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# A Human Cadaveric Study on Variations in Formation and Branching Pattern of Lumbar Plexus with Its Clinical Implications

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**Original Research Article**

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**Abstract:** Considering lumbar plexus being the 'no man land' for many surgeons due to its difficult approach and various articles stating about the frequency in the failure of lumbar plexus block, it becomes prudent to know the possible variations in formation and branching pattern of lumbar plexus. Dissection in 60 lumbar plexus, variations like Ilioinguinal and Iliohypogastric nerves having 10% and 5% variations respectively in its branching pattern. Genitofemoral nerve showing variation in 20.2% i.e. high split with different root value or even being duplicated or showing abnormal communication with femoral nerve. Femoral nerve showed variation in 15% of lumbar plexus like bifurcations, late formation or early division of the nerve and even origin of lateral cutaneous nerve of thigh from the femoral nerve. Lateral femoral cutaneous nerve had 18.3% variations like being bifurcated i.e. doubled, varied origin with late formation or even being absent in one plexus. Presence of Accessory obturator nerve in 11.6% of the plexus and the above variations made the author feel the necessity to conduct the study.

**Keywords:** Lumbar Plexus, Psoas Major, Ilioinguinal Nerve, Iliohypogastric Nerve, Femoral Nerve, Obturator Nerve, Lateral Femoral Cutaneous Nerve, Genitofemoral Nerve.

## INRODUCTION

Lower abdominal surgeries like retroperitoneal laparoscopies, gynaecological procedures, inguinal hernia repair, iliac crest bone grafting has become very common to encounter post operative radiculopathy or peripheral neuropathy like meralgia paraesthetica, groin pain etc.

Hence, in this study, the main objective is to add on more details on possible variations and also to compare the findings with previous literature to bring in more clarity [1]. A thorough knowledge on possible variations in the formation and branching pattern of lumbar plexus will have a lesser chance for iatrogenic injury of the plexus.

## MATERIALS AND METHODS

The study was done during routine educational dissection on 30 formalin embalmed human cadavers in the department of anatomy, BMCRI, Bangalore (Karnataka) for a period of 3 years. Cadavers with any signs of injury or surgical scar in the lower abdominal region were excluded from the study. The skin, superficial fascia, muscles of anterior abdominal wall and all abdominal viscera were removed to expose the posterior abdominal wall. The fibres of psoas major muscle were then meticulously detached from the intervertebral discs and vertebral bodies. Each branch of lumbar plexus was identified by its relation with psoas major and with 12$^{th}$ rib. Out of total 60 lumbar plexuses studied, 30 specimens i.e. 50% belonged to the right side and rest 30(50%) belonged to the left side. Bothe male and female cadaver of age group ranging from 25 till 75 were considered for the study, with a total of male 24 and female 6 cadavers. Any variations in both lumbar plexus formation and branching pattern were recorded and photographed.

## RESULTS

In the present study, major variations were found in branching pattern and origin of lateral femoral cutaneous nerve, genitofemoral nerve, femoral nerve and ilioinguinal nerve. Rest of the nerves have no great contribution in its variation. Presence of accessory obturator nerve was also significantly observed. The Lumbar plexus showed no significant variation in relation with psoas major muscle

Female cadavers were significantly less when compared to the male cadavers and no significant

differences were found when comparing both the sides of lumbar plexus in a cadaver; hence sexual dimorphism and bilateral comparison is not taken into much consideration, unless otherwise required in case of clinical significance.

**Iliohypogastric nerve (IH)**

In 3 lumbar plexus, iliohypogastric formation was from T12 and L1 (5%) and rest all i.e. 57 plexus out of 60 (95%) showed origin from L1 alone

**Ilioinguinal nerve (II)**

All specimens have ilioinguinal arising from L1 alone. Iliohypogastric and ilioinguinal nerve in two plexus (3.3%) showed early split at the origin level itself. In 3 plexus, ilioinguinal nerve was found to be absent.

**Genitofemoral nerve (GF)**

The origin of genitofemoral nerve varied from L1 alone in one specimen, L2 and L3 in one specimen and rest all specimens i.e. 58 plexus showed normal root value i.e from L1 and L2. The nerve showed an early split in 7 specimens out of which 5 plexus, both genital and femoral component arose from L2 alone and other 2 plexus has genital component arising from L 2 and femoral component from L3. In two specimens, the split of two components rejoined after 6cm away from the origin to form single stem within pelvic cavity.

**Lateral femoral cutaneous nerve (LFCN)**

Root value of 57 plexus out of 60 arose from L2 and L3, two plexus had its origin from L2 alone and in one plexus origin was from L1 and L2. There were two lateral cutaneous nerve in 4 specimens out of which 2 plexus showing double lateral cutaneous, both arising from L2 and L3 was bilateral in a male cadaver (Fig no: 03 ). Other two plexus was observed unilaterally on left side in a male cadaver and another on left side in a female cadaver from L3 alone (Fig-2).

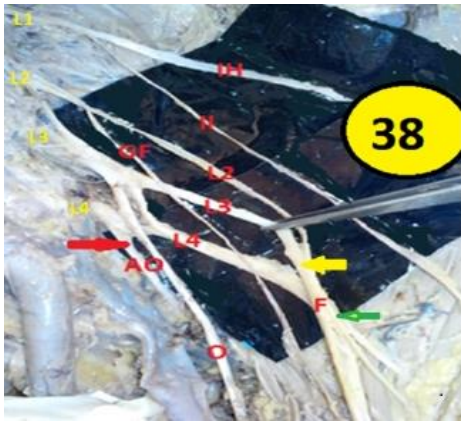


**Fig-1: (a) late formation of femoral nerve (yellow arrow) (b) Presence of accessory obturator nerve (red arrow) (c) Absence of lateral cutaneous nerve of thigh (d) Early division of femoral nerve (green arrow)**


**Fig-2: (a) prefixed lumbar plexus (b) Double LFCN**

Late formation of lateral cutaneous nerve was also observed in one plexus which rejoined soon after the nerve emerged from the psoas major muscle. Lateral cutanous nerve found to be absent in a male cadaver on left side (Fig no: 01) and in one specimen lateral cutaneous nerve was joining the femoral nerve, around 6 cm after formation (Fig -4).

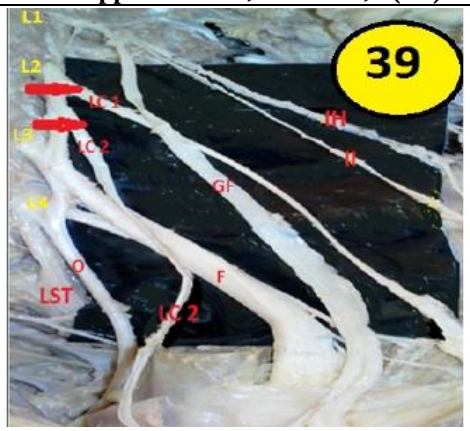


**Fig-3: (a) Genitofemoral (GF) nerve from L1 (b) Double LFCN**

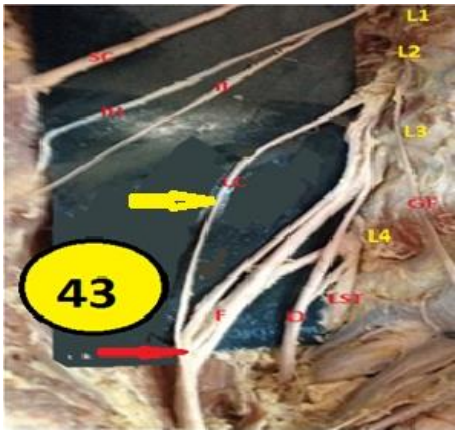


**Fig-4: (a) late formation of femoral nerve (red arrow) (b) LFCN (yellow arrow) joins femoral nerve (red arrow)**

**Femoral nerve (FN)**

56 lumbar plexus out of 60 was arising from L2, L3 and L4 (93.3%). In 2 plexus (3.3%) femoral nerve was arising from L1, L2, L3, L4. In one plexus the nerve showed its origin from L3, L4 and 1 plexus from L2, L3, L4 and L5 i.e. post fixed (Fig no: 05).

In 6 specimens (10%), femoral nerve showed bifurcation i.e. a separate branch from the main trunk was divided soon after its formation. (Fig-6) and in one specimen, femoral nerve showed multiple segments which rejoined after 4 cm from its origin (Fig no: 01). In three plexus (5%), lateral cutaneous nerve was emerging from the femoral nerve. This sort of variation in the branching pattern will adversely affect the outcome of femoral nerve block.

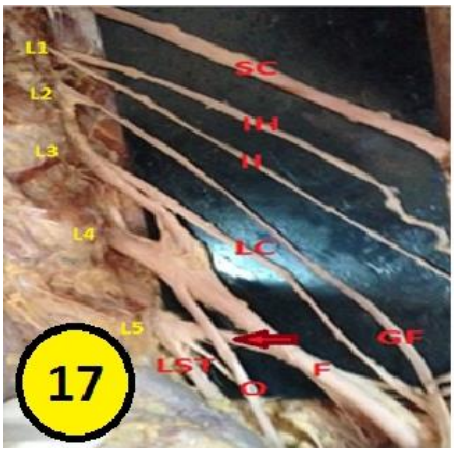


**Fig-5: Post fixed lumbar plexus (red arrow)**

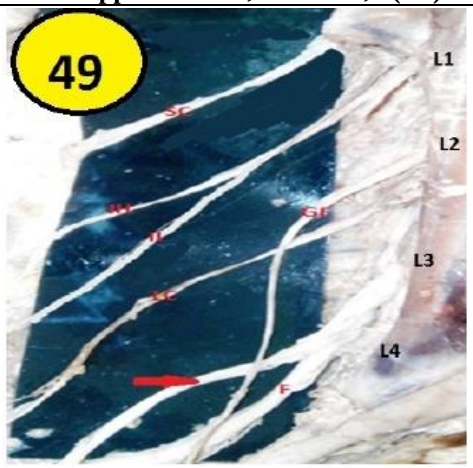


**Fig-6: Early branching of femoral nerve (red arrow**

**Obturator nerve (ON)**

This nerve showed no variations in its root value.

**Accessory obturator nerve (AON)**

The existence of accessory obturator nerve was observed in 7(11.6%) out of 60 lumbar plexus, arising from L3 and L4. Only in one male cadaver accessory obturator nerve was bilateral, rest 6 plexus showed the nerve arised unilaterally- out of which 2 plexus in female cadavers both on the right side and 4 was in male cadavers, where 3 was on the right and one was on the left side (Fig-1).

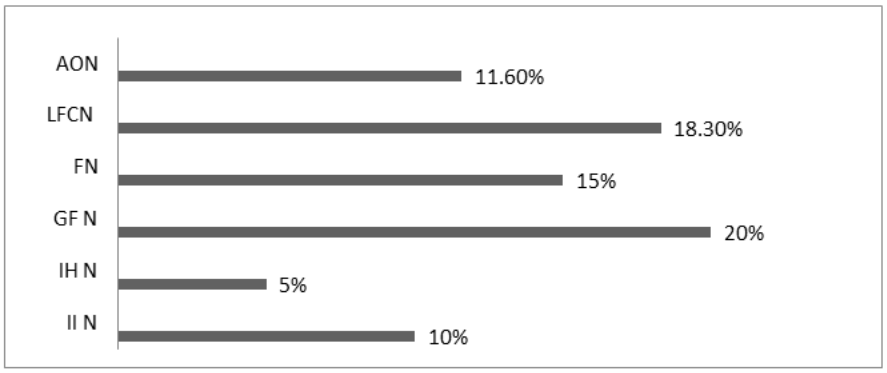


**Fig-7: Percentage of variations shown by the branches of lumbar plexus**

## DISCUSSION

**Pre-fixed and post-fixed lumbar plexus**

In our study, T12 contribution to form lumbar plexus i.e prefixed lumbar plexus is 3 (5%) out of 60 lumbar plexus. In all these specimens, it was observed that iliohypogastric nerve was arising from T12 along with subcostal nerve (Fig no: 1) and in only one lumbar plexus showed post fixed i.e. contribution in the formation of femoral and obturator nerve from L5 (Fig - 5).

**Table-1: Contribution of T12 in formation of lumbar plexus-Comparison with other authors**

| SL no | Author/s name | Percentage of specimen showing T12 contribution (%) |
|---|---|---|
| 01 | Hollinshed | 34 |
| 02 | Woodburn | 50 |
| 03 | Ghandhi K.R *et al.* | 13.3 |
| 04 | Present study | 05% |

**Iliohypogastric nerve**

When compared to other literature, in the present study iliohypogastric nerve showed very less variations both in root value and branching pattern. The nerve was showing morphological normal origin i.e. from L1 in most of the plexus except in 3 lumbar plexus, which emerged from T12. Ghandhi K.R et al. observed that iliohypogastric nerve was arising from L1 in 86.6% [1]. Hollinshed proposed that iliohypogastric emerged from T12 and L1 in 34% of the specimens and from L1 alone in 32% [2]. In a study done by Deepti Arora *et al*. specified that iliohypogastric nerve was emerging from L1 alone is 78.33% and found the nerve to be absent in 13.34% [3]. Anloague P.A observed that in 20.1% of specimen's iliohypogastric nerves were found to be absent [4]. In the present study we did not

encounter absent iliohypogastric nerve in any given plexus.

**Ilioinguinal nerve**

In the present study, Ilioinguinal nerve emerged in all lumbar plexus from L1 alone. It was found absent in 3 cadavers bilaterally accounting for 10%. Bergman reported that ilioinguinal nerve arises from a common root with a ratio of 86.5% i.e. from L1, while 11% arises from two different segments (T12 and L1, L1 and L2, or L2 and L3) [10]. Arora et al mentioned in their study that the ilioinguinal nerve was seen arising from T12 & L1 in 8.33%, from L1 alone in 73.33%, from L1 & L2 in 1.67%, from L2 alone in 1.66% of plexuses and also reported the nerve being absent in 14.9% [3].

**Femoral nerve**

Number of variations found in femoral nerve is relatively more. For femoral nerve block it is suggested by Analogue PA, that the chances of compression is more for femoral nerve due to tight ilio-psoas compartment, especially post surgical. Therefore having vivid knowledge on its possible variations in root value and branching pattern play a paramount importance among anaesthetists, anatomist and orthopaedic surgeons to avoid iatrogenic injury to the nerve [4].

**Clinical implications**

Gurbachan signh Gindha *et al*., mentions that high division of femoral nerve at the root level itself can lead to incomplete femoral nerve block and relates the late formation of femoral nerve being interfered by the muscle fibres of psoas major will increase the chances of nerve compression leading to neuropathic pain over the distribution [5]. In the present study, late formation of femoral nerve was observed in 3 plexus (Fig-1) and even bifurcation of femoral nerve from the root level was observed in 6 lumbar plexus accounting for 10% (Fig-6).

Rajesh *et al*. States those variant slips of the psoas major muscle splits the femoral nerve into two or three separate slips as it was found in three plexus in his study [6]. Rajesh B et al. observed that in four specimens the lateral femoral cutaneous nerve was originating from the femoral nerve and in the present study the same was found in three plexus [6] (Fig-4) and in one plexus, lateral femoral cutaneous nerve was joining the femoral nerve on the right side of a male cadaver (Fig-5).

**Clinical implications**

This sort of above variations might lead to an inappropriate femoral nerve block, increasing the chance of nerve compression as well an ineffective treatment for patients suffering from meralgia paresthetica [4].

**Genitofemoral nerve**

Bergman et al gave a statement that genitofemoral nerve is the one which has shown maximum variations both in its root value as well as its branching pattern within pelvic cavity and was observed that genitofemoral nerve has single root in 80% and rest 20% is from two roots could be from L1,L2 or L2,L3 [10]. In present study two plexus showed its origin from L1 (Fig-3) and around 3 plexus showed two roots from where genital and femoral nerve was arising from L2 and L3 respectively (Fig-4).

High splitting of genitofemoral nerve is very often mentioned in literature. Anloague PA stated that a mid split was observed in 26.5% and high split in 20.6% were psoas major fibres was passing between the roots [4]. In present study 11.6% specimens showed high split of genitofemoral nerve. Arora et al has found absent genitofemoral nerve in 10% specimens [3]. No such variation was found in the present study. Most of the plexus had genitofemoral nerve arising from L2 and L3 except in 8.3% plexus which showed its origin from L2 alone (Fig-5), similar was mentioned by Gindha *et al*., [11].

**Clinical implication**

Variations in the regional anatomy of genitofemoral nerve might be a cause for radiculopathy following post abdominal hernial repair. Hence, a prior knowledge on the variations might be helpful in avoiding surgical trauma to the nerve.

**Lateral femoral cutaneous nerve of thigh (LFCN)**

In the present study, LFCN shows varied origin i.e. from L2 alone in 3 plexus, from L1 and L2 in 1 plexus and solely from L3 in 1 plexus and was found absent in 2 specimens (Fig no: 01). Arora et al. observed LFCN origin from L2 in 1.7% and said it was found to be absent in 16.67% [13]. Bifuraction or double LFCN was mentioned in one plexus by Analogue PA et al [4]. While in the present study bifurcation of LFCN was observed in 2 plexus (Fig-2 and 3). LFCN was taking its origin from femoral nerve in 3 plexus i.e 5% (Fig-4) and the same was reported in 8.3 % by Arora *et al*., [3]. Low formation of LCFN was stated by Sushma *et al.* in 2.9% specimens [12]. LFCN joins femoral nerve after its formation in one lumbar plexus (Fig no: 05) which has been mentioned in a study done by Uzmansel et al in 2 specimens [8].

**Clinical implications**

Multiple variations in LFCN might lead to an inappropriate lumbar plexus block, increasing the chance of nerve compression as well an ineffective treatment for patients suffering from meralgia paresthetica [4].

**Obturartor nerve**

Arora D et al mentioned that 53.32% of plexuses showed normal formation, 3.33% found to

arose from T12, L1, L2,L3 and 11.67% from L1,L2 and L3 and L1, L2, L3, L4 in 26.67% of lumbar plexuses [3]. In the present study, obturator nerve showed no variations in the formation as all plexus had its normal morphological origin i.e. from anterior division of L2, L3 and L4. The only variation which is worth mentioning regarding obturator nerve is the presence of accessory obturator nerve, which showed its existence in 11.6% i.e. in 7 plexus.

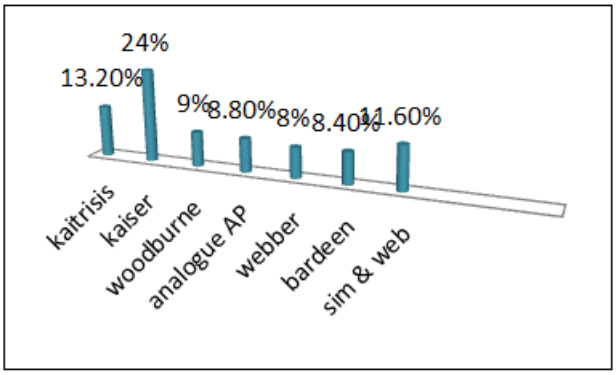


**Fig-8: Comparison with findings of other authors on existence of accessory obturator nerve**

## CONCLUSIONS

In this study, the attempt is to add on more details in the branching pattern and most appropriate clinical importance, as there are many lower or retro abdominal surgeries ongoing hence a detailed knowledge in the variation will avoid iatrogenic injuries to the nerves thus preventing post operative complications and might help the clinician to treat the patients accurately.

### List of abbreviations

IH N: Iliohypogastric nerve
II N: Ilioinguinal nerve
GF N: Genitofemoral nerve
LFCN: Lateral femoral cutaneous nerve
FN: Femoral nerve
ON: Obturator nerve
AO N: Accessory obturator nerve

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