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A Human Cadaveric Study on the Anatomical Variations in the Formation and Branching Pattern of the Lumbar Plexus and Its Relation with the Psoas Major Muscle

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ABSTRACT

In the present study of 60 lumbar plexuses (obtained from 30 cadavers), several variations in the formation and branching pattern of the lumbar plexus were observed. The iliohypogastric nerve varied in its root value in 3 plexuses (5%). The ilioinguinal nerve showed variation in 5 plexuses (8.3%) — complete absence in 3 (5%) and an early split shared with the iliohypogastric nerve in 2 (3.3%). The genitofemoral nerve was the most variable branch (20%), showing an early (high) split, alternative root values, and rejoining of its genital and femoral components within the pelvis. The femoral nerve varied in 9 plexuses (15%), exhibiting bifurcation, additional root contributions, and origin of the lateral femoral cutaneous nerve from its trunk. The lateral femoral cutaneous nerve varied in 11 plexuses (18.3%), including duplication, varied origin with late formation, and complete absence in one plexus. An accessory obturator nerve was identified in 7 plexuses (11.6%). These variations underscore the clinical importance of a detailed knowledge of lumbar-plexus anatomy in reducing iatrogenic nerve injury during lower-abdominal and retroperitoneal procedures.

Keywords*: lumbar plexus; anatomical variation; psoas major; genitofemoral nerve; femoral nerve; cadaveric study.*

INTRODUCTION

Lower-abdominal surgeries — including retroperitoneal laparoscopy, gynaecological procedures, inguinal hernia repair, and iliac-crest bone grafting — have become common, and postoperative radiculopathy or peripheral neuropathy (such as meralgia paraesthetica or groin pain) is frequently encountered. The main objective of the present study is to add detail on the possible variations of the lumbar plexus and to compare the findings with the existing literature for greater clarity. A thorough knowledge of the possible variations in the formation and branching pattern of the lumbar plexus reduces the chance of iatrogenic injury to the plexus.

MATERIALS AND METHODS

The study was carried out during routine educational dissection of 30 formalin-embalmed human cadavers in the Department of Anatomy over a period of three years. Cadavers with any sign of injury or a surgical scar in the lower-abdominal region were excluded. The skin, superficial fascia, muscles of the anterior abdominal wall, and all abdominal viscera were removed to expose the posterior abdominal wall. The fibres of the psoas major muscle were then meticulously detached from the intervertebral discs and vertebral bodies. Each branch of the lumbar plexus was identified by its relationship to the psoas major and the 12th rib (Figure 1). The 30 cadavers yielded 60 lumbar plexuses, of which 30 (50%) were from the right side and 30 (50%) from the left. Twenty-four cadavers were male and 6 were female, with ages ranging from 25 to 75 years. All variations in the formation and branching pattern of the lumbar plexus were recorded and photographed.

Limitation. The sample was heavily male-weighted (24 male versus 6 female cadavers), which should be considered when interpreting the findings.

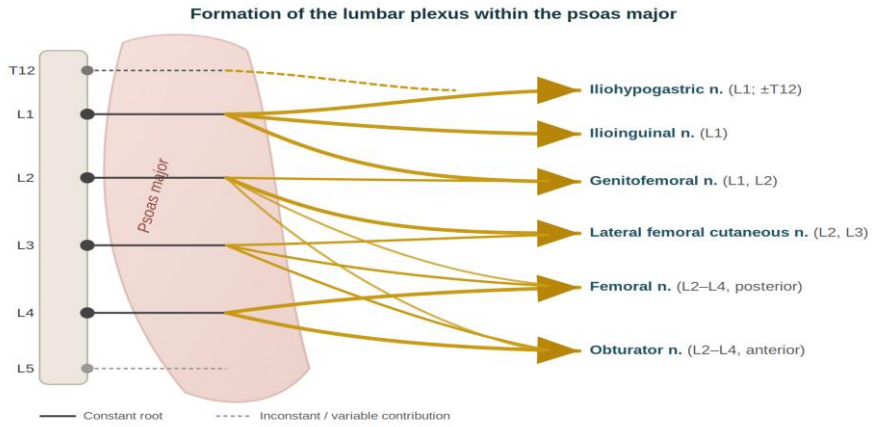

Figure 1. *Schematic of the normal formation of the lumbar plexus from the ventral rami of L1–L4 (with a variable contribution from T12), and its relationship to the psoas major muscle, within which the plexus lies.*

RESULTS

In the present study, the major variations occurred in the branching pattern and origin of the lateral femoral cutaneous nerve, genitofemoral nerve, femoral nerve, and ilioinguinal nerve. The remaining nerves contributed little to the observed variation. A summary of all observed variations is presented in Table 1, and their relative frequencies are shown in Figure 2.

Table 1. *Anatomical variations of the lumbar plexus observed in 60 hemi-plexuses.*

Nerve	Variation observed	n	%
Iliohypogastric	Origin from T12 + L1 (pre-fixed)	3	5.0
Ilioinguinal	Complete absence	3	5.0
	Early split shared with iliohypogastric	2	3.3
Genitofemoral	Early (high) split into genital + femoral components	7	11.7
	Variant root value (L1 alone; L2+L3)	2	3.3
	Components rejoined within pelvis	2	3.3
Lateral femoral cutaneous	Duplication (two trunks)	4	6.7
	Variant origin (L2 alone; L1+L2)	3	5.0
	Late formation with rejoining	1	1.7
	Complete absence	1	1.7
	Arising from / joining the femoral nerve	1	1.7
Femoral	Bifurcation of the trunk	6	10.0
	Additional / variant root contribution	4	6.7
	Gave origin to the lateral femoral cutaneous nerve	3	5.0
Obturator	No variation in root value	0	0
Accessory obturator	Present	7	11.6

Iliohypogastric nerve. In 3 lumbar plexuses (5%) the iliohypogastric nerve was formed from T12 and L1; in the remaining 57 (95%) it arose from L1 alone.

Ilioinguinal nerve. In all plexuses in which it was present, the ilioinguinal nerve arose from L1 alone. In 2 plexuses (3.3%) the iliohypogastric and ilioinguinal nerves showed an early split at the level of origin, and in 3 plexuses (5%) the ilioinguinal nerve was absent.

Genitofemoral nerve (GFN). The origin varied: L1 alone in one specimen, L2 and L3 in one specimen, and the normal root value (L1 and L2) in the remaining 58. An early split was seen in 7 specimens; in 5 of these both the genital and femoral components arose from L2 alone, and in the other 2 the genital component arose from L2 and the femoral component from L3 (Figure 3b). In 2 specimens the two components rejoined about 6 cm distal to the origin to form a single stem within the pelvic cavity.

Lateral femoral cutaneous nerve (LFCN). In 57 of 60 plexuses the LFCN arose from L2 and L3; in 2 it arose from L2 alone, and in 1 from L1 and L2. A doubled (duplicated) LFCN was found in 4 specimens (Figure 3c): in 2 (both from L2 and L3) it was bilateral in a male cadaver, while the other 2 were unilateral — one on the left side of a male cadaver and one on the left side of a female cadaver (from L3 alone). Late formation of the LFCN, with the segments rejoining soon after emerging from the psoas major, was seen in 1 plexus. The LFCN was absent on the left side of one male cadaver, and in 1 specimen it joined the femoral nerve approximately 6 cm after formation.

Femoral nerve (FN). The femoral nerve arose from L2, L3, and L4 in 56 of 60 plexuses (93.3%). In 2 plexuses (3.3%) it arose from L1–L4, in 1 from L3 and L4, and in 1 from L2–L5 (post-fixed). Bifurcation — a separate branch dividing from the main trunk soon after formation — occurred in 6 specimens (10%); in 1 specimen the nerve formed multiple segments that rejoined 4 cm from the origin. In 3 plexuses (5%) the lateral femoral cutaneous nerve arose from the femoral nerve (Figure 3d). Such variation in the branching pattern may adversely affect the outcome of a femoral nerve block.

Obturator and accessory obturator nerves. The obturator nerve showed no variation in its root value. An accessory obturator nerve was identified in 7 plexuses (11.6%).

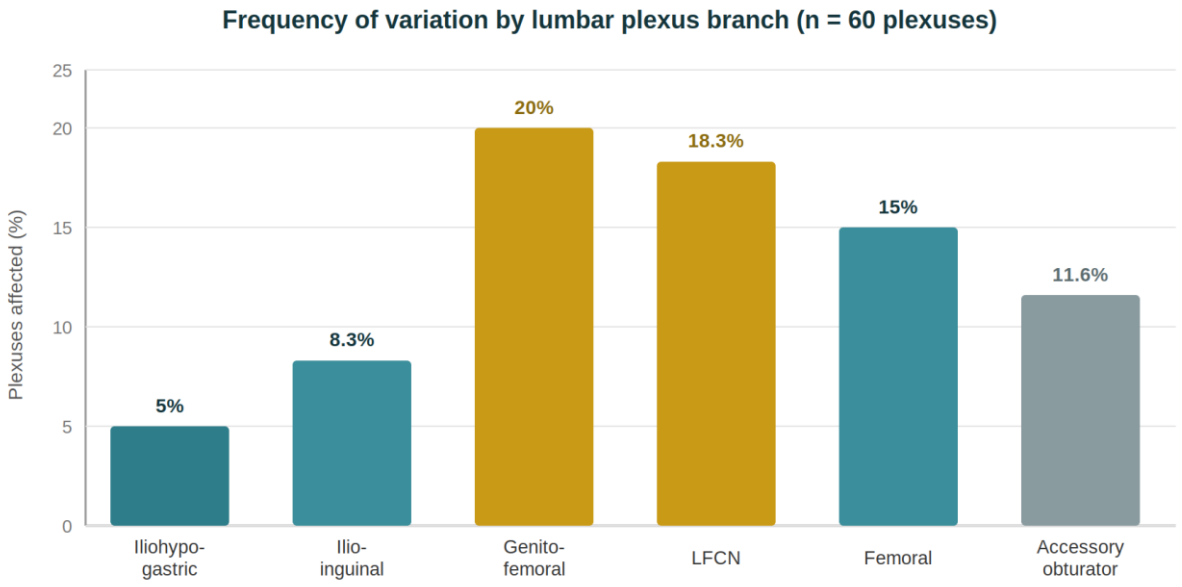

Figure 2. *Frequency of variation for each branch of the lumbar plexus, expressed as a percentage of the 60 plexuses studied.*

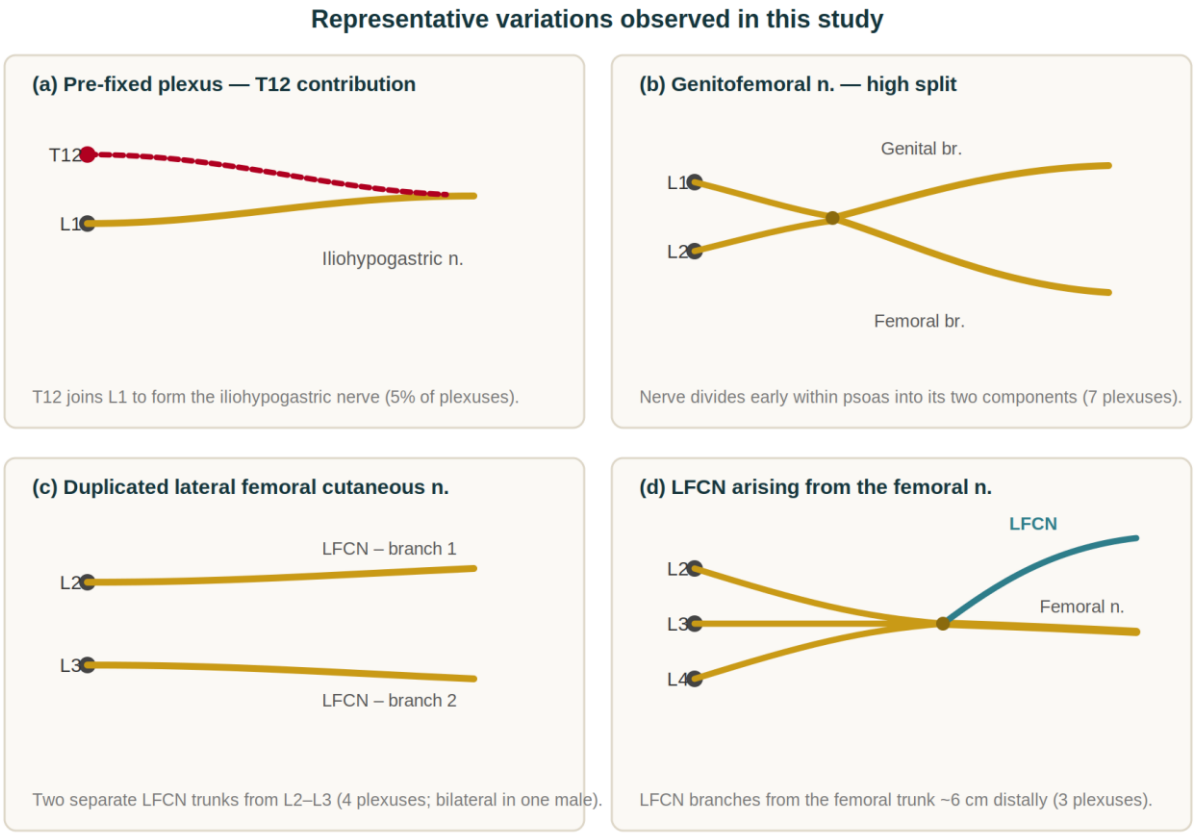

Figure 3. *Representative variations observed: (a) pre-fixed plexus with a T12 contribution to the iliohypogastric nerve; (b) high (early) split of the genitofemoral nerve into genital and femoral components; (c) duplicated lateral femoral cutaneous nerve; (d) lateral femoral cutaneous nerve arising from the femoral nerve.*

DISCUSSION

Pre-fixed and post-fixed lumbar plexus. In the present study a T12 contribution (pre-fixed plexus) was found in 3 of 60 plexuses (5%); in each, the iliohypogastric nerve arose from T12 together with the subcostal nerve (Figure 3a). A post-fixed plexus, with an L5 contribution to the femoral and obturator nerves, was seen in one plexus (1.7%).

Iliohypogastric nerve. Compared with other reports, the iliohypogastric nerve showed relatively few variations in root value and branching pattern. It arose from L1 alone in most plexuses (57 of 60, 95%) and from T12 and L1 in the remaining 3 (5%). Hollinshead reported that the iliohypogastric nerve emerged from T12 and L1 in 34% of specimens and from L1 alone in 32%.

Clinical implications. Variations of this kind may lead to an inadequate femoral nerve block, increase the risk of nerve compression, and result in ineffective treatment of patients with meralgia paraesthetica.

Genitofemoral nerve. Bergman et al. noted that the genitofemoral nerve shows the greatest variation in both root value and intrapelvic branching, arising from a single root in about 80% of cases and from two roots (L1–L2 or L2–L3) in about 20%. In the present study the genitofemoral nerve arose from L1 alone in one plexus, and in two plexuses its genital and femoral components arose separately from L2 and L3, respectively.

CONCLUSIONS

The present study documents the branching pattern of the lumbar plexus and its clinical relevance. Because lower-abdominal and retroperitoneal surgeries are increasingly common, a detailed knowledge of these variations may help avoid iatrogenic nerve injury, prevent postoperative complications, and allow clinicians to treat patients more accurately.

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