

A Study to Document the Formation of Lumbar Plexus, its Branching Pattern, Variations and its Relation with Psoas Major Muscle

P. G. Anandhi¹, V. N. Alagavenkatesan², Pushpa³, P Shridharan⁴

ABSTRACT

Introduction: Lumbar plexus is one of the main nervous pathways supplying the lower limb which is bound to show variations. Clinicians esp. surgeons should be aware of the potential variations to plan the surgical therapies to avoid possible injuries to the structure. Current research aimed to study the formation of the lumbar plexus, observe its branching pattern and its relation with psoas major muscle and to document any variations in the formation and branching pattern.

Material and methods: It was an observational study involving 50 dissections from 25 embalmed cadavers were done in the Institute of Anatomy, Madurai Medical College, Madurai, India over a period of 2 years from June 2015- June 2017.

Results: Many significant variations were found in the anatomy of the lumbar plexus' branches namely iliohypogastric, ilioinguinal, genitofemoral, lateral femoral cutaneous nerve and accessory obturator nerve.

Conclusion: Knowledge of the variations in the branching pattern and formation of the lumbar plexus is essential to prevent nerve injury during routine surgical procedures like iliac bone graft, inguinal hernia surgery, low transverse incision of gynecological procedures, etc., The unusual pattern may create confusion in interpretation due to mismatch between symptoms of the patient and the findings in imaging modalities.

Keywords: Anatomical Variations, Nerve Block, Psoas Major Muscle

plexus, and the fifth lumbar nerve enters wholly to form the sacral plexus. Whereas the fourth lumbar nerve takes part partially in the formation of the lumbar and sacral plexus. Because of this forking nature, the fourth lumbar nerve is called as furcal nerve or nervus furcalis. Sometimes the third lumbar nerve (L3) or the fifth nerve (L5) may be forking in nature, and on such occasion, the sacral plexus may be called as prefixed or post fixed respectively. According to Quains Element of Anatomy, lumbar plexus is formed by the ventral primary division of upper four lumbar nerves, placed inside the substance of psoas major muscle, lying in front of the transverse process of corresponding lumbar vertebrae.¹ Farny J demonstrated the lumbar plexus at the level of L5, is within the substance of psoas major muscle rather than between the muscle and quadratus lumborum.² Yusuf Izcl concluded that the thinnest nerve is L1 (4.1 mm) and the thickest root is L4 (5.5mm). The longest is iliohypogastric nerve (210mm), and the ilioinguinal nerve is the thinnest (1.2mm) of lumbar plexus.³ Deniz Uzmsanel et al found multiple variations in a 35-year-old female cadaver - double ilioinguinal nerve, an accessory branch joined with the genital branch of the genitofemoral nerve, accessory lateral femoral cutaneous nerve arising from femoral nerve.⁴ Kusum R Gandhi described prefixation of lumbar plexus in one cadaver bilaterally.⁵ Deepti Arora et al reported variable iliohypogastric nerve in 8.33%, genitofemoral nerve 13.36%, absent lateral femoral cutaneous nerve in 16.67%.⁶ Kotian reported multiple variations in the formation and the branching pattern of lumbar plexus in fetal cadavers.⁷ Deepti Arora observed an unusual pattern of lumbar plexus on the left side of a male cadaver. It was prefixed on the left side with a contribution from the twelfth thoracic nerve. The ventral rami of T12 to L3 formed three loops. Genitofemoral nerve

INTRODUCTION

The first lumbar nerve (L1) joined by the branch from the twelfth thoracic nerve gives off the iliohypogastric and ilioinguinal nerve. A branch from ventral ramus of L1 joins with the second nerve to form genitofemoral nerve (L1, L2). The second lumbar nerve contributes to the greater part of genitofemoral, lateral femoral cutaneous nerve, femoral nerve, and obturator nerve through its ventral and dorsal divisions. The second, third and greater part of the fourth lumbar nerve divide into the anterior and posterior division. The posterior divisions join together to form the femoral nerve. The anterior division of ventral rami of L2, L3, L4 form the obturator nerve. Accessory obturator nerve if present, is formed by the anterior division of L3, L4. Dorsal division of L2, L3 form the lateral femoral cutaneous nerve. A small portion of fourth lumbar nerve (L4) unites with fifth ventral rami to form lumbosacral trunk which descends to form the sacral plexus. The upper three lumbar spinal nerves enter wholly into the formation of the lumbar

¹Associate Professor, Institute of Anatomy, Madurai Medical College, Madurai, ²Associate Professor, Department of Medicine, Madurai Medical College, Madurai, ³Institute of Anatomy, Madurai Medical College, Madurai, ⁴Assistant Professor, Department of Medicine, Madurai Medical college and Government Rajaji Hospital, Madurai, India

Corresponding author: Dr. V. N. Alagavenkatesan, Associate Professor, Department of Medicine, Madurai Medical College, Madurai, India

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arose from second loop and lateral femoral cutaneous nerve from the third loop. The whole trunk divided into femoral and obturator nerve.⁸ The iliohypogastric nerve is formed mainly from the first lumbar nerve and may also receive fibers from 12th thoracic nerve (T12). Kusum R.Gandhi observed that iliohypogastric and ilioinguinal nerve arose from a common trunk in 11.66%. In 88.33% they had separate origin.⁵ According to Gray's Anatomy, iliohypogastric nerve arises from the first lumbar nerve and connects ilioinguinal and subcostal nerve.⁹ Rajesh B Astik observed variant origin of femoral nerve in 25% of plexus.¹⁰ Archana BJ concluded that accessory obturator nerve was present in 2% males, 2% females. The incidence of accessory obturator nerve being 8%, origin from L2, L3 in 2% and from L3, L4 in 6% cases.¹¹ This study aimed to record the formation of the lumbar plexus, observe its branching pattern and its relation with psoas major muscle and to document any variations in the formation and branching pattern.

MATERIAL AND METHODS

It was an Observational study done in the Institute of Anatomy, Madurai Medical college from June 2015- June 2017. 25 adult human cadavers from both the sexes from the Institute Of Anatomy, Madurai Medical College were included for the study. The specimen will be excluded if there is evidence of surgical intervention on the abdomen or any abdominal injuries. 50 dissections from 25 embalmed adult human cadavers were done. Extensive dissection of lumbar plexus was conducted bilaterally in 17 male and 8 female cadavers, and its formation and branching pattern were noted down. The features of the normal and abnormal pattern were recorded for future tabulation. Exploration of the lumbar plexus was done as per Cunningham's Manual Of Practical Anatomy. The abdomen was opened by routine method. The peritoneal cavity was reached and all visceral organs like

the stomach, liver, spleen, pancreas, kidney, jejunum, ileum, ascending, transverse, descending, and sigmoid colon was removed along with mesentery. Aorta and its branches like the coeliac trunk, superior, and inferior mesenteric vessels were excised and removed. By exposing the iliopsoas fascia branches like femoral, lateral cutaneous nerve of thigh, iliohypogastric, ilioinguinal nerves were identified on the lateral border of psoas major muscle. Obturator nerve was seen medial to psoas major. The genitofemoral nerve was seen on the surface of psoas major muscle. Psoas major muscle was removed piece by piece to study the formation and situation of lumbar plexus. Branches of lumbar plexus were traced to iliac crest laterally and inguinal ligament anteriorly.

Parameters to be studied: Formation of lumbar plexus, relation of branches of lumbar plexus to psoas major, formation of iliohypogastric nerve, ilioinguinal nerve, formation and division of genitofemoral nerve into genital and femoral branches, formation of lateral femoral cutaneous nerve, femoral nerve, obturator nerve, presence or absence of accessory obturator nerve.

RESULTS

Out of 25 cadavers studied, 17 were male, and 8 were female. In all 50 specimens, lumbar plexus was seen to be situated in the posterior aspect of the substance of psoas major muscle, anterior to the transverse process of lumbar vertebrae, emerging from the intervertebral foramina below the corresponding vertebrae. The lumbosacral trunk passed downwards to join with the first sacral nerve to form sacral plexus. This normal pattern was observed in 49 out of 50 specimens. In one specimen fiber contribution in the formation of lumbar plexus was moved cranially and hence it was classified as the high form or prefixed in type.

Root value	Male cases				Female cases			
	Right	%	Left	%	Right	%	Left	%
L1	14	28	15	30	7	14	7	14
L1 with contribution from T12	1	2	2	4	1	2	1	2
T12	1	2	-	-	-	-	-	-
Absent	1	2	-	-	-	-	-	-

Table-1: Observation in the formation of Iliohypogastric Nerve

Root value	Male cases				Female cases			
	Right	%	Left	%	Right	%	Left	%
L1 with T12 contribution	1	2			1	2	2	4
L1	15	30	15	30	4	8	6	12
L1,L2	1	2	2	4	1	2	-	-
L2	-	-	-	-	1	2	-	-
Double ilioinguinal nerve	-	-	-	-	1	2	-	-

Table-2: Formation of ilioinguinal nerve

Emerges on	No. of specimen	Percentage
Anterior surface	46	92%
Posterior surface	4	8%

Table-3: Relation of genito femoral nerve to psoas major

Root value	Male cases				Female cases			
	Right Side	%age	Left Side	%age	Right side	%age	Left side	%age
L1,L2	16	32%	15	30%	8	16%	8	16%
L2	1	2%	1	2%	-	-	-	-
L2,L3	-	-	1	2%	-	-	-	-
Additional genital branch	1	2%	-	-	-	-	-	-

Table-4: Formation of genitofemoral nerve

Root value	Male				Female			
	Right side	%age	Left side	%age	Right side	%age	Left side	%age
L2,L3	11	22%	14	28%	7	16%	7	14%
L1,L2	1	2%	1	2%	1	2%	-	-
L2	1	2%	-	-	-	-	-	-
Arise from femoral nerve	3	6%	2	4%	-	-	-	-
Double lfcn	1	2%	-	-	-	-	1	2%

Table-5: Observations of the present study

The iliohypogastric nerve was formed from L1 in 29 plexus (14 in the right side and 15 in left side) in male cases and 14 plexus (7 in the right and 7 in left side) of female cases (table-1). The nerve arose from T12 in 1 male cases (1 in right side). The iliohypogastric nerve was found to be absent in right side of the right side of one male case. T12 contributed to the formation of iliohypogastric nerve in 5 plexus of which 1 in the right and 2 on the left side of the male cadaver. One on right and left side of the female cadaver.

The iliohypogastric nerve was found to have the normal origin in 86% cases and variant origin in 14% cases.

The ilioinguinal nerve was found to arise from L1 in 15 plexus along the right and left the side of male case respectively. In female case 4 in the right and 6 in left side arose from L1. One plexus in the right side of the male and female case and 2 in the left side of the female case arose from L1, L2. 1 case on the right side of the female case was found to arise from L2. The double ilioinguinal nerve was seen in 1 plexus in the right side of the female cadaver. Ilioinguinal nerve was found to have the normal origin in 84% cases and variant origin in 16% cases (table-2).

Genitofemoral nerve emerged on the anterior surface in 46 specimens and on the posterior surface in 4 specimens. Genitofemoral nerve emerged as the common trunk in 45 specimens, and as separate branches in 5 specimens. The genitofemoral nerve was found to originate from L1, L2 in 31 cases in male (16 right sides and 15 on the left side of the male cadaver) and 16 plexus in females (8 on the right and left side). The nerve arose from L2 in 2 plexus (one on right and left side of the male cadaver), and it originated from L2, L3 in 1 plexus. An additional genital branch was seen on the right side of the male cadaver (table-3).

Femoral nerve was seen to be formed from the dorsal divisions of L2, L3, L4 in 49 specimens. In one female cadaver which had the high form (prefixed plexus) on the right side, this femoral nerve had the root valve of L1, L2, L3. Obturator nerve was formed from the ventral division of L2, L3, L4 in all specimen except the prefixed plexus, in which it was formed from L1, L2, L3. Accessory obturator nerve was found in 2 plexus in the right and one on the left

side of male cases. In female cases, it was found in 1 plexus in the left side (table-4,5).

DISCUSSION

In all 50 specimens, the lumbar plexus was seen in the posterior part of the substance of psoas major muscle. This coincides with the observation of Farny J. et al. who had done 4 cadaveric dissections and demonstrated that the lumbar plexus is within the posterior part of the substance of psoas major muscle rather than between the psoas major muscle and quadratus lumborum.²

In the present study, it was observed that the iliohypogastric nerve received a contribution from T12 in 10% of cases. Kusum R Gandhi reported it in 13.3% whereas Deepti Arora reported it in 8.33%. While Bardeen C.R and W.Henry Hollinshed proposed that iliohypogastric nerve originated from T12 and L1 in 34% and Woodburn found it in 50% of cases. J.Symington of Quain's Anatomy states that twelfth thoracic nerve gives a branch to the first lumbar nerve which in turn divides into the iliohypogastric and ilioinguinal nerve. J.Jayarani (2015) also reported the contribution of T12 in the formation of the iliohypogastric nerve is 2%. Observation of the present study coincides with Kusum R Gandhi.^{1,5,8,12}

Gray's Anatomy states that ilioinguinal nerve arises from ventral rami of L1. In the current study, the ilioinguinal nerve is found to arise from L1 in 80% of cases, and this observation is supported by E.A.Schafer and J.Symington in Quains Element of Anatomy.¹

Double ilioinguinal nerve was noted in 1 specimen in the current study. This coincides with the study of Sushma R Kotian (2015) and Uzmansel et al. who also had reported the presence of the double ilioinguinal nerve in one plexus in his study. Thus knowledge of ilioinguinal nerve is essential to avoid injury during surgical procedures in lower abdominal regions. The second most common neuropathy reported is due to injury to the iliohypogastric and ilioinguinal nerve during Pfannenstiel incision in obstetrical and gynecological procedures.^{4,7}

The lateral femoral cutaneous nerve was found as a branch arising from the femoral nerve in 5 plexus (10%) in the

present study. Diaz Filho¹³ (2003) and Denizuzmansel⁴ (2006) had observed in one specimen. Rajesh Astik¹⁰ (2011) had reported it in 6.2%. Deepti Arora⁸ (2015) reported it in 8.3%. The femoral nerve is found to be split by few fibers of psoas major muscle in one specimen 2% in the present study. Spratt et al.¹⁴ (1996) reported a similar finding in 2.2%, Vazquez et al.¹⁵ (2007) in 7%, Jakubowicz¹⁶ (1991) in 2.5%. In the present study, accessory obturator nerve was found to have a frequency of 8%, and it coincides with the findings of Webber¹⁷ (8%), Bardeen¹⁸ (8.40%) and Anloague¹⁹ (8.80%).

CONCLUSION

The lumbar plexus has been found to be situated in the posterior abdominal wall within the psoas major muscle or in the posterior part of the muscle. The psoas muscle and fascia covering the muscle acts as a conduit for nerve root of lumbar plexus. Starting approximately from twelfth thoracic vertebral level, this potential compartment continues below being bordered posterolaterally by fascia of quadratus lumborum and iliacus muscle. This natural gutter acts as a repository for local anesthetic agents which provides an excellent method of unilateral lower extremity anesthesia during surgery on lower extremities. Knowledge of the variations in the branching pattern and formation is essential to prevent nerve injury during routine surgical procedures like iliac bone graft, inguinal hernia surgery, low transverse incision of gynecological procedures.

During retroperitoneal endoscopic surgeries, when the psoas major muscle is separated, the branches of the lumbar plexus is exposed to the potential risk of injury. Obturator neuropathy has been reported after total hip replacement surgery, due to intrapelvic extrusion of cement used surgery. Excision of such cement and preservation of nerve is essential if the nerve is intact and functional to get relief from excruciating pain. In case of presence of accessory obturator nerve, this nerve has to be blocked in addition to obturator nerve to prevent adductor spasm. Thus, this study on formation and branching pattern of lumbar plexus is essential to surgeons, orthopedic surgeons, retroperitoneal endoscopic surgeries and anesthesiologist for lumbar plexus block.

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