Anatomical study of the iliohypogastric, ilioinguinal and genitofemoral nerves using high-resolution ultrasound

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Aims and objectives

The iliohypogastric (IH), ilioinguinal (II) and genitofemoral (GF) nerves are at risk to injury from the lower abdominal incision (Pfannenstiel incision, appendectomy, inguinal herniorrhaphy) or trocar insertion performed in laparoscopic surgery [1]. Injury to these nerves result in groin pain that may involve the perineum and the medial thigh [1]. In addition, it has been shown that it is possible to block the IH, II and GF nerves using US guidance [1] or fluoroscopy [2]. Direct peripheral nerve visualization is now possible with high-resolution ultrasound [3] for large fascicular nerves [4] and for small monofascicular nerves [5]. Therefore, in this study, we aimed to determine whether high-resolution ultrasound (US) can identify the IH, II and GF nerves and their relations.
Methods and materials

Anatomical Correlation

The anatomical correlation portion of this project was approved through the anatomical donations program at the University of Barcelona.

The anatomy of the iliohypogastric, ilioinguinal and genitofemoral nerves were examined in 5 human cadavers (3 males and 2 females: 89, 42, 52, 55, 66 years old, respectively). Dissections extended from the anterolateral abdominal wall to the perineum and inguinal region. The superficial planes were identified and removed. Then, the three nerves were identified among the Transversus abdominis, Obliquus internus and Obliquus externus, isolated, exposed and their calibres at this level were manually calculated. Then, the three nerves were followed distally and the distal branches of these nerves were visually identified and marked with plastic bars. Their calibres were calculated too. The visual inspection was performed by an anatomist and by a musculoskeletal radiologist. The contralateral side of a cadaver was used as anatomical correlation to visualize the nerve using broadband linear-array transducers (frequency band: linear 12-7 MHZ, and linear 18-5 MHZ). US examinations were performed by two radiologists (A.T. and B.B.). The iliohypogastric, ilioinguinal and genitofemoral nerves were considered to be identified when a fascicular structure was seen at the level of the antero-lateral abdominal wall. The distal branches of each nerve were identified when a monofascicular structure was seen on different planes on both static and dynamic US images distally to the main nerve trunks as previously reported for other nerves[6-7].

US In Vivo Examination

US imaging of the iliohypogastric, ilioinguinal and genitofemoral nerves was performed bilaterally in 30 healthy volunteers (15 women and 15 men: median age 44 years, age range 22-69 years, body mass index range: 21-29) using broadband transducers (frequency band: linear 12-7 MHZ, and linear 18-5 MHZ) (Fig.1).

Two musculoskeletal radiologists with differing expertise (8 and 3 years of experience in musculoskeletal imaging and ultrasound, respectively) performed the US examinations in consensus.

The iliohypogastric, ilioinguinal and genitofemoral nerves were considered to be identified when a fascicular structure was seen at the level of the antero-lateral abdominal wall. The distal branches of each nerve were considered to be identified when a monofascicular structure with no color-Doppler signals (to differentiate the nerve from a small vessel) was seen on different planes on both static and dynamic US images distally to the main nerve trunks as previously reported [6-7].
Images for this section:

Fig. 1: Schematic drawing on volume-rendering computed tomography showing probe positioning around the antero-lateral abdominal wall. Arrowhead= probe; traced line= dynamic scan direction.

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Results

Anatomical Correlation

At dissection, visual inspection of the iliohypogastric, ilioinguinal and genitofemoral nerves showed that the caliber of the nerves was approximately 2/3 mm at the level of anterolateral abdominal wall between the abdominal muscles. Sometimes the nerves were accompanied by an artery or by a vein that were collapsed and easily differentiated from the nerve trunks. More distally, dissections extended from the anterolateral abdominal wall to the perineum and inguinal region and identified several distal branches belonging to the main nerve trunks and sometimes forming anastomosis. In general, the iliohypogastric, ilioinguinal and genitofemoral nerves divided at least in two or three distal branches with a diameter less than 1 mm. These distal branches were marked with plastic bars (Fig. 2).

With high-resolution US the main nerve trunks were identified. On cadavers, US identification of the terminal branches of the three main trunks was considered not possible due to the difficulties in separating small monofascicular nerves from small collapsed veins and arteries.

US In Vivo Examination

On volunteers, color-Doppler was useful to differentiate small vessels from monofascicular structures at the level of the anterolateral abdominal wall, inguinal area and perineum.

Visualization of the IH, II, GF nerves was always possible proximally before the division of the nerves in their distal branches at the level of anterolateral abdominal wall. Moreover, visualization of the distal branches was possible in 60% of volunteers.

The IH started to become visible with US at the posterior part of the Transversus abdominis, in this area it was always visible. Then it was visible between that muscle and the Obliquus internus abdominis (Fig. 3, Fig.4) and then it divided into a lateral and an anterior cutaneous branch which were visible in 22/30 volunteers bilaterally.

The II nerve started to become visible with US below the iliohypogastric near the anterior part of the iliac crest in all volunteers (Fig. 5). Then, the nerve pierced the Obliquus internus and divided. The division branches were visible in 18/30 volunteers.
To find the IH and II nerves we kept the US probe perpendicular to the inguinal canal and we looked cranially and posteriorly to the antero-superior iliac spine. Starting from this point, it was possible to visualize the hyperechoic bony cortex of the iliac crest, all three layers of the abdominal wall muscles (Obliquus Externus and Internus and Transversus Abdominis). The nerves were visualized in the fascial planes between the Obliquus Internus and the Transversus muscles. The IH and II nerves were usually in close proximity to each other and color-Doppler was used to identify the deep circumflex iliac artery.

The GF nerve was considered visible when at least two major branches such as the external spermatic and at least one of the lumboinguinal nerves were visible. The external spermatic nerve through the abdominal inguinal ring was always visible.

The external spermatic nerve through the abdominal inguinal ring was always visible. When scanning this nerve, color-Doppler was used to differentiate vessels (testicular artery, artery to vas deferens, and the pampiniform venous plexus). Sometimes we asked the patient to perform a gentle Valsalva maneuver to distend the vascular structures within the canal. The lumboinguinal nerve, beneath the inguinal ligament, superficial and lateral to the femoral artery was visible in 16/30 of the volunteers.
**Fig. 2:** Cadaver dissection with overview of distal branches of the iliohypogastric, ilioinguinal and genitofemoral at the level of inguinal area.

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**Fig. 3:** Gray-scale transverse US image of the iliohypogastric nerve between the Transversus abdominis and Obliquus internus abdominis. Note the monofascicular pattern typical of small nerves. Doppler technique was used to exclude the vascular nature of this structure.

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Fig. 4: Gray-scale longitudinal US image of the iliohypogastric nerve between the Transversus abdominis and Obliquus internus abdominis.

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Fig. 5: Gray-scale transverse with color-Doppler image of the nerves showing the difference among nerve and vessels.

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Conclusion

In conclusion our study showed that high-resolution ultrasound can identify the iliohypogastric (IH), ilioinguinal (II) and genitofemoral (GF) nerves at the level of the abdominal wall and that visualization of the terminal branches of these nerves is possible in up to 60% of volunteers.
References


