Descriptive Study

Ultrasound-Guided Injections at the Lateral Femoral Cutaneous Nerve: The Inguinal Ligament as a Barrier

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Disclaimer: There was no external funding in the preparation of this manuscript.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 11-18-2019
Accepted for publication: 12-20-23019

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Background: Ultrasound-guided perineural injections at the lateral femoral cutaneous nerve (LFCN) may confirm the correct diagnosis and provide symptom relief in meralgia paresthetica. Although correct visualization of the nerve is generally described as feasible, failure rates of the procedure may be as high as 30%.

Objectives: This study investigated the spread of injected fluids in ultrasound-guided perineural injections at the LFCN. The aim of the study was to evaluate whether the inguinal ligament impedes the distribution of injected fluids along the course of the LFCN.

Study Design: We used a descriptive research design.

Setting: Research was conducted at an anatomical research facility.

Methods: In fresh, nonembalmed cadavers, 2 mL of ink were injected with ultrasound-guidance at the LFCN below the inguinal ligament. The course of the nerve was then dissected to show the extent of nerve staining.

Results: Spread of the injected ink proximal to the inguinal ligament was found in 67.65% of specimens, while the ink did not pass the inguinal ligament in 32.35%. Concerning proximal spread, specimen body mass index was not of any relevance.

Limitations: This cadaver study is only a simulation of the real clinical setting and does not allow any insight into the efficacy of the injection in living patients.

Conclusions: The inguinal ligament is a barrier in the distribution of injected fluids in about one-third of specimens. This might be a major cause of failure in ultrasound-guided injections. The results from our study are in line with previously published failure rates and our findings might provide the anatomic basis to advance injection techniques.

Key words: Cadaver study; injection; lateral femoral cutaneous nerve; LFCN; meralgia paresthetica; nerve entrapment; sonography; ultrasound

Pain Physician 2020: 23:E363-E367

Meralgia paresthetica is caused by entrapment of the lateral femoral cutaneous nerve (LFCN) occurring either iatrogenically or spontaneously in association with various conditions (1-3). Estimates of the incidence in the general population have been stated as 3.26 to 4.30 per 10,000 patient years (4,5), but may be higher in subgroups of patients with obesity, diabetes, and other diagnoses (1,3). Compression of the LFCN causes characteristic symptoms such as pain, hypesthesia, or

paresthesia at the anterolateral aspect of the thigh. The clinical diagnosis may be proven by electrodiagnostic exams with a specificity of up to 98.75% (6). The natural course of meralgia paresthetica is not fully understood and treatment guidelines based on randomized controlled trials are missing. However, if conservative treatment measures fail, both steroid injection around the nerve or surgical treatment are potential therapeutic alternatives (2). Perineural injections with a mix of a local anesthetic and steroids may confirm the correct diagnosis and treat the condition.

Injections based on anatomical landmarks yield unsatisfying results as the accuracy may be as low as 0% to 5% (7). Ultrasound has gained in importance as a diagnostic and therapeutic aid and nerve characteristics have been described in both patients with meralgia paresthetica and healthy controls (8-10). A plethora of publications exists on ultrasound-guided injection approaches (7,11). However, despite the data available on LFCN injections and the broad availability of ultrasound systems, success rates are still variable. Persistence of symptoms has been reported in 20% to 80% of patients after primary injection (11,12), while complete failure of full LFCN-coverage may be as high as 15% to 32% (13,14).

As the LFCN may be affected by entrapment both proximal and distal to the inguinal ligament (15), injection of steroids at the typical injection site distal to the inguinal ligament may only cover a part of the compromised nerve segment. We hypothesize that this may be the main cause for failure.

The aim of this anatomic study was to evaluate the distribution of injected fluids along the LFCN in a typical ultrasound-guided injection and whether the inguinal ligament would act as a barrier.

Methods

After approval of the study by the local ethics committee (EK Nr: 1083/2018), 18 fresh, nonembalmed cadavers were enrolled in the study. Cadavers from body donors were selected randomly as they became available, authorized by signed informed consent before death. Cadavers with clear signs or medical records of surgery to the inguinal region were excluded. Specimens were placed supine on an operating table at room temperature. Body weight, waist, and hip circumference were measured according to the recommendations of the World Health Organization (WHO) (16). Ultrasound examinations were performed by a radiologist using a clinical ultrasound system (Aplio i800 with a Linear Transducer i18LX5, Canon Medical Systems Europe B.V., Zoetermeer, The Netherlands). Two mL of diluted blue ink (Tinte 4001, Pelikan Holding AG, Feusisberg, Switzerland) were injected under ultrasound guidance using a 22-gauge needle. The site of injection was chosen where the nerve can be visualized best, distal to the inguinal ligament, and distal to the anterior superior iliac spine (Fig. 1).

The specimen was then dissected with careful exploration of the course of the LFCN and its surrounding structures by anatomists. The point where the LFCN crosses the inguinal ligament was marked on the underlying bony ridge of the superior ramus of the pubic bone. This point was used as the reference for the measured distances of injection fluid spread. Data was analyzed using SPSS Version 24.0 (IBM Corporation, Armonk, NY). The Mann-Whitney test was used to determine whether the body mass index (BMI) was different between the group with fluid spread proximal to the inguinal ligament and the group without.

Results

For the final analysis, 34 lower extremities (17 left, 17 right) of 18 cadavers were available. There was a predominance of 12 female vs 6 male cadavers with a mean age of 82.61 years (63.54-99.45 ± 9.39) at their death. Mean BMI was 24.84 (16.73-44.73 ± 7.08), with 13 of the cadavers (72.22%) below a BMI of 25. Three cadavers had a BMI of 25 to 30, while 2 had a BMI of greater than 35 and 40, respectively. Mean waist-hip ratio was 0.94 (0.78-1.14 ± 0.10); therefore the WHO criteria (16) for abdominal obesity (≥ 0.90 for males, ≥ 0.85 for females) were fulfilled by all male and all but 2 female cadavers.

The mean distance (measured in a horizontal plane) between the anterior superior iliac spine and the LFCN was 1.18 cm (0.00-5.00 ± 1.25). Ink was injected in all cadavers at a mean distance of 2.15 cm (0.00-8.00 ± 1.79) distal to the anterior superior iliac spine, and a sonographic distribution directly around the nerve was observed in all cases. Spread of the injected ink proximal to the inguinal ligament was found in 23 extremities (67.65%), staining the LFCN below the iliac fascia. Ink did not surpass the inguinal ligament in 11 extremities (32.35%). The Mann-Whitney test showed no significant difference in BMI between the 2 groups (P = .210). Six of the 18 cadavers (33.33%) showed spread proximal to the inguinal ligament only on one side. Distal distribution of ink along the course of the nerve was found in all extremities, up to a mean dis-

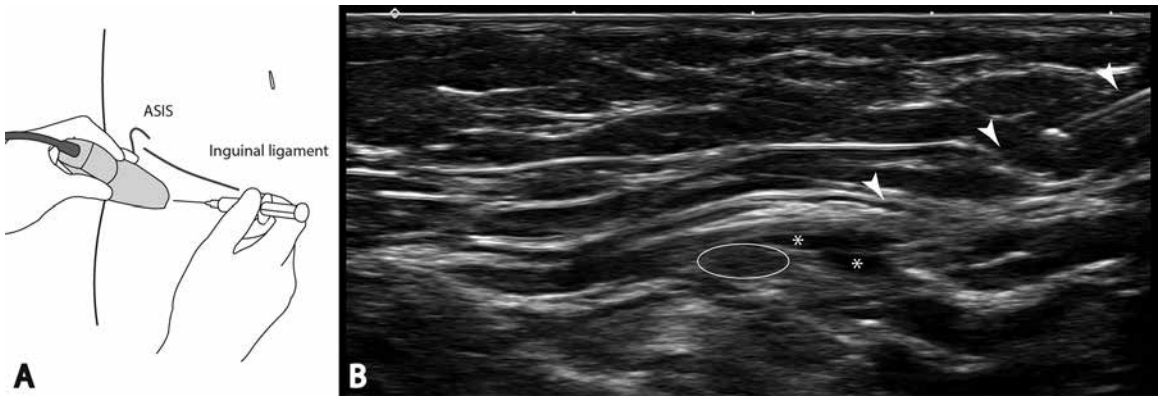

Fig. 1: *A: Graphic illustrating the injection procedure. Injection is performed distal to the inguinal ligament and distal to the ASIS. B: Ultrasound image during the injection. The needle (arrowheads) is advanced towards the nerve parallel to the image plane. Distribution of the injected fluid (asterisks) is visualized around the LFCN (circle).*
Abbreviations: ASIS, anterior superior iliac spine; LFCN, lateral femoral cutaneous nerve.

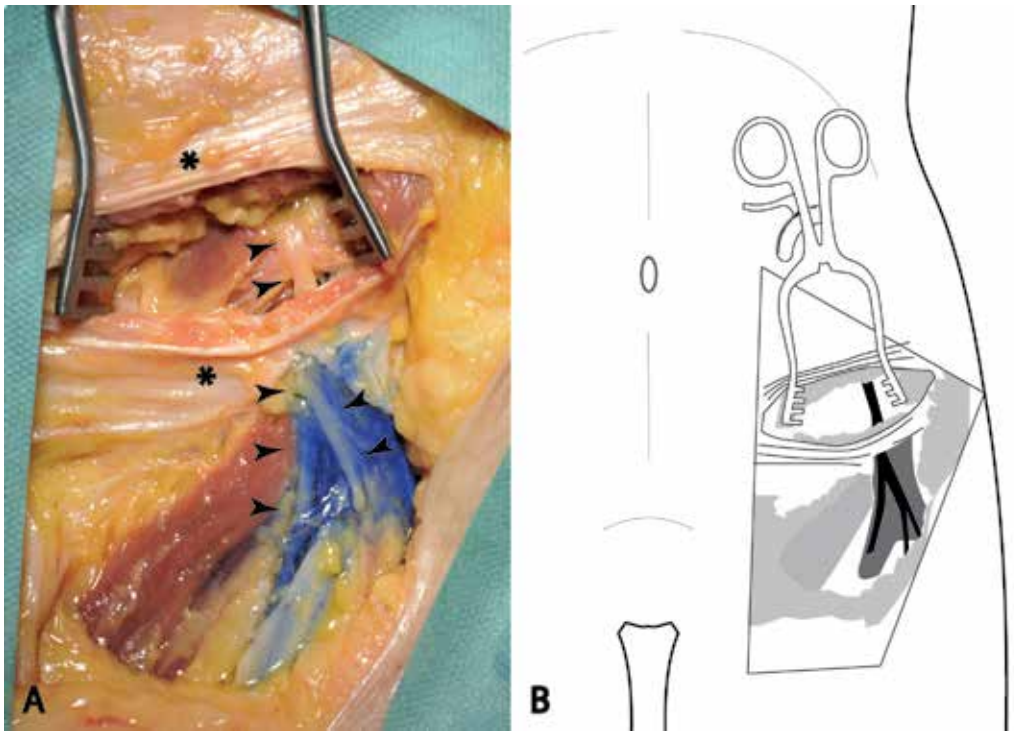

Fig. 2: *A: LFCN (arrowheads), ink (blue stain). The inguinal ligament (asterisks) is split longitudinally; abdominal muscles are retracted. No ink is found proximal to the inguinal ligament. B: LFCN (black), ink (dark grey).*

tance of 7.41 cm (2.00-14.00 ± 2.66). Eleven specimens had one single LFCN trunk, while the LFCN was divided into 2 branches in 5 specimens and one specimen had 3 branches at the level of the inguinal ligament.

Discussion

Injection of steroids and local anesthetics around the LFCN has shown the potential to provide symptom relief or even complete remission in up

to 83% of patients (2) and is one of the mainstays of treatment in meralgia paresthetica. Even though ultrasound may increase the accuracy of the intervention, symptoms may persist in 20% to 80% of patients after injection (11,12). One reason may be the failure to completely cover the segments or branches of the LFCN affected by entrapment, which has been reported for 15% to 32% of individuals treated (13,14). This anatomic study evaluated whether the inguinal ligament would limit the proximal spread along the course of the LFCN after a typical injection distal to the inguinal ligament.

In 23 of 34 lower extremities (67.65%), ink was found proximal to the inguinal ligament after an injection of 2 mL. Thus, in almost one-third (32.35%) of specimens, no ink staining was found proximal to the inguinal ligament. Concerning proximal spread, specimen BMI was not of any relevance. Hence, BMI-related tension of the inguinal ligament does not seem to inhibit the proximal spread of injected fluids.

A possible cause of failure may be the volume of the injected fluid. While Moritz et al (8) used 0.3 to 0.5 mL of local anaesthetic, other authors used much higher volumes of up to 10 mL (11-14). It may be hypothesized whether larger injection volumes would lead to a better proximal spread.

A recent meta-analysis (17) defined multiple patterns of the nerves course at its exit from the pelvis. In total, more than 20% of patients have multiple LFCN branches in the thigh, again highlighting the possibility of incomplete block results. In a series of 20 cases (11), 16 patients (80%) reported residual symptoms 6 weeks after ultrasound-guided injection with 6 mL of local anesthetics and steroids. In 14 of these patients, another segment of the LFCN showed sonographic signs of swelling, requiring subsequent injections. Multiple injections yielded a complete relief of symptoms in 75% of patients after 12 months. The authors hypothesized that perineural adhesions and fibrosis might impair nerve gliding and thus cause an affection of multiple levels of the LFCN. A possible shortcoming of that study (11) is that patients who were symptom-free after the first injection were not screened for multiple segments of nerve thickening at follow-up; therefore the clinical relevance of that sonographic finding remains unexplained. In our data, although only 2 mL were injected, the LFCN was covered in ink distally up to a mean distance of 7.41 cm (2.00-14.00 ± 2.66). Therefore, most distal segments of nerve-thickening in the inguinal region were probably covered at the first injection. Hence, one might speculate whether resolution of symptoms after 12 months might have been achieved by a single injection anyway, or if this represents the natural course of meralgia paresthetica.

Our study has limitations. First of all, this cadaver study may only serve as a simulation of the real clinical setting and does not allow any insight into the true efficacy of the injection in living patients. Moreover, different injection volumes were not studied. The limited availability of cadaver specimens did not allow the authors to exclusively enroll cadavers with a high likelihood of the presence of meralgia paresthetica. The mean age of our specimens does not reflect the peak incidence of the condition, and the predominance of female cadavers seems irrelevant (4,5). Only 2 cadavers were classified as obese (BMI > 30), but waist-hip ratio criteria for abdominal obesity (16) were fulfilled in all but 2 specimens.

This study of ultrasound-guided perineural injections demonstrates the spread of low volumes of injected fluid around the LFCN, injected distal to the inguinal ligament. The inguinal ligament may function as a barrier in the proximal spread of fluid in about one-third of patients. Therefore, we hypothesize that a second injection proximal to the inguinal ligament might lead to a satisfying coverage of the LFCN in cases of meralgia paresthetica.

Disclosure / Acknowledgments:

None of the authors has any conflict of interest to disclose.

Author contributions: Dr. Rossmann, Dr. Meng, and Ms. Zessner-Spitzenberg had full access to all data in the study. Dr. Rossmann and Dr. Meng take full responsibility for the integrity of the data and the accuracy of the data analysis.

Drs. Meng, Weninger, and Ms. Zessner-Spitzenberg designed the study protocol. Ms. Zessner-Spitzenberg and Drs. Sandurkov, Heber, and Rossmann performed the investigation presented in this manuscript. Dr. Rossmann compiled the data, managed the literature searches and summaries of previous related work, and wrote the manuscript. Drs. Rossmann and Meng created all artwork used in this publication. Dr. Meng provided revision for intellectual content and final approval of the manuscript.

None of the authors of the manuscript received any remuneration. Further, the authors have not received any reimbursement or honorarium in any other

manner. The authors did not receive any financial or material support from outside the Center for Anatomy and Cell Biology, Medical University of Vienna, where the research project has been conducted (Level 0). No financial arrangements have been made in relation to this publication.

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