

## An Anatomic Study of the Lumbar Plexus with Respect to Retroperitoneal Endoscopic Surgery

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**Study Design.** The distribution of the lumbar plexus was analyzed using cadavers.

**Objective.** To clarify the safety zone to prevent nerve injuries with respect to retroperitoneal endoscopic surgery.

**Summary of Background Data.** Surgical approaches to the retroperitoneal space vary among surgeons. Recently, retroperitoneal endoscopic surgery has been applied to various spinal disorders. When the psoas major muscle is separated during retroperitoneal endoscopic surgery, there is a potential risk of injury to the lumbar plexus or nerve roots. However, there is sparse knowledge regarding the relationship between the greater psoas muscle and the lumbar plexus.

**Methods.** A total of 30 cadavers were analyzed. Six lumbar spines of the cadavers were cut in parallel with the lumbar disc space. Each axial section was photographed and captured into a computer. The distribution of the lumbar plexus was analyzed using computer images. The positions where the genitofemoral nerve emerged on the abdominal surface of the psoas major muscle were analyzed using 24 cadavers.

**Results.** L2/3 and above, all parts of the lumbar plexus, and nerve roots were located from the dorsal fourth of the vertebral body and dorsally. The genitofemoral nerve descends obliquely forward through the psoas major muscle, emerging on the abdominal surface between the cranial third of the L3 vertebra and the caudal third of the L4 vertebra. The safety zone of the psoas major muscle to prevent nerve injuries, excluding the genitofemoral nerve, is at L4/L5 and above.

**Conclusions.** The safety zone, excluding the genitofemoral nerve, is at L4-L5 and above. [Key words: anatomy, endoscopic surgery, genitofemoral nerve] *Spine* 2003;28:423-428

Since laparoscopic discectomy was reported, endoscopic surgery has been applied to various kinds of lumbar spine diseases.<sup>3,7,10</sup> Retroperitoneal endoscopic surgery has been applied to anterior interbody fusion for disc herniation, anterior decompression and interbody fusion for burst fracture, and discectomy for extreme lateral

disc herniation.<sup>2,11</sup> When the psoas major muscle is separated during retroperitoneal endoscopic surgery, there is a potential risk of injury to the lumbar plexus or nerve roots. McAfee *et al*<sup>9</sup> reported on 18 patients who underwent endoscopic retroperitoneal interbody fusions. In that study, there were three patients with postoperative complications. There was sepsis in one case, a bone dowel partial fracture in one case, and temporary genitofemoral nerve palsy in one case. However, there is little knowledge regarding the relationship between the greater psoas muscle and the lumbar plexus in light of endoscopic surgery.<sup>1,12</sup> The aim of this study is to clarify

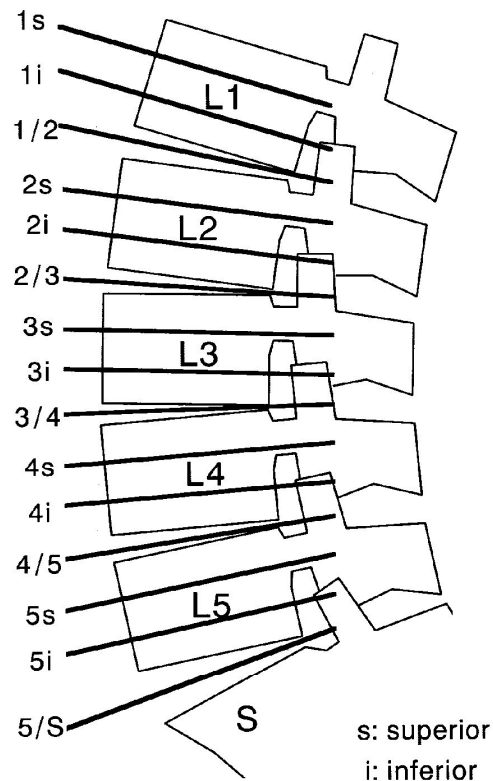


Figure 1. Cut levels of the lumbar spine of a cadaver and their abbreviated names. The cranial third of the L3 vertebral body is referred to as L3s (L3 superior), and the caudal third of the L3 vertebral body is referred to as L3i (L3 inferior).

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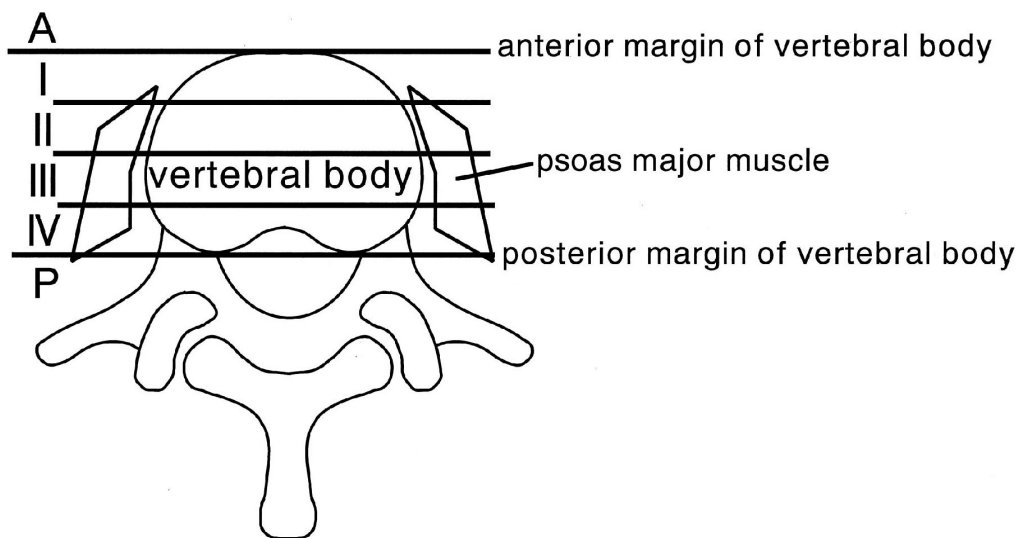


Figure 2. Zone definition of the localization of the lumbar plexus and nerve roots at each image. The area between the anterior edge of the vertebral body and the posterior edge of the vertebral body was divided into four zones. The most anterior zone was defined as zone I, the second anterior zone was zone II, the third anterior area was zone III, and the most posterior area was zone IV. The area posterior to the posterior edge of the vertebral body was defined as zone P, and the area anterior to the anterior edge of the vertebral body was defined as zone A.

the safety zone of the psoas major muscle during retroperitoneal endoscopic surgery using cadavers.

#### Materials and Methods

**Localization of the Lumbar Plexus and Nerve Roots.** Lumbar spines were removed from six embalmed human cadavers and immediately frozen at  $-80^{\circ}\text{C}$ . From the L1-L5 vertebral body, each specimen was cut in parallel with the lumbar disc space and the lumbar vertebra at the cranial third and caudal third of the each lumbar vertebral body (Figure 1). The distribution of the lumbar plexus and nerve roots in each axial section was photographed. Each image was captured into a computer. The relationship between the greater psoas muscle and the lumbar plexus was analyzed using computer images. The area between the anterior and posterior edges of the vertebral body was divided into zones I, II, III, and IV (Figure 2). The area anterior to the anterior edge of the vertebral body was defined as zone A, and the area posterior to the posterior edge of the vertebral body was defined as zone P. The relationship between the localization of the lumbar plexus and nerve roots and each zone was examined.

**The Relationship Between the Greater Psoas Muscle and the Genitofemoral Nerve.** The positions where the genitofemoral nerve emerges on the abdominal surface of the psoas major muscle were analyzed using 24 embalmed cadavers. The three characteristics used to identify the genitofemoral nerves are piercing the psoas major muscle at its upper medial portion, piercing the fascia transversalis to enter the abdominal wall around the deep inguinal ring, and not having a lateral cutaneous branch.

#### Results

##### *The Relationship Between the Localization of the Lumbar Plexus and Nerve Roots and the Vertebral Body*

All parts of the lumbar plexus and nerve roots were found in zones IV and P at L2-L3 and above (Figure 3A). All of the lumbar plexus, except for the genitofemoral nerve, and all nerve roots were found in zone II and abdominally at L4-L5 and above (Figure 3B).

A typical case is presented. The nerve tissue was found in zone IV and dorsally at L2-L3 (Figure 4A). At L3s (L3 superior) and caudally, the genitofemoral nerve was found in zone II on the right side and in zone III on the left side (Figure 4B). At L3i (L3 inferior) on both sides, the genitofemoral nerve was found in zone I (Figure 4C). At L5-S, the genitofemoral nerve was found in zone A; the L4 nerve root, L5 nerve root, femoral nerve, and obturator nerve were found in zones II, III, and IV (Figure 4D). Intraobserver reliability was 0.87.

##### *The Relationship Between the Psoas Major Muscle and the Genitofemoral Nerve*

As for the level to which the genitofemoral nerve passes the psoas major muscle among the 24 examples (48 sides) investigated in this study, L3-L4 had 15 sides and L4s had 14 sides. The level of the positions where all of the genitofemoral nerve passed through the psoas major muscle was between L3s and L4i (95% confidence inter-

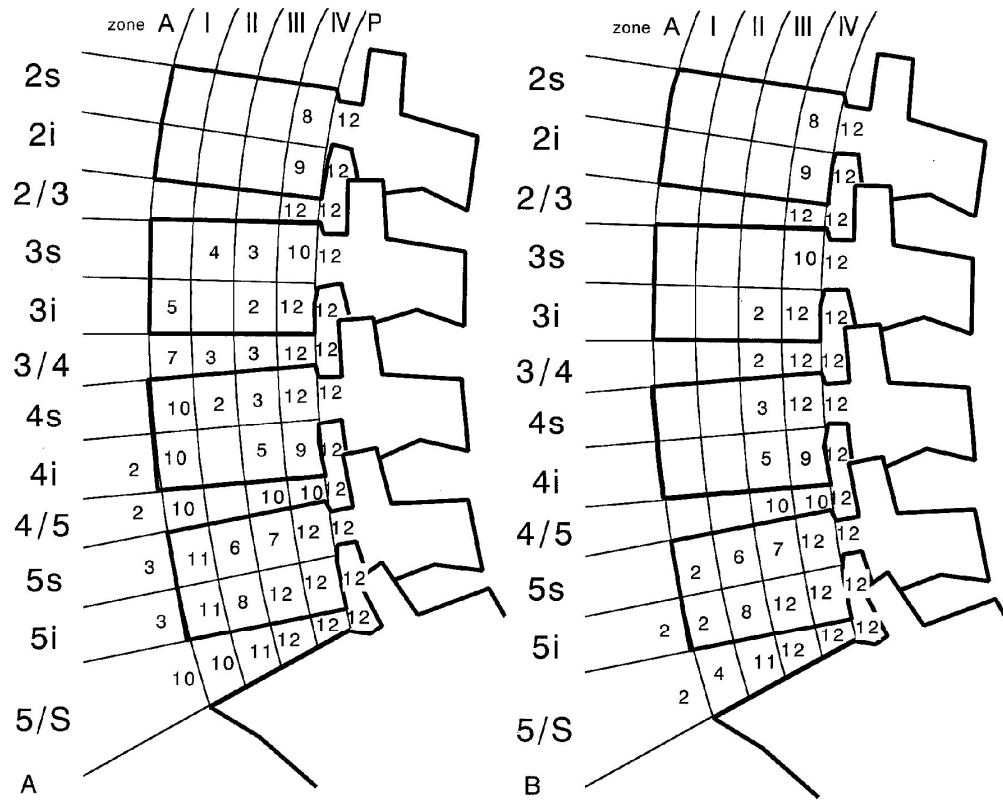


Figure 3. **A**, The number with which the lumbar plexus and the nerve roots by the 12 sides existed. **B**, The number with which the lumbar plexus and nerve roots, excluding the genitofemoral nerve, existed.

val; range, 92–100%) (Table 1). Intraobserver reliability was 0.82.

■ Discussion

**Safety Zone of the Lumbar Plexus and Nerve Roots**

Nerve damage is one of the complications that should be avoided during retroperitoneal endoscopic surgery. From the results of this study, it was thought that the safety zone may be at L2-L3 and above. Between the cranial third of the L3 vertebral body and L4-L5, only the genitofemoral nerve was located in the abdominal zone rather than the center of the vertebral body. If the possibility of damaging the genitofemoral nerve is not considered, the safety zone should be at L4-L5 and above. When spreading the psoas major muscle at L2-L3 and below, start from the abdominal edge of the vertebra, because nerves are not located in the abdominal surface of the vertebra. The lumbar plexus and nerve roots were contained in the psoas major muscle. Therefore, split between the psoas major muscle and vertebral body without dissecting the psoas major muscle.

L5-S1 is located on the caudal side from the abdominal aortic bifurcation. Therefore, during the method of

spreading the psoas major muscle posteriorly for extreme lateral L5-S1 lumbar disc herniation, there is a risk of iliac artery and vein damage. At L5-S1, the space between the psoas major muscle and the lumbar quadratus muscle is wide as compared with L4-L5 and above. Therefore, the lateral surface of the vertebral body can be reached from the gap of these muscles. The method of retracting the psoas major muscle anteriorly and reaching to the lateral surface of the vertebral body may be useful<sup>2</sup> (Figure 5). However, according to the present study, it is the danger zone, where the lumbar plexus and nerve roots were included in the center of the vertebral body and dorsally, that is to be operated in the case of this approach. At L5-S1, there is the L4 nerve root, L5 nerve root, femoral nerve, and obturator nerve between the psoas major muscle and the lumbar quadratus muscle. Therefore, those nerve tissues must be checked and protected with endoscope.

**The Possibility of Genitofemoral Nerve Damage**

The genitofemoral nerve forms the lumbar plexus to supply the abdominal wall with the ilioinguinal nerve, iliohypogastric nerve, and subcostalis nerve. The distribu-



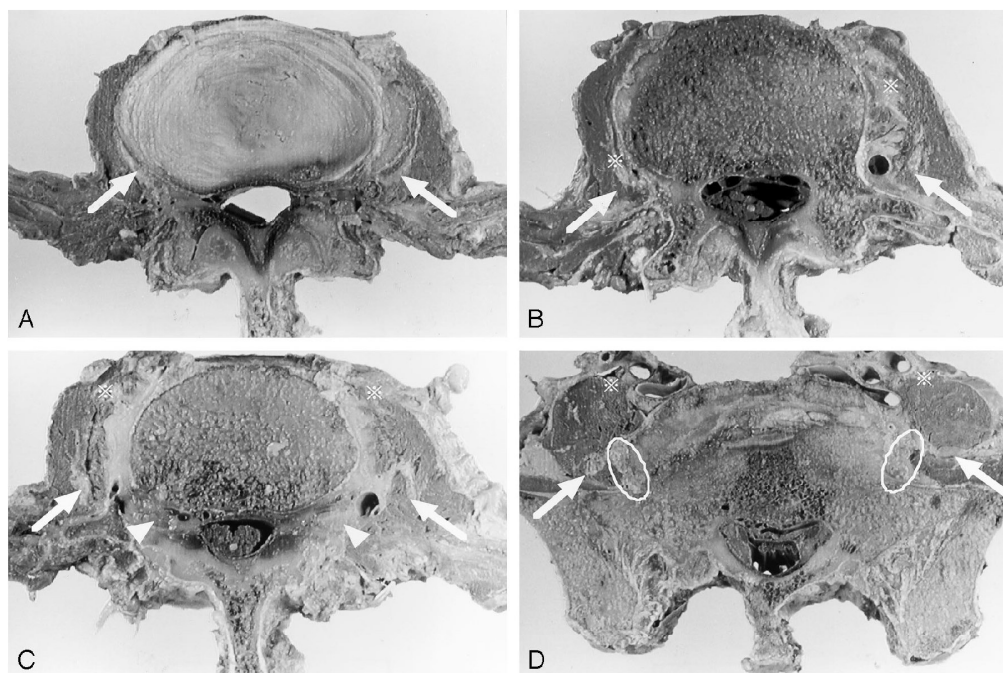


Figure 4. **A**, Cut image at L2-L3 (down shot) displays the L1 and L2 nerve roots that exist in zone IV. **B**, Cut image at L3s (down shot) displays the L1 and L2 nerve roots that exist in zones P and IV. ✕; shows the genitofemoral nerve that exists in zones II and III. **C**, Cut image at L3i (down shot) displays the L1 and L2 nerve roots that exist in zone IV. Allows heads to show L3 nerve roots that exist in zone P. ✕; show genitofemoral nerves that exist in zone I. **D**, Cut image at L5-S (down shot) displays white frames that show the L4 and L5 nerve roots that exist in zones II, III, and IV. Displays obturator nerves and femoral nerves that exist in zones II and III. ✕; shows genitofemoral nerves that exist in zone A.

tion and origin of these nerves have been sufficiently examined.<sup>5,8</sup> The genitofemoral nerve mainly branches from the L1 and L2 nerve root, pierces through the psoas major muscle toward the anterior side from the posterior side, and subsequently descends in accordance with the abdominal surface of the psoas major.<sup>6,13</sup> However, the authors paid no attention to the level of the genitofemoral nerve emerging on the surface of the psoas major muscle. From the results of this study, it was found that the level where the genitofemoral nerve passes the psoas major muscle ranges from the cranial third of the L3

vertebral body to the caudal third of the L4 vertebral body. That is, in the case of spreading the psoas major muscle, it is thought that at the more caudal level the genitofemoral nerve may be damaged. In fact, a case of transitory genitofemoral nerve paralysis after anterior fusion of the L3-L4 vertebral body with the retroperitoneal endoscope has been reported.<sup>9</sup> On the other hand,

**Table 1. The Positions Where the Genitofemoral Nerve Emerges on the Abdominal Surface of the Greater Psoas Muscle, Except for One Side, Which Has No Genitofemoral Nerve**

Cut Level of Lumbar Spine	Genitofemoral Nerves That Had Pierced Through the Psoas Major Muscle (n)
L3s	5
L3i	10
L3-L4	15
L4s	14
L4i	3

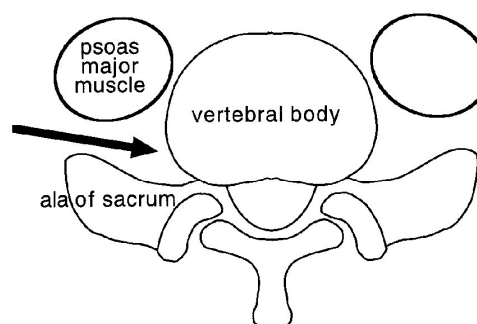


Figure 5. Cut image at L5/S1 displays the course of the retroperitoneoscopic lateral lumbar approach.

entrapment neuralgia of the genitofemoral nerve is known as one of the complications of inguinal herniorrhaphy. However, reports of having succeeded in remitting the symptoms (pain and paresthesia) without a serious problem, even if neurectomy of the genitofemoral nerve is done as medical treatment of these complications, have also been made.<sup>4</sup> If such a conventional report is considered when the genitofemoral nerve is damaged, there is the possibility that a sensory disturbance will arise at the scrotum and medial thigh, which is the innervation area of the genitofemoral nerve. It is thought that genitofemoral nerve palsy rarely becomes a serious problem. However, before an operation accompanied by the spreading of the psoas major muscle at the L3 vertebral body and below, the patient must be informed of the possibility of sensory disturbance by genitofemoral nerve damage, and it is considered necessary to obtain comprehension beforehand.

#### ■ Key Points

- The muscle should be split more anteriorly than the dorsal fourth of lumbar vertebral body from the cranial third of the L3 vertebral body and above to prevent nerve injuries.
- When the psoas major muscle is split at the L3 or L4 vertebral body, there is a risk of injury to the genitofemoral nerve.

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#### ■ Point of View

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As surgeons<sup>1</sup> have become increasingly aware of surgical morbidity for anterior lumbar spine surgery, new techniques and approaches have been devised to access the anterior column of the lumbar spine less invasively and with less surgical morbidity. Transperitoneal endoscopic surgery has provided predictable access to the L5-S1 intervertebral space; however, L4-L5 and above has been less predictable in obtaining predictable access without the risk of significant intraoperative complications. The location of the great vessels anteriorly and their ana-

tomically variations have provided less favorable access compared with a more lateral transposoatic approach to the anterior vertebral column. The lumbar plexus represents the most important structure in the psoas that could be injured, and the anatomic variations and locations of these structures have yet to be clearly defined.

“An Anatomic Study of the Lumbar Plexus with Respect to Retroperitoneal Endoscopic Surgery” by Moro *et al* is an important anatomic study that describes the important relationship of the lumbar plexus to the greater psoas muscle when considering anterior lumbar surgical intervention. Whether using an endoscopic or mini-open technique, it is important to conceptualize the most common locations of lumbar plexus structures before dissecting the psoas muscle to obtain access to the vertebral body or intervertebral disc space. Injuries to the genitofemoral nerve and other lumbar plexopathies have

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