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A cadaveric anthropometric study of femoral nerve. Anatomical guide to successful femoral nerve block

Estudio antropométrico cadavérico del nervio femoral. Guía anatómica para el bloqueo exitoso del nervio femoral

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Resumen

Introducción: el nervio femoral es uno de los nervios principales que inerva una amplia área de la extremidad inferior en humanos y a menudo se considera para el bloqueo nervioso regional para obtener anestesia durante las cirugías de extremidades inferiores, el manejo del dolor perioperatorio, postoperatorio y traumático. Sin embargo, el bloqueo ciego del nervio femoral se considera complicado y la literatura que documenta la morfología del nervio femoral y su relación con puntos de referencia palpables es insuficiente.
Métodos: En el estudio actual, ambas extremidades inferiores se diseccionaron en 54 cadáveres fijados con formalina (108 muestras) y se midieron varios parámetros en el pliegue inguinal para localizar el nervio femoral.
Resultados: La distancia promedio entre el nervio femoral y la arteria femoral fue de 0.64 ± 0.21 cm, desde la columna ilíaca superior anterior fue de 7.60 ± 1.30 cm y desde la piel fue de 2.42 ± 1.16 cm en el pliegue inguinal. El diámetro promedio del nervio femoral fue de 0.72 ± 0.18 cm y la arteria femoral fue de 0.90 ± 0.15 mm en el pliegue inguinal. El ancho de la articulación interfalángica distal del dedo meñique del mismo lado se midió para determinar si existe alguna correlación positiva entre este valor y la distancia entre la arteria y el nervio femoral, pero este estudio solo pudo encontrar una correlación débil negativa entre ellos.
Conclusión: Este estudio proporcionó un conjunto de datos morfológicos para ayudar a localizar el nervio femoral en el pliegue inguinal. Estos datos serán útiles para obtener un bloqueo ciego del nervio femoral en situaciones de emergencia y prehospitalarias y pueden ayudar en los procedimientos guiados por ultrasonido.

Palabras clave: bloqueo del nervio femoral, distancia de la arteria del nervio femoral, distancia del nervio femoral-asis, diámetro del nervio femoral

Abstract

Introduction: *The femoral nerve is one of the major nerve innervating a wide area of lower limb in humans and often considered for regional nerve block to obtain anesthesia during lower limb surgeries, perioperative, post- operative and traumatic pain management. However, the blind femoral nerve block is regarded complicated and literature documenting the morphology of femoral nerve and its relation to palpable landmarks is insufficient.*
Methods: *In current study both lower limbs were dissected in 54 formalin fixed cadavers (108 specimen) and various parameters were measured at inguinal crease to locate femoral nerve.*
Results: *The average distance of femoral nerve from femoral artery was 0.64± 0.21cm, from anterior superior iliac spine was 7.60± 1.30 cm and from skin was 2.42± 1.16 cm at inguinal crease. The average diameter of femoral nerve was 0.72± 0.18 cm and femoral artery was 0.90± 0.15 mm at inguinal crease. The width of distal interphalangeal joint of little finger of same side was measured to find out if any positive correlation exist between this value and femoral nerve-artery distance, but this study could only find a negative weak co-relation between them.*
Conclusion: *This study provided a set of morphologic data to help to locate femoral nerve at inguinal crease. These data will be useful to obtain blind femoral nerve block in emergency and pre- hospital set ups and may aid in ultrasound guided procedures.*

Key words: *femoral nerve block, femoral nerve-artery distance, femoral nerve-asis distance,*
femoral nerve diameter

Introduction

Injuries related to hip joint and femur critically disrupt walking, standing, and other lower limb movements. Pain and suffering resulting from femoral and hip trauma is severe and agonizing and demands effective and speedy pain management. Femoral nerve (FN) block is an effective regional anesthesia for providing analgesia in various hip and femoral trauma and perioperative care if they are executed appropriately.[1-5]

Since its introduction during local anesthetic procedure in1989.[6,7] ultrasound-guided nerve blocks have become increasingly popular with clinicians, because of precise action and faster onset of anesthesia and analgesia.[7,8]

It is also free from harmful adverse effects of pain analgesic medicines like G.I. bleeding, liver dysfunction, platelet dysfunction leading to intra or postoperative bleedings.[7,9]

The femoral nerve (FN) originates from the ventral rami of the second, third and fourth lumbar nerves (lumber plexus) and descends on ilieo psoas groove. Beneath the inguinal ligament it enters the femoral triangle of thigh lying lateral to femoral artery (FA). The nerve remains separated from the artery by the femoral sheath and small amount of psoas muscle fibers.[10-12]

Branches of femoral nerve (FN) innervate pectineus, sartorius and quadriceps femoris muscles; articular surface of the acetabulum, the anterior wall of the hip joint, anterior aspect of the femur, anteromedial aspect of the knee joint and anteromedial of thigh skin.[10,12,13]

Another important branch of femoral nerve is saphenous nerve which is a sensory nerve and innervates the skin of the medial leg and medial side of the foot.

Despite the advantages, the femoral nerve block remains an infrequently tried anesthetic technique.[5,14-17]

Anesthetists and non-anesthetic clinicians finds the FN blocking technically complex and could be challenging at times.[5,17]

Understanding detailed regional anatomy around the targeted block area is a must for a successful and uncomplicated nerve block. If proper landmark identification is not done, unwanted nerve or vascular accident occurs and multiple punctures and readjustment of needle position and angle are often required.[5,18-20]

A detailed measurement of the femoral nerve and related anatomical structures is insufficient in the published literatures.

The aim of the study is to explore and identify fixed anatomical points close to the femoral nerve in the inguinal region and measuring their distances and relationship with the femoral nerve in order to facilitate accurate and successful femoral nerve block. This study also tried to find if any anthropometric correlation exists between little finger width and femoral artery and femoral nerve distance as previously mentioned in a study to facilitate accurate blind FN block.[5]

Methods

The current study was done at anatomy department dissection lab at our institution over a period of three years (January, 2016 to December, 2019). 54 formalin fixed cadavers (24 male, 30 female) were utilized for the study. Ages of the cadavers ranged between 78-83 years.

Cadavers were placed supine on dissection tables. Anterior superior iliac spine (ASIS) and pubic tubercle (PT) were felt and marked with pins. Inguinal crease of all cadavers were marked and colored pins were placed along the line.

First horizontal incision was made on the skin along upper limit of inguinal crease. Tibial tuberosity of leg was felt and a second horizontal incision was made on the skin across it around the knee. A third midline vertical incision joining the two horizontal incisions was made.

The incision along inguinal crease was strictly maintained throughout the study. All the researchers had to watch and agree before making that incision. The skin was reflected along the incision line. The superficial fascial contents including fat, connective tissue and superficial blood vessels were dissected and removed; the deep fascia (fascia lata) was incised and reflected to expose the femoral nerve, vessels and adjacent muscles.

Deep to the fascia lata, the front of the thigh muscles were exposed. The margins of sartorius and adductor longus muscles were cleaned and identified. The Femoral triangle and its contents (Femoral vessels and nerve) were identified.

Measurements were taken by digital caliper and measuring tapes. Angles were measured using protractor and goniometer scales. Cadaver thighs were placed in abducted position making an angle of approximately 20 degrees with the midline during the dissection process and measurement procedures.

The distance between femoral nerve and artery was measured at femoral crease, which was marked by pins before making the skin incision. **(Fig. 1)**

The distance between adjacent borders of femoral nerve and femoral artery was recorded. The diameter of femoral nerve and femoral artery was measured at the same place. The linear distance between ASIS to FN on femoral crease was measured and distance between the inguinal ligament and inguinal crease was measured at the level of femoral nerve. The angle between inguinal crease and Femoral Nerve was measured and recorded. The depth of the femoral nerve from skin was measured at the incision line along inguinal crease.

Then, on same sided upper limb, 5th finger width at distal interphalangeal (DIP) joint was measured. **(Fig. 2)**

The 5th finger width was measured to find out any correlation between its value and femoral nerve-artery distance, which was investigated in a previous study.

All of the data were tabulated and entered in Microsoft excel software and analyzed. For calculation of correlation co-efficient, the Pearson's correlation coefficient calculator (online version) was used.

Result

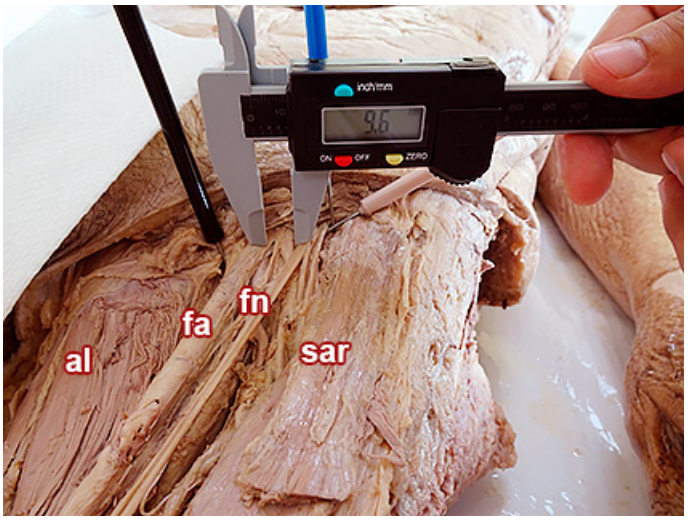

Fig. 1: Measurement of distance between adjacent border of femoral nerve and artery at inguinal crease.
al) adductor longus; fn) femoral nerve; fa) femoral artery; sar) Sartorius

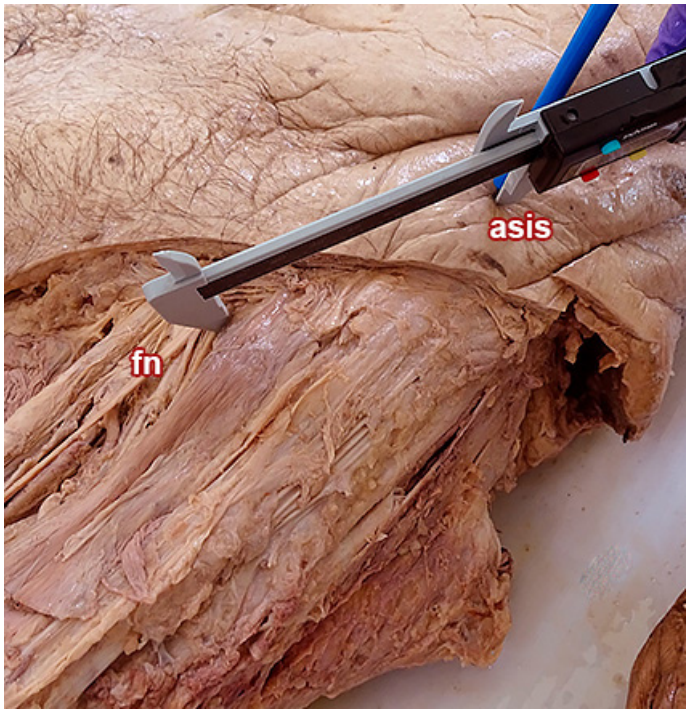

Fig. 2: Measurement of distance between ASIS and femoral nerve.
fn) femoral nerve; asis) anterior superior iliac spine

The average distance between the adjacent borders of femoral neve and femoral artery at inguinal crease was .64 cm (± .21). The distance between ASIS and femoral nerve at inguinal crease varied across 5.6-10.2 cm, though the mean was 7.60cm. **(Table I)**

Parameters	Mean	SD	Range
Femoral nerve-Femoral artery distance	0.64	0.21	0.37-0.98
ASIS- Femoral nerve distance	7.60	1.30	5.6-10.2
Skin–Femoral nerve depth	2.42	1.16	0.5-4.6
Femoral nerve diameter	0.72	0.18	0.4-1.09
Inguinal ligament-Inguinal crease distance	2.58	0.69	1.5-4
Femoral artery diameter	0.90	0.15	0.65-1.14
5th digit DIP width	1.29	0.12	1.04-1.55

Table I: Showing values of various parameters (cm)

The depth of femoral nerve varied widely depending on the built of the cadaver, in a thin built cadaver it was only 0.05 cm deep to the skin where as in obese cadaver it was as deep as 4.6 cm.

The average femoral nerve diameter at inguinal crease was 0.72 ± 0.18 cm. The femoral nerve was found to be a collection of branches instead of a single nerve at inguinal crease and the diameter of the whole bunch was recorded as femoral nerve diameter.

The inguinal ligament was located proximally and parallel to the inguinal crease, the average distance between them varied from 1.5-4 cm.

The average diameter of femoral artery at inguinal crease was 0.90 ± 0.15 cm.

Variations were observed in branching pattern of femoral artery- the level of origin of deep femoral artery, the origin of lateral circumflex femoral artery and muscular branches of femoral artery.

In some cadavers 25%), one or more branches arising from femoral artery were detected between the femoral artery and femoral nerve at inguinal crease, although in majority of cadavers no additional arterial branches were noted between the main trunks of femoral nerve and artery. **(Figs. 3, 4. Table II)**

The width of DIP of little finger was compared with the formal nerve-artery distance of same side, only a weak negative correlation (co-relation co-efficient r = -0.1793) was found in our study. **(Fig. 5)**

Fig. 3: Measurement of angle between inguinal crease and femoral nerve asis) anterior superior iliac spine

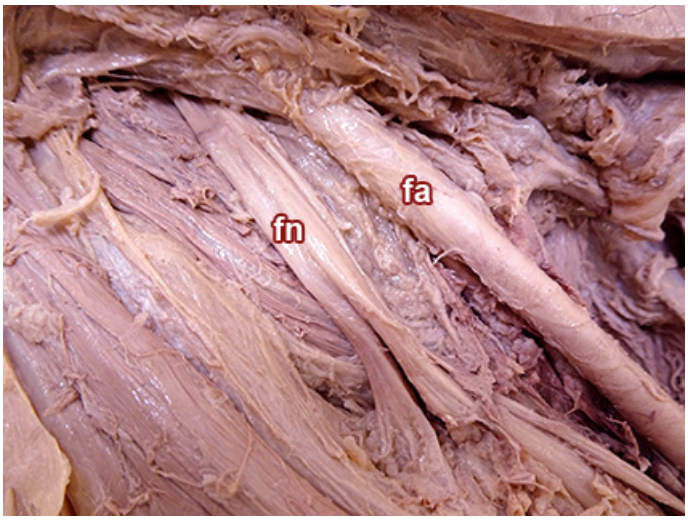

Fig. 5: Femoral nerve and artery at inguinal crease without any intervening arterial branches fa) femoral artery; fn) femoral nerve

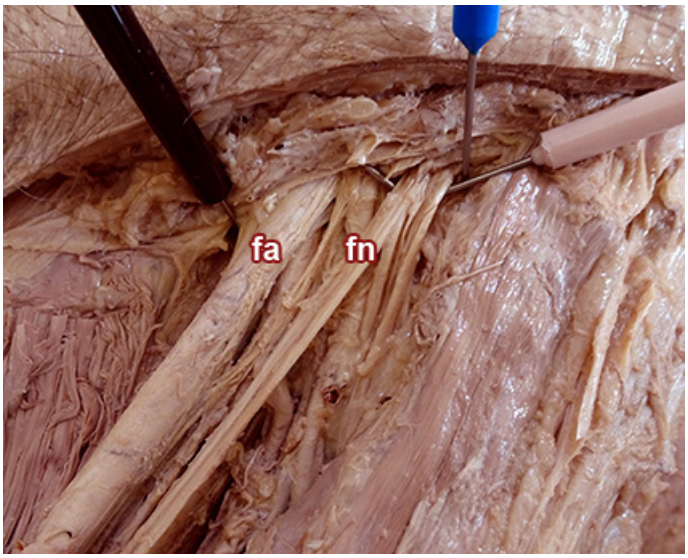

Fig. 4: Femoral nerve and artery at inguinal crease with intervening arterial branches in between fa) femoral artery; fn) femoral nerve

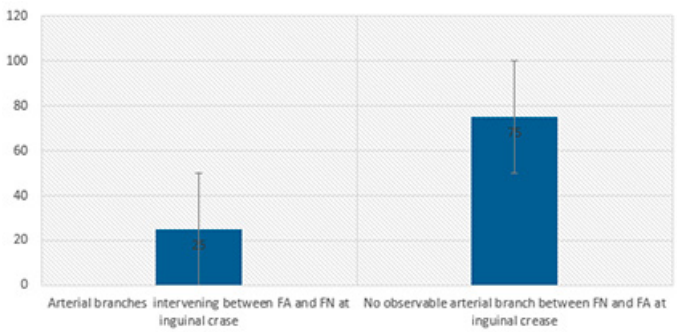

Table II: Bar diagram showing comparison between structures observed at inguinal crease in cadavers

Discussion

In present study, we found the average distance between adjacent margins of FN and FA was 0.64 cm (+/- 0.21 cm.), (range 0.37- 0.98 cm) at the level of inguinal crease.

As mentioned by Volka et al inguinal crease is identified as visible skin fold distal to the inguinal ligament and parallel to it, medially intersecting the junction of scrotal or genital skin with the thigh.[5]

The inguinal crease was chosen to perform all measurements related to femoral nerve because of previously reported high proportionate needle and nerve contacts at this point.[15]

The femoral nerve was found to be immediately deep to fascia lata at inguinal crease, skin to nerve depth varied from 0.5 cm to 4.6 cm (average 2.42 cm) depending on cadaveric built from skinny to obese. The variation of skin to nerve depth was supported by previous studies.[12,21]

The FN- FA average distance and the range found in this study is much less than the ultrasound measurement study (range 0.82-2.01, mean 1.33 cm), by Vedran et al.[5]

The difference of methodologies of two study can explain this as we measured the distance between adjacent borders of FN & FA where as Vedran and team measured the distance between the midpoints of FN and FA and by ultrasound.[5]

Vedran et al found strong correlation between the FN-FA distance and little finger width at DIP joint and used the dominant hand for this comparison.[5]

We found a very weak negative correlation between the same parameters as we compared the actual FN-FA distance with little finger width at DIP joint of same sided hand. Moreover, it was observed the measurements in radiology and physical cadavers do differ Dahlstrom et al.[22]

Our study reemphasized the importance of physically collecting measurements from a cadaveric specimen when trying to accurately describe human anatomy.

We believe the distance of lateral border of FN from Anterior Superior Iliac spine (ASIS) could be a reliable parameter to localize the femoral nerve in clinical settings. In our study the average distance between FN-ASIS was 7.60 cm +/- 1.3 (range 5.6- 10.2 cm).

Gustafson et al found the average distance between ASIS and pubic symphysis as 14.5 +/- 1.34 cm and found the femoral nerve near midpoint of this landmarks in approximately 46% (+/- 5) cases- which corroborates with current study.[11]

The average nerve diameter in our study was 0.72 cm where as in the study by Gustafson et al, the average diameter of femoral nerve was 0.79 cm.[11] The average FA diameter in our study was 0.90 cm.

The present study found the femoral nerve made 55-60 degrees angle medially with inguinal crease. Volka et al described a FN block making a needle angle at 60 degree catches the nerve quite precisely.[15]

We found the inguinal ligament at an average distance of 2.58 +/- 0.69 cm above the inguinal crease (range limits: 1.5 cm - 4.0 cm). This data is falling in range with study by Czyzewska et al who provided a range of 1.42 - 3.03 cm and explained the variation had a strong co-relation with height and sex of the patient.[23]

We observed the branching pattern of femoral artery occasionally had inconsistency. We noticed a prominent muscular branch arising from lateral aspect of femoral artery at the level of inguinal crease coursed in between the femoral artery and femoral nerve and provided vascular supply to vastus group of muscles in 3 different cadavers.

In 24 dissected sides, we noticed the lateral circumflex femoral artery arose directly from femoral artery very close to or at the inguinal crease and passed between the anterior and posterior divisions of femoral nerve. These arterial variations should be kept in mind to avoid accidental piercing during femoral nerve blockade and need further exploration for proper documentation.

Ultrasound guided nerve block has higher success rates and claims to have less complications associated with peripheral nerve blockade; however both nerve injury and intravascular injection are not uncommon.[12,24]

Identifying the femoral nerve with ultrasound may not have a one hundred percent accuracy and could be challenging at situations. It is operator's skill dependent. Accurate execution and needling requires good hand eye coordination and more over it may need additional instruments like Peripheral nerve stimulator to double confirm the nerve position.[2,5,12,25]

Use of all these instruments comes with increase in expenditure and needs extra hands too. The instruments are only available at high end tertiary set ups so in a summery it requires expertise, skill, money and manpower and cannot be executed at prehospital or most of the emergency situations.[5, 18-20]

Blind femoral nerve block relies on surface anatomy of visible and palpable bone landmarks. In emergency set ups and pre hospital situations where speedy and accurate interventions are required the blind percutaneous nerve block is the preferred method and studies suggested satisfactory analgesia can be achieved with proper training and appropriate execution.[2,12,26,27,28]

The anatomy and morphology we observed remained consistent with other studies suggesting the specimens represented general population.

Limitation of the study is as mentioned in literatures, exposures to embalming make the cadaver tissue change in water and morphologic contents however these distortion minimally effects the artery, nerves and bone landmarks. Another limitation is we could not cross check the data in a clinical setting or on a cadaver to successfully locate the femoral nerve.

We measured the angle of FN with inguinal crease which will help the direction and angle of needle introduction. The anthropometric data is region specific, it changes with race and country and individuals. Our study indicated measurement of width of 5th DIP finger is not a very reliable universal indicator to find the puncture site for FN block.

Conclusion

We do recommend the approach to skin puncture for a FN block by making good surface anatomy strategy and use multiple parameters like distance from ASIS, distance between FN and FA and diameter of femoral nerve for confirming the accurate needle puncture site on inguinal crease.

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