e-ISSN: 0975-5160, p-ISSN: 2820-2651

Available online on www.ijtpr.com

International Journal of Toxicological and Pharmacological Research 2023; 13 (7); 85-90

Original Research Article

An Examination of the Anatomical Variations in the Formation, Branching, Pattern, and Relationship Between the Lumbar Plexus and the Psoas Major Muscle in Humans

Milan Amar Bahadur Singh

Tutor Dept. of Anatomy Parul Institute of Medical Sciences and Research Waghodia Vadodara

Received: 02-05-2023 / Revised: 15-06-2023 / Accepted: 11-07-2023

Corresponding author: Milan Amar Bahadur Singh

Conflict of interest: Nil

Abstract:

Background: Between the anterior and posterior masses of the psoas major muscle, the lumbar plexus is located. In 60 percent of plexuses, the twelfth thoracic nerve via the dorsolumbar nerve contributes to their formation together with the anterior rami of the first four lumbar nerves. The lumbar and sacral plexuses are solely responsible for the lower limb's nerve supply. The muscles and skin of the suprapubic and inguinal areas of the abdominal wall are supplied by nerves coming from the upper lumbar plexus. The Ili hypogastric and ilioinguinal nerves emerge from the lateral edge of the psoas major and cross the quadratus lumborum to supply the skin of the abdominal wall next to the lower limb.

Aim: The aim of the present study was Examination of the anatomical variations in the formation, branching, pattern, and relationship between the lumbar plexus and the PSOAS major muscle in humans.

Material and Method: The Department of Anatomy undertook this observational investigation. 15 human cadavers were initially used in this investigation. The average age of the cadavers, who were split evenly between 10 men and 5 women, was 70.0 years. The Department of Anatomy, Histology, and Embryology held all autopsy evidence. In order to eliminate out iatrogenic anatomical aberrations, specimens were disqualified if there was proof of surgical intervention involving the belly, lumbar spine, or lumbar plexus. Two of the planned cadavers were eliminated because there was proof of an abdominal surgical procedure, leaving 15 that were suitable for this study.

Result: Before leaving the psoas major, the nerve split into its terminal branches in five instances. Only the second lumbar ventral ramus and, in two instances, the first two lumbar nerves were used to create the nerve. On six times, it came from the femoral nerve directly. In more than 70% of plexuses, the lateral femoral cutaneous nerve erupted from the intervertebral spaces next to L5 or the lateral border of the psoas major.

Conclusion: Last but not least, cadaveric dissection revealed that the lumbar somatic plexus is located at the L4-5 level within the substance of the psoas major, indicating that psoas compartment techniques offer indirect access to the plexus. Dissection revealed that all previously documented lumbar plexus block techniques appear to be anatomically valid, but changes may improve effectiveness and lower risks.

Keywords: Anatomical Variation, Lumbar Plexus, Branching and Psoas Major

Introduction

Between the anterior and posterior masses of the psoas major muscle, the lumbar plexus is located. The first four lumbar nerves' anterior rami make up this plexus, with the dorsolumbar nerve of the twelfth thoracic nerve contributing in 60% of plexuses.[1] The muscles and skin of the suprapubic and inguinal areas of the abdominal wall are supplied by nerves coming from the upper lumbar plexus. The iliohypogastric and ilioinguinal nerves emerge from the lateral edge of the psoas major and cross the quadratus lumborum to supply the skin of the abdominal wall next to the lower limb. The cremaster muscle and skin of the femoral triangle, scrotum, labium majus, and mons pubis are all supplied by the genitofemoral nerve.[2] The anterior aspect of the psoas major is where this nerve descends from the first two lumbar nerves, emerging opposite the L3 or L4 vertebra.[3] The lateral femoral cutaneous, femoral, and obturator nerves—the three primary nerves of the lumbar plexus—help to innervate the lower limb. In instance, a total blockade of the lower leg may result from the blockage of these nerves in addition to the sciatic nerve. The femoral nerve, which arises from the lateral edge of the psoas major muscle next to the L5 or S1 vertebra, is the greatest terminal branch of the lumbar plexus. Between the lateral femoral cutaneous and obturator nerves, it passes posterior to the fascia iliac in a gutter created by the iliacus and psoas major.[4]

The lumbar plexus is a projection of the intervertebral foramina, posterior to the psoas major muscle, that arises from the ventral rami of the L1-L4 nerve roots.[5] The subcostal nerve, a connecting branch of the T12, frequently connects the first lumbar nerve. The anterior and posterior primary divisions of the L2-L4 ventral rami split first. The psoas major and quadratus lumborum receive their muscle branches from the T12 and L1 nerves as well as the L2-L4 anterior primary divisions. Six peripheral nerves are produced once both primary divisions enter the lumbar plexus.[6] The L1 nerve divides into a caudal and cranial branch within this plexus. The cranial branch splits into the iliohypogastric and ilioinguinal nerves; in individuals when the subcostal nerve contributes to the lumbar plexus, the former is also generated by the subcostal nerve.[7] The genitofemoral nerve is created when the anterior division of the L2 nerve and the caudal branch of the L1 nerve combine. The obturator nerve is created by the anterior divisions of the L2-L4 roots. The posterior divisions of the L2 and L3 roots give rise to the lateral femoral cutaneous nerve, while the posterior divisions of the L2, L3, and L4 roots combine to form the femoral nerve.[8] However, such extrapolation based on a good understanding of pertinent anatomy frequently still serves to direct therapeutic reasoning, especially in circumstances when higher-level scientific data is insufficient.[9] The importance of anatomy is still taught in physical therapy programs in the United States, both as part of the prerequisites for entering the program and as a requirement for the basic sciences course content at the entry-level.[10]

The psoas major's substance has a common plane where the lumbar plexus's branches travel. They stay inside the fascia iliaca compartment after exiting the psoas major.[11] This continuous perineural space around the plexus is essential for the single procedure blocking of these nerves because it enables anesthesia to permeate the entire area. Based on our descriptive anatomy study of human cadavers and the preceding description of normal architecture, the aim of this study was to describe the anatomical changes in the lumbar plexus from its beginning at the ventral roots of (T12) L1-L4 to the exit from the pelvic cavity. We will discuss potential clinical implications with regard to the diagnosis of anatomical variations of the lumbar plexus by contrasting our results to the anatomical variance described elsewhere in the literature.

Material and Methods

The Department of Anatomy undertook this observational investigation. 15 human cadavers were initially used in this investigation. The average age of the cadavers, who were split evenly between 10 men and 5 women, was 70.0 years. The Department of Anatomy, Histology, and Embryology held all autopsy evidence. In order to eliminate out iatrogenic anatomical aberrations, specimens were disqualified if there was proof of surgical intervention involving the belly, lumbar spine, or lumbar plexus. Two of the planned cadavers were eliminated because there was proof of an abdominal surgical procedure, leaving 15 that were suitable for this study. The abdominal regions of any of the cadavers showed no evidence of trauma, surgery, or wound scars. The psoas major, quadratus lumborum, and the vertebral column were just a few of the nearby structures that were discussed in regard to the lumbar plexus' anatomy and relationships to them. Within the psoas major tissue, the plexus was separated. Examined were the lumbar plexus and its connections to fascial planes, including the psoas compartment. The plexus and its branches' anatomical changes that can affect the lumbar plexus' effectiveness were noted and captured on camera.

Dissection

The fascia and connective tissue that surrounded the psoas major muscle were cut away at the start of each dissection. Outside of the psoas major muscle, the ilioinguinal, iliohypogastric, genitofemoral, lateral femoral cutaneous, and femoral nerves were discovered. To view the nerves as they emerged from the ventral rami without injuring them, attachments of the psoas major muscle were cut from the lumbar vertebral bodies. The obturator nerve and the lumbar plexus nerves listed above were discovered in the psoas major muscle belly. The number of branches, width, and length of each branch of nerves that terminated inside the psoas major muscle were counted as nerves to the muscle. The posterior abdominal wall was made visible by removing the skin, superficial fascia, muscles of the anterior abdominal wall, and all abdominal viscera. By dissecting the psoas major muscle piece by piece, the femoral nerve's origin was exposed. A thread that was scaled was used to measure the lengths of the L2, L3, and L4 roots from their respective intervertebral foramen to the creation of the femoral nerve as well as the length of the femoral nerve from its formation to the point where it entered deeply into the inguinal ligament. To determine the femoral nerve's, obturator nerve's, or accessory obturator nerve's contribution to supplying the pectineus muscle, the epineurium of the L2, L3, and L4 roots, as well as the nerve to pectineus, were opened. We then followed the fascicles in the nerve to pectineus back into the trunk of the femoral nerve. The femoral nerve's varying development and branching pattern were noted, and its varying link to the iliopsoas complex, if any, was captured on camera and documented. The medial and lateral margins of the psoas major were measured for distance from the midline along with other structures. A micro caliper with a 0.02 mm accuracy was used to measure the length and width of each individual branch of the psoas major muscle. The branch's terminal ramification into the substance of the psoas major muscle is where the maximum length was measured.

Statistical Analysis

Statistical analysis was conducted using SPSS for Windows 11.0. Student's t-tests were used to analyze differences in measurements between plexuses in males and females and left- and right-sided plexuses. Non-parametric data were compared using the Chi-squared and Fisher exact tests, and odds ratios were computed where applicable.

Result:

Anatomical variation of the lumbar plexus (including the six peripheral nerves originating from this plexus) was noted in 13 of the 15 (88%) cadavers dissected. The percentage of variation of each nerve was calculated and is presented in Table 1.

Table 1: Percent variation of the lumbar plexus

Nerve	Number of Variations N=30	Percent Variations N=30	Unilateral Variation	Bilateral Variation	Female N=4	Male N=9
Lumbar Plexus	26	85%			85.4%	84.2%
Iliohypogastric	5	18.48%	22%	72%	45%	45%
Ilioinguinal Lateral	0	0.0%	-	-	-	-
Femoral Cutaneous	3	15.51%	45%	45%	45%	45%
Femoral	11	30.24%	57%	30%	40.2%	48.44%
Genitofemoral	13	45.03%	55%	37%	45%	45%
Obturator	0	0.0%	-	-	-	-

Overall, 30 of the 150 nerves studied showed variations. The mean prevalence of anatomical variation was 18.1% (SD 16.6%). Variations were found most frequently in the femoral, iliohypogastric, lateral femoral cutaneous, and genitofemoral nerves.

Table 2: Level of the emergence of the lumbar plexus nerves from psoas major

The lumbar plexus was located within the psoas major between its main (anterior) and accessory (posterior) sections and developed from the first four lumbar ventral rami. The iliohypogastric, ilioinguinal, and lateral femoral cutaneous nerves emerged from the lateral border of the psoas major and crossed the anterior side of the quadratus lumborum.

Nerve	Emerge Adjacent	Percentage of plexuses
Iliohypogastric nerve	L1-2	20
	L2	62
	L2-3	5
Ilioinguinal nerve	L1-2	5
	L2	62
	L2-3	16
	L3	3
Genitofemoral nerve	L2-3	5
	L3	43
	L3-4	15
	L4	12
	L4-5	3
	Other	5
Lateral femoral	L3	2
cutaneous nerve	L4	14
	L4-5	24
	L5	19
	L5-S1	23
	S1	3
	S1-2	2
	S2-3	2

Femoral nerve	L4	18
	L4-5	25
	L5	28
	L5-S1	10
	S1	5
	S1-2	2
Obturator nerve	L4-5	2
	L5	10
	L5-S1	50
	S1	20
	S2	2
Lumbosacral trunk	L5	3
	L5-S1	22
	S1	43
	S1-2	15
	S2-3	3

The first lumbar ventral ramus was the source of the iliohypogastric and ilioinguinal nerves, which typically exited from the lateral edge of the psoas major next to L2. The nerves came out of the psoas major in one plexus as a single trunk. Commonly, the genitofemoral nerve originates from the psoas major's anterior side close to L3. Before leaving the psoas major, the nerve split into its terminal branches in five instances. Only the second lumbar ventral ramus and, in two instances, the first two lumbar nerves were used to create the nerve. On six times, it came from the femoral nerve directly. In more than 70% of plexuses, the lateral femoral cutaneous nerve erupted from the intervertebral spaces next to L5 or the lateral border of the psoas major. The second to fourth ventral rami's posterior divisions are where the femoral nerve originates. The femoral nerve entered the psoas compartment at various levels, from L4 to S1, emerging from the psoas major.

Discussion

Human fetuses' lumbar plexi have morphometric traits that are similar to those of adults. It is situated anterior to the transverse process of the lumbar vertebrae and within the posterior portion of the psoas major muscle. From L1 to L4, the lumbar spinal ganglion sizes and spinal nerve thickness gradually grew. The ilioinguinal nerve, the femoral nerve, the iliohypogastric nerve, and the ilioinguinal nerve were the thinnest, longest, and shortest of the nerves that make up the plexus, respectively. The lumbar plexus originated within a plane in the psoas major material, according to cadaveric dissection. This muscle was anteromedial to the quadratus lumborum and was protected by the psoas fascia. The anterior part of the quadratus lumborum is crossed by the lumbar plexus branches as they emerge from the psoas major. Any posterior para-vertebral approach must therefore pierce this muscle in order to reach the lumbar plexus.

Bergman et al., 2001[12] showed that the Lumbar plexus is formed by the contribution from the ventral rami of the first three lumbar spinal nerves and a part of the fourth lumbar spinal nerve. The L1 nerve is joined to a skinny branch from the 12th thoracic nerve, which is then included in the development. The L4 spinal nerve, also known as the furcal nerve, branches to both the lumbar and sacral plexuses. Bergman et al. 2001[12] demonstrated that both plexuses were connected through a single furcal nerve at a rate of 91.8%. Of the 80% of cases with single furcal nerve which is formed by the L4 spinal nerve, whereas prefix or postfix plexus was observed at a rate of 20%. Double furcal nerve was observed at 0.8%, and a connection was not established between each plexus at a rate of 7.4%. In our study, only a single furcal nerve that arose from L4 spinal nerve was observed in all plexuses.

Chayen et al.1976[13] described an L4-5 posterior psoas compartment approach that introduces anesthetic into the fascial plane between the psoas major and quadratus lumborum. The lateral femoral cutaneous, femoral, and obturator nerves, however, are frequently located within the psoas major at this spinal level. They typically come out of the psoas major around the L5 vertebra or the intervertebral disc between the L5 and the S1 vertebra. In more than half of the dissected plexuses, the femoral nerve in particular emerged close to L5 or lower. This is in line with Farney and colleagues' discovery that the lumbar plexus is located at the level of L5 within the substance of the psoas major.[14]

Dias Filho et al. 2003[15] reported the origin of the lateral cutaneous nerve of the thigh from the femoral nerve inferior to the inguinal ligament in one case in their study. Uzmansel et al. 2006[16] reported the origin of the accessory lateral cutaneous nerve of the thigh from the femoral nerve above the inguinal ligament in their case report. Macalister 1889[17] described the origin of the nerve to pectineus from the femoral nerve within the abdomen with the medial cutaneous nerve of the thigh.

Jakubowicz 1991[18] reported splitting of the femoral nerve by lateral fibers of the psoas major muscle in 2.5% and by muscle fibers of the iliacus in 2.5% of fetal lumbar plexus. Jelev et al. 2005[19] reported accessory iliopsoas muscle splitting the left femoral nerve in a female cadaver. By muscle slip of the psoas major in three plexuses and by accessory iliacus slip in two plexuses, we discovered the splitting of the femoral nerve into two slips. Above the inguinal ligament, the femoral nerve slips merged with one another at various distances. Patients with referred pain to the hip and knee joints should be on the lookout for a variety of muscular slips of the psoas major or auxiliary slips from the iliacus that stress the femoral nerve.[20] The clinical significance is related to the lumbar plexus's tight association with the psoas major muscle and its neural architecture. Given that the nerves of the psoas muscle are located within its substance in cadavers, this tight anatomical link is perhaps even more significant. When neural tissues are sensitive to movement or tension or when they are inflamed, the psoas major and iliacus muscles play a protective role.

This study has a number of limitations that need to be acknowledged. First and foremost, the cadavers included in this study were embalmed, and their average age at death was 70.0 years. Although it is possible to argue that age and embalming are unlikely to have an impact on morphology in a way that is pertinent to the aim of this study, we must nevertheless exercise caution when extrapolating these results to other age groups. It must be underlined that the goal of this study was to investigate nerve morphology in order to define the anatomical variance of the lumbar plexus. The occurrence of anatomical variants shows that lumbar plexus anatomy is highly varied. It is required to conduct more research on the effects of age, gender, and ethnicity on the structure and blockage of the lumbar plexus. The natural sample diversity in human cadaveric specimens collected from a particular region is a limitation for this investigation. The results of our study might only apply to the demographic makeup of our area and might not generalize to other ethnic groups or geographical areas. The limited ability to distinguish between tissues caused by full chemical fixing of cadavers prevented the dissection of certain available specimens. To ensure reproducibility, cadaveric dissections were carried out and examined by a surgeon with training in peripheral nerve surgery.

Conclusion

Last but not least, cadaveric dissection revealed that the lumbar somatic plexus is located at the L4-5 level within the substance of the psoas major, indicating that psoas compartment techniques offer indirect access to the plexus. Clinical efficacy may be increased by administering anesthesia directly into the psoas major. Dissection revealed that all previously documented lumbar plexus block techniques appear to be anatomically valid, but changes may improve effectiveness and lower risks. The relationship between anatomical variation and its impact on patient presentation and differential diagnosis, particularly with regard to the impact of anatomical variation on neural mechano-sensitivity, is the subject of our proposal for additional study.

References

1. Horwitz M. The anatomy of the lumbosacral nerve plexus Its relation to variations in vertebral segmentation, and, the posterior sacral nerve plexus. Anatomical Record 1939; 74:91-106.
2. Berry M, Bannister L, Standring S. Nervous system. In: Williams P, ed. Gray's Anatomy. Churchill Livingstone, New York 1995;38: 901-1398.
3. Dietemann J, Sick H, Wolfram-Gabel R, Cruz da Silva R, Koritke J, Waken Heim A. Anatomy and computed tomography of the normal lumbosacral plexus. Neuroradiology 1987; 29:58- 68.
4. Salmons S. Muscle. In: Williams P, ed. Gray's Anatomy. Churchill Livingstone, New York 1995;38: 737-900
5. Clemente CD. Gray's Anatomy. American ed. Baltimore, MD: Williams & Wilkins, 1985;30.
6. Moore KL, Dalley AF. Clinically Oriented Anatomy. Baltimore, MD: Lippincott, Williams & Wilkins, 1999;4.
7. Palastanga N, Field D, Soames R. Anatomy & Human Movement: Structure & Function Boston, MA: Butterworth Heinemann, 1998;3.
8. Sauerland EK. Grant's Dissector. Baltimore, MD: Williams & Wilkins, 1994;11.
9. Linder HH. Clinical Anatomy. East Norwalk, CT: Appleton & Lange, 1989.
10. Pratt NE. Clinical Musculoskeletal Anatomy. New York, NY: Lippincott, 1991.
11. Dalens B, Tanguy A, Vanneuville G. Comparison of the fascia iliaca compartment block with the 3-in-1 block in children. Anaesth Analg 1989; 69:705-713
12. Bergman RA, Afifi AK, Miyauchi R. Lumbar plexus. In: An illustrated encyclopedia of human anatomic variation: Part III: Nervous system: Plexus 2001.
13. Chayen D, Nathan H, Chayen M. The psoas compartment block. Anaesthesiology 1976; 45:95-99
14. Farny J, Drolet P, Girard M. Anatomy of the posterior approach to the lumbar plexus block. Can J Anaesth 1994; 41:480-485

15. Dias Filho LC, Valenc MM, Guimaraes FA, Medeiros RC, Silva RA, Morais MG, Valente FP, Franca SM: Lateral femoral cutaneous neuralgia: an anatomical insight. Clinical Anatomy, 2003; 16(4): 309–316.
16. Uzmansel D, Aktekin M, Kara A: Multiple variations of the nerves arising from the lumbar plexus. Neuroanatomy, 2006; 5(1): 37–39.
17. Macalister A: Text-book of Human Anatomy. 1889:467-490.
18. Jakubowicz M: Topography of the femoral nerve in relation to components of the iliopsoas muscle in human fetuses. Folia Morphological, 1991; 50(1-2): 91–101.
19. Jelev L, Shivarov V, Surchev L: Bilateral variations of the psoas major and the iliacus muscles and presence of an undescribed variant muscle-accessory iliopsoas muscle. Annals of Anatomy, 2005; 187(3): 281–286.
20. Spratt JD, Logan BM, Abrahams PH: Variant slips of the psoas and iliacus muscles, with splitting of the femoral nerve. Clinical Anatomy, 1996; 9(6): 401–404.