5–S1 plays an important role in lumbar lordosis,[5-7] and there are various types of fusion operations at L5–S1, including anterior lumbar interbody fusion (ALIF), transforaminal lumbar interbody fusion (TLIF), posterior lumbar interbody fusion (PLIF), and oblique lateral interbody fusion (OLIF). Among them, ALIF and OLIF allow an interbody cage with a larger size and angle to be inserted than do the TLIF and PLIF thus ALIF and OLIF are more effective in lower lumbar lordosis correction.[8-10] ALIF and OLIF require mobilization of the common iliac vein (CIV) to access the disc space, and injury to the CIV is one of the major fatal complications of these surgical procedures.

Several studies have reported the occurrence of vascular complications in ALIF and OLIF (3.3% vs. 4.3%, respectively),[11-14] and other papers on preoperative radiological evaluation have tried to find clues so that such vascular complications can be minimized.[15-17] However, no studies suggest how to prevent complications by using the anatomical structures related to the CIV at the anterior surface of the L5–S1 disc as markers, from a specific viewpoint of the spinal surgeon.

In this study, we investigated the anatomical relationship of the structures in front of the L5–S1 disc through a cadaveric study and tried to find an anatomical clue to reduce CIV injury during the anterior interbody fusion surgery at the L5–S1 level.

MATERIALS AND METHODS

Ten cadavers (6 males and 4 females) were prepared for this study. All cadavers were donated to the department of anatomy for educational and research purposes. All the cadavers were Korean, with no history of spinal or abdominal surgery.

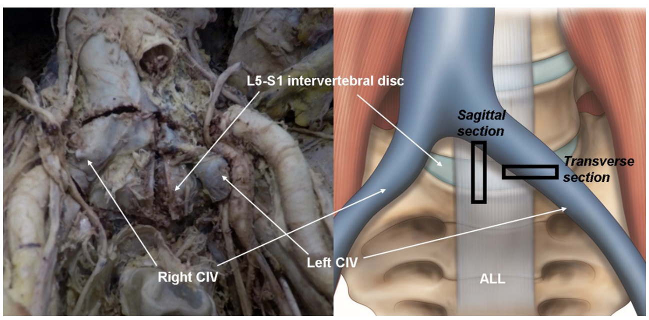

Fig. 1. A cadaver specimen and its schematic diagram. After removing the peritoneum and presacral fascia, the section from the lower part of the L5 to the upper part of the S1 vertebra was removed with the common iliac vein (CIV) attached. After decalcification, 2 sections were created to evaluate the relationship among the structures. The sagittal section included the vertebral bodies of L5 and S1, L5–S1 disc, periosteum, and the anterior longitudinal ligament (ALL); the transverse section included the ALL and left CIV on the middle to left side of the L5–S1 disc.

1. Preparation of Cadaveric Specimens

After removing the peritoneum and the presacral fascia, a specimen containing the L5 and S1 vertebral bodies and the L5–S1 disc with the left CIV attached to the L5–S1 disc surface was obtained from each cadaver (Fig. 1). The specimens were fixed for 72 hours in 10% neutral buffered formalin and then decalcified in Kristensen's solution for approximately 2 weeks. After decalcification, we cut the specimens into 2 different sections for the microstructural study.

1) Sagittal section

A section including the vertebral bodies of L5 and S1, L5–S1 disc, periosteum, and the anterior longitudinal ligament (ALL) to study the structural relationship of the bone, disc, and the periosteum at the transitional area between the vertebral bone and the disc.

2) Transverse section

A section including the ALL and left CIV on the left side of the L5–S1 disc to examine the relationship between the prevertebral structures and CIV.

The 2 sections were embedded in paraffin blocks and stained with hematoxylin and eosin.

Fig. 2. A sagittal section showing 'perivertebral membrane'. (A) Entire longitudinal view of perivertebral membrane (PM). This figure was composed of 15 separate but continuous photographs in a specimen. The PM was observed anterior to the L5 and S1 vertebrae and the anterior longitudinal ligament (ALL) consistently. Inset: The PM was clearly distinguished from the ALL by potential empty space (hematoxylin and eosin [H&E] stain, ×200). (B) The periosteum (PO) was located between the L5 vertebra and the ALL. It was clearly distinguished from the ALL by a narrow empty space (H&E stain, ×200). AF, annulus fibrosus; CB, cancellous bone.

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RESULTS

Gross examination of the structures showed that the CIV bifurcation in each cadaver had a wide angle and the surface of the L5–S1 disc was exposed. An intervening adipose tissue layer (IATL) was present between the vertebrae and CIV and between the disc and CIV. In the 4 cadavers, the CIV was clearly separated from the vertebrae and the disc surfaces by the IATL. In 3 cadavers, the IATL was thin and in the other 3, there was almost no IATL, therefore the CIV is attached to the vertebrae and the disc surface.

Under the microscope, a thin membranous layer covering the ALL, periosteum, and disc was observed. The thickness of the membranous layer was about 0.2 mm (range, 0.1–0.25 mm), which was 8 to 10 times thinner than the ALL, and it was composed of fibrous tissue. We named this structure as 'perivertebral membrane.'

1. Sagittal Section

The perivertebral membrane was observed in front of the L5 and S1 vertebrae and the disc consistently (Fig. 2). The perivertebral membrane was anterior to ALL and was clearly distinguished from it by a narrow space. The fibers of the perivertebral membrane, periosteum, and ALL were arranged vertically. ALL extended over the anterior surface of the L5 vertebra and L5–S1 disc. The periosteum was located between the L5 vertebra and ALL and was separated from it by a narrow empty space. Thus, as we moved anteriorly from the body of the vertebra, the arrangement of the structures was as follows: bone, periosteum, ALL, and the perivertebral membrane. The annulus fibrosus (AF) was located behind the ALL outside of the nucleus pulposus. The AF could be distinguished from the ALL due to the different direction of its fibers.

2. Transverse Section

The perivertebral membrane was present in the outermost layer under the CIV, which covered the ALL and AF (Fig. 3). The left CIV was located above the perivertebral membrane,

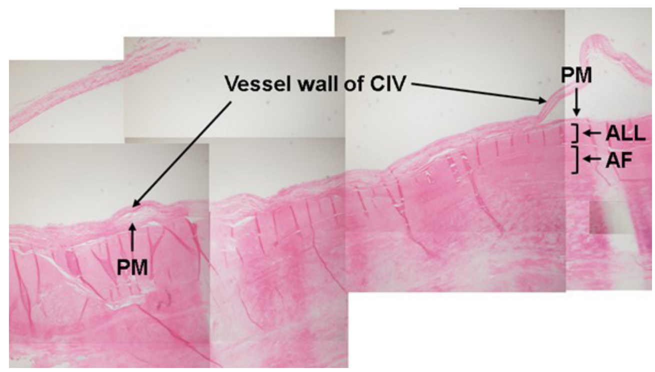

Fig. 3. A transverse section at the level of L5–S1 disc. The perivertebral membrane (PM) was present in the outermost layer, followed by the anterior longitudinal ligament (ALL) and the annulus fibrosus (AF). On the right side of the photograph, the vessel wall and the PM were well separated by the intervening adipose tissue layer (IATL), but the IATL became thin as it went to the left side and there was adhesion between the 2 structures. This figure was composed of 4 separate but continuous photographs in a specimen (hematoxylin & eosin stain, ×200). CIV, common iliac vein.

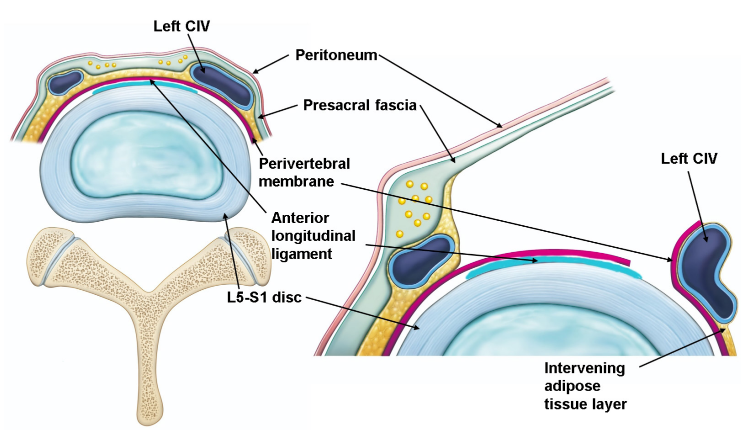

Fig. 4. A schematic diagram of the perivertebral membrane. In case where the intervening adipose tissue layer between the left common iliac vein (CIV) and L5–S1 disc was absent, the perivertebral membrane was cut with a knife, and blunt dissection was performed to open the potential space underneath it. As such, CIV mobilization with the perivertebral membrane attached to the CIV was performed to minimize CIV injury.

and IATL was present between the CIV and the perivertebral membrane. Fig. 4 shows a schematic representation of these structures. However, in the three specimens, the CIV was attached to the perivertebral membrane when there was no IATL.

DISCUSSION

The L5–S1 segment contributes the most in the development of lumbar lordosis.[5-7] Among the surgical procedures at the L5–S1 level, ALIF and OLIF are more effective in correcting lordosis than the posterior approaches (TLIF and PLIF).[8-10] However, ALIF and OLIF require the mobilization of CIV during surgery, and vascular injury occurring during this procedure is one of the most devastating complications.[11] In particular, because the left CIV is located in front of the disc and is in contact with the disc surface, it is essential to dissect and retract the left CIV when removing the disc.[15]

Several studies report methods for the preoperative evaluation of CIV before surgery at the L5-S1 level.[15-17] Chung et al.[15] reported that CIV mobilization is easier when the perivascular adipose tissue is present under CIV. The IATL observed in our study is probably the same structure as the perivascular adipose tissue reported in this paper. According to our study, it is located between the CIV and the anterior surfaces of the vertebral body and disc rather than wrapped around the vessels; thus, it would be considered appropriate to call it IATL.

Three of the 10 cadavers had no adipose tissue layer, with adhesion between the CIV and perivertebral membrane. Chung et al.[15] reported that the incidence rate of major left CIV injury was as high as 26.7% in the patients with iliac veins without perivascular adipose tissue. This is similar to the absence of IATL observed in our study, which may increase the risk of vascular injury during CIV mobilization. Therefore, in the patients with no adipose tissue layer, other methods of iliac vein mobilization should be devised to reduce iliac vein injury when performing ALIF or OLIF.

In particular, the recently introduced OLIF for L5–S1 is a minimally invasive technique that has an advantage similar to that

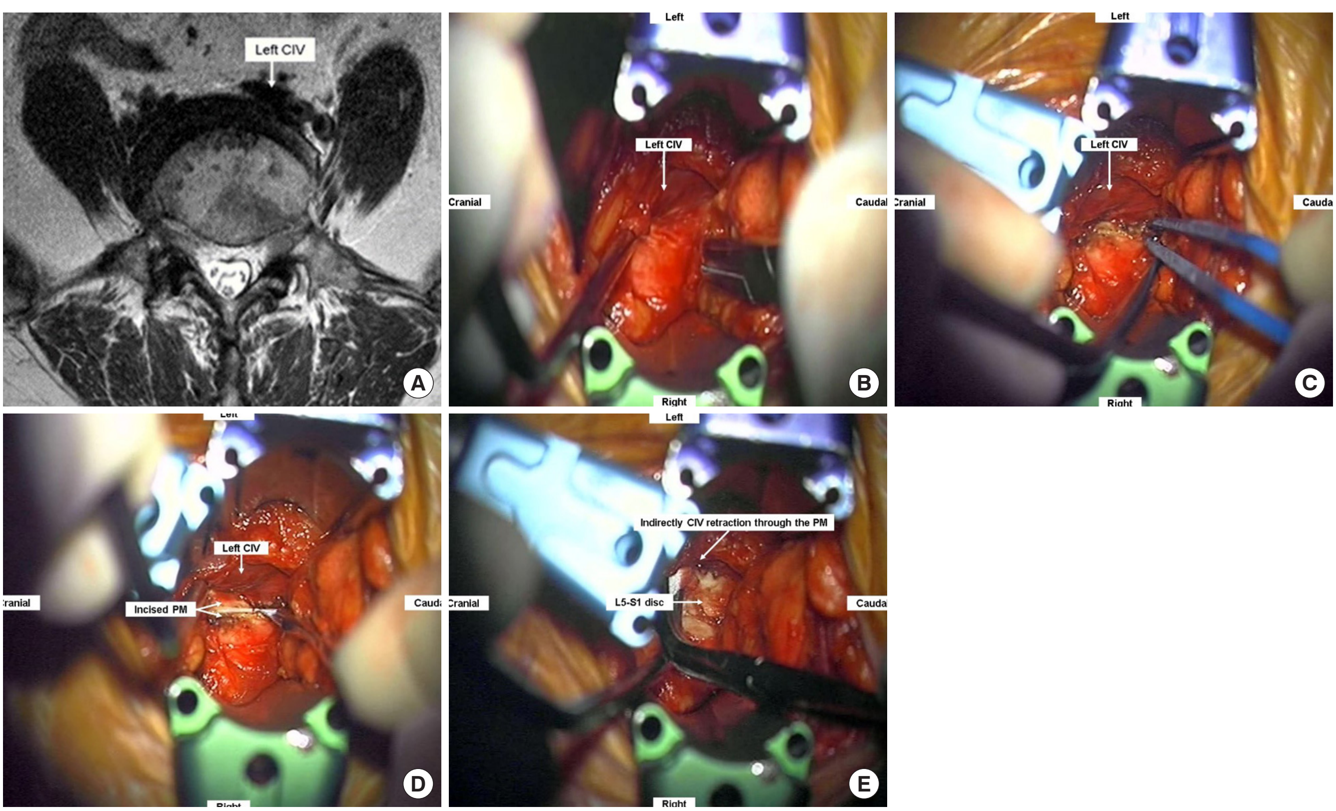

Fig. 5. Intraoperative illustrations of dissection underneath the perivertebral membrane. (A) A case without intervening adipose tissue layer between the left common iliac vein (CIV) and L5–S1 disc on preoperative magnetic resonance imaging. (B) The CIV manipulation was difficult. After cauterizing the perivertebral membrane (PM) near the left CIV (C), it was opened with a scalpel (D). (E) Then the left CIV retraction was performed indirectly through the incised PM.

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of ALIF as it allows a cage to be inserted with a larger lordotic angle. It also has the advantage of being performed in the same posture as OLIF for L1–5.[14] The most dangerous step during OLIF at the L5–S1 level is dissecting and retracting the left CIV laterally to the left side, and if there is adhesion between the CIV and the disc surface, a fatal vascular injury may occur.[15,18] Therefore, the surgeon needs to carefully evaluate the left CIV preoperatively to determine whether there is IATL under the left CIV before performing the surgery.

According to previous studies evaluating the anterior anatomy of the lumbosacral spine, the presacral fascia is located dorsal to the peritoneum, the superior hypogastric plexus is embedded in the presacral fascia, the right and left CIV are present in the dorsal part of the presacral fascia, and there is no special structure between the CIV and the L5–S1 disc except for ALL.[19,20] However, according to our study, a perivertebral membrane existed between the CIV and L5–S1 disc; based on these results, a schematic diagram was illustrated in Fig. 4.

The perivertebral membrane observed in our study might be helpful in protecting the CIV. It encircled the periphery of the ALL, periosteum, and disc, and it was separated from their surfaces by a potential space. Therefore, the perivertebral membrane could be cut and dissected from the ALL, periosteum, and disc by opening the potential space underneath this membrane. Moreover, CIV injury occurs during CIV mobilization.[11] When the CIV was adhered to the adjacent structures (intervertebral disc, ALL, or periosteum), because of the absence of IATL, the perivertebral membrane was cut with a scalpel and blunt dissection was performed to open the potential space under the membrane. If CIV mobilization is performed indirectly through the perivertebral membrane attached to the CIV, CIV injury could be minimized. Based on these points, we had applied it to patients as well, in particular, in cases with no IATL between the CIV and disc, this method was helpful for the safe mobilization of the CIV (Fig. 5).

Most of the anatomical studies performed for the lower lumbar region have focused on the vascular structures or autonomic nerves,[21-25] but there has been no study mentioning the perivertebral membrane that was observed in our study. We could not determine how far the perivertebral membrane extends to the lateral side, and the results of this study were obtained using a small number of cadavers. Therefore, further anatomic evaluation through additional large-scale studies is needed, and complementary clinical studies on whether the perivertebral membrane can be used during L5–S1 approaches should be conducted as well.

CONCLUSION

A thin membrane, the perivertebral membrane, between the CIV and disc at the L5–S1 level of the cadaveric specimens was observed. In cases with CIV adhesion to the disc surface due to the absence of IATL, we may be able to mobilize CIV safely by sharp dissection and retraction of the perivertebral membrane.

CONFLICT OF INTEREST

The authors have nothing to disclose.

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