Anatomical Variations in Formation and Branching Pattern of the Border Nerves of Lumbar Region

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Natl J Clin Anat 2019;8:57–61

Background  Ilioinguinal, iliohypogastric, and genitofemoral nerves are together known as “border nerves” of the lumbar plexus. Aim of this study was to find out the variations in formation and branching pattern of these nerves and correlate with their clinical relevance.

Materials and Methods  For this study 30 formaldehyde preserved cadavers were used, and the nerves were studied on both the sides, thus making the sample size of 60.

Results  Iliohypogastric nerve was absent in 6.6% and double in 1.6%. It was prefixed with a twig from T12 in 6.6% and had origin from both L1 and L2 in 1.6%. The ilioinguinal nerve was absent in 3.3% and double in 3.3%. The genitofemoral nerve exhibited a large number of variations. It was absent in 1.6%. Early division of the nerve prior to emergence from the psoas major muscle was noticed in 13.3%, and early division soon after emergence from the muscle was noted in 3.3%. In one cadaver, on one side, genital branch was absent, and it continued as femoral branch only. In another cadaver, the nerve continued as genital branch only. In two other cases, genital and femoral branches were seen to arise separately from the lumbar plexus. The nerve had its origin from L1 and L2 in 25%, L2 and L3 in 25%, L1 in 3.3%, L2 in 46.66%, and L3 in 1.6% of the cases.

Conclusion  Knowledge of these variations would be of immense help during surgical approach and giving nerve block for anesthesia and postoperative analgesia in this region.

Abstract

Keywords  ► iliohypogastric nerve  ► ilioinguinal nerve  ► genitofemoral nerve

Introduction  Ilioinguinal, iliohypogastric, and genitofemoral nerves are collectively known as border nerves, because they supply the skin in the borders between the thigh and anterior abdominal wall.¹² They arise from lumbar plexus within the substance of psoas major. Iliohypogastric and ilioinguinal nerves generally have a root value of L1. They emerge from the upper part of lateral border of the psoas major muscle, of which iliohypogastric is proximal. They exit the abdominal cavity by piercing transverses abdominis above the iliac crest, and in front and below the anterior superior iliac spine, respectively. The genitofemoral nerve usually arises from L1 and L2, and emerges from the anterior surface of the psoas major muscle. It divides into genital and femoral branches proximal to the inguinal ligament. They exit the cavity by passing through the inguinal canal and the femoral sheath, respectively.

These nerves are commonly involved in iatrogenic injuries following anesthetic nerve block or surgeries performed in the lower abdomen.³ Knowledge of normal and variant anatomy of these nerves is essential while putting the skin incisions on lower abdominal quadrants and while performing surgeries in inguinal regions. Utmost care should be taken not to include these nerves while suturing, to avoid postoperative neuropathies.⁴ Knowledge of their variations plays a crucial role in better management of groin pain.⁵ Ilioinguinal and iliohypogastric nerve blocks are given to produce anesthesia in inguinal surgeries, particularly in the pediatric population.⁶⁷ For surgical interventions on the scrotum, genitofemoral block is preferred to obtain better results rather than local anesthetic infiltration.⁸ Awareness of the normal course and branching pattern of these nerves and their variations is important for
successful administration of the nerve block, not leading to any postoperative complications.37910

Materials and Methods

After obtaining ethical clearance, this study was conducted in the anatomy department of Vinayaka Mission’s Kirupananda Vairiyar Medical College & Hospital (Salem) and Vinayaka Mission’s Homeopathic Medical College (Salem). Thirty adult formalin fixed cadavers, with no evidence of surgical intervention on the abdomen and pelvic cavity, were used for this study. The lumbar plexus was dissected on both sides as per Cunningham’s Manual of Practical Anatomy, 15th edition.11 Iliohypogastric, ilioinguinal, and genitofemoral nerves were traced from their origin to exit in the abdominal cavity. Variations were photographed and noted down.

Results

Iliohypogastric nerve was absent in 4 (6.6%) out of 60 lumbar plexuses. A nerve with a twig from T12 was found in four (6.6%) plexuses. It originated from L1 and L2 in one (1.6%) plexus. Unilateral double nerve was found in one (1.6%) plexus (Fig. 1). Ilioinguinal nerve was absent in two (3.3%) plexuses and double in another two (3.3%) plexuses (Fig. 2).

Genitofemoral nerve was absent in one (1.6%) plexus. In 3.3% cases, genital and femoral branches were seen to arise separately. Early division of the nerve into genital and femoral branches prior to entering the substance of psoas muscle occurred in 8 (13.3%) out of 60 lumbar plexuses (Fig. 1). In two (3.3%) plexuses, the nerve split after emerging from the muscle in the middle of its course (Fig. 3). Unilateral absence of genital branch was observed in one (1.6%) cadaver and unilateral absence of femoral branch in another (1.6%). Origin of the nerve from L1 and L2 occurred in 15 (25%) plexuses, L1 only in 2 (3.3%) plexuses, L2 only in 28 (46.6%) plexuses, L3 only in 1 (1.6%) plexus, and from both L2 and L3 in 15 (25%) plexuses (Fig. 4). Variation in formation occurred in a total of 46 (76.67%) plexuses.

Variations in iliohypogastric, ilioinguinal, and genitofemoral nerves are summarized in Table 1.

Discussion

Literature review shows numerous variations of ilioinguinal, iliohypogastric, and genitofemoral nerves. It was reported that the ilioinguinal and iliohypogastric nerves exhibited the anatomy as described in the textbooks in only 41.8%, with
12.5% absence of one or both and 5% presence of one or both accessory nerves. Variant origin, branching pattern, and mode of emergence from the psoas major have also been reported by several authors.

**Iliohypogastric Nerve**

In this study, iliohypogastric nerve took origin from L1 in 83.6% of the cases, whereas Klaassen et al observed its origin from L1 in only 7% of the cases. Contribution from T12 was observed in 6.6%, which was slightly higher than that obtained by Jayarani (2%) and Arora et al (3.3%), but lower than that obtained by Klaassen et al (14%) and Bardeen and Elting (36%). Origin of the nerve from T12 alone (7%) and T11 and T12 (6%) was also noticed earlier, but we did not observe any such variation. Contributions from T11 and T12 are also mentioned by other authors.

It is believed that a reciprocal relation exists between the development of T12 and iliohypogastric nerves (L1). The nerve took origin from L1 and L2 in one (1.6%) specimen in this study, similar to that observed by Jayarani (2%). Absence of the nerve in this study (6.6%) was much lower than that reported by Analogue and Huijbregts (20.6%). When absent, its function is taken over by the genitofemoral nerve. We observed unilateral double iliohypogastric nerve in one cadaver, which has not been reported so far.

**Ilioinguinal Nerve**

Absence of ilioinguinal nerve was noted in 3.3% in this study and in 2% by Jayarani. Absence was also reported by Bergman et al. In all cases, it took origin from L1 only, though variant origin has been described by other authors. Klaassen et al observed its origin from T12, L1 in 14%, L1 and L2 in 11%, and L2 and L3 in 10%. Bergman et al reported its origin from L1-L2 and L2-L3 in 11% and origin from L3 and absence of the nerve in 2.5%. Origin from L1 and L2 (2%), L2 alone (2%), and L3 alone (2%) was reported by Jayarani. Double ilioinguinal nerves were observed in 2 (3.3%) plexuses in this study, and also reported bilaterally in one cadaver by Uzmanzel et al.

**Genitofemoral Nerve**

It took origin from L1 and L2 in only 25% of the cases. Origin from L2 alone was more frequent (46.67%) than the classic origin from L1 and L2 described in most of the textbooks. This was followed by origin from L2 and L3 in 25%. Other variations in origin such as from L1 (3.3%) and L3 (1.6%) were rare findings. Origin from T12 and L1 was noted in all prefixed plexuses by Gandhi et al (13.3%). Origin from a single root (L1 or L2) was reported to be more common (80%) than that obtained by Klaassen et al (8.3%) and Jayarani (8%).

Early division of the nerve into genital and femoral branches at its formation was noticed in 13.3%, which was slightly higher than that obtained by Sim and Webb (8.3%) and Jayarani (8%); but lower than that observed by Gandhi et al (21.7%), Anloague and Huijbregts (26.5%), Rab et al (42%), and Uzmanzel et al (42%). Early division of the nerve in the middle of its course, after emerging from psoas major, was noticed in 3.3%.

**Clinical Implications**

Ilioinguinal and iliohypogastric nerves and their branches are closely related to surgical incisions in lower abdominal quadrants such as Pfannenstiel incision, lower paramedian incision and oblique lumbar incision for nephrectomy, and incisions for herniorrhaphy and appendicectomy. Literature review shows ilioinguinal and iliohypogastric nerve entrapment following inguinal and abdominal surgeries. It is reported to be the second most common neuropathy, arising as a complication following Pfannenstiel incision. Genitofemoral entrapment neuropathy following inguinal and femoral herniorrhaphy has been observed by earlier authors. Moreover, persistent ilioinguinal neuropathy can cause weakness in the lower abdominal wall, predisposing the formation of a direct hernia. Therefore, care should be taken while giving the above incisions and also while suturing back the different layers of the abdomen.

Iliohypogastric and ilioinguinal nerve blocks provide safe and effective surgical and postsurgical analgesia in inguinal and lower abdominal surgeries, including caesarean section. It is commonly used anesthetic in inguinal surgeries in pediatric patients. Addition of genitofemoral nerve block was noticed to be useful at the time of sac retraction though not effective in postoperative analgesia. The genitofemoral nerve block is preferred over local filtration in scrotal anesthesia as it reduces the chances of injury to the male genitalia.
Failure of ilioinguinal and iliohypogastric nerve blocks has been reported to be as high as 10 to 25%. Successful analgesia can be achieved only if there is a thorough knowledge of anatomy of the concerned nerves and their variations. Improper needle position while administering the block can result in postoperative nerve injuries. Ultrasound-guided nerve blocks have been shown to provide far better outcome compared to conventional blind nerve blocks. Yet, in developing countries, the conventional methods continue to be the mainstay in most surgical settings. Hence, it is imperative for the surgeons and anesthetists to have a thorough knowledge of the different variations in the above three nerves.

Embryological Basis of Variations
Transcription factors are believed to be responsible for formation, relation, and distribution of motor nerve fibers during their development. Transcription factors include cell surface receptors such as neural cell adhesion molecules, L1 cell adhesion molecules, and N-cadherin. They recognize and bind to components of extracellular matrix during neurite growth. Several trophic factors such as nerve growth factor, neurotrophin 3 and 4 that are released from the target tissue, regulate expression of these cellular adhesion molecules. The axonal growth cones sense the concentric gradient of trophic factors in the environment and grow along the gradient toward the target. The regulation of the developing axons is by the expression of chemoattractants and chemorepellants. Any alterations in signaling between mesenchymal cells and neuronal growth cones result in the development of variations.

Conclusion
Variations in the border nerves of the lumbar plexus are not uncommon. Absence of iliohypogastric, ilioinguinal, and genitofemoral nerves were 6.6%, 3.3%, and 1.6%, respectively, in our study. Genitofemoral nerve showed maximum variations in origin (76.7%), and iliohypogastric showed variant origin in 8.2% only. Double iliohypogastric and double ilioinguinal nerves were observed in 1.6% and 3.3% specimen, respectively. The genital and femoral branches arose separately from lumbar plexus in 3.3%. Early divisions of the nerve prior to emergence from the psoas muscle and soon after emerging from the muscle were 13.3% and 3.3%, respectively. Knowledge of these variations is required for administering nerve blocks, performing surgeries in lower abdominal region, and in management of groin pain.

Funding
None.

Conflicts of Interest
None.

References
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