Preoperative Ultrasound in Patients with Meralgia Paresthetica to Detect Anatomical Variations in the Course of the Lateral Femoral Cutaneous Nerve

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OBJECTIVE: **Sometimes during surgery for meralgia paresthetica, it can be difficult to find the lateral femoral cutaneous nerve (LFCN). The aims of this study were to study the prevalence of different anatomical variations in patients, compare preoperative ultrasound (US) data with intraoperative findings, and investigate the effect of type of anatomical variation on duration of surgery and success rate of localizing the LFCN.**

METHODS: **Fifty-four consecutive patients with idiopathic meralgia paresthetica who underwent either a neurolysis or neurectomy procedure were included. All patients preoperatively underwent US of the LFCN. Anatomical variations were categorized into type A, B, C, D, and E using the classification of Aszmann and Dellon. The cross-sectional area of the LFCN at the inguinal ligament and the distance of the LFCN to the anterior superior iliac spine were noted. Correlations with intraoperative findings were investigated, as well as the effect on duration of surgery and success rate of finding the LFCN. Clinical outcome was assessed using the Likert scale.**

RESULTS: **The most frequent anatomical variant was type B (79%), followed by type C (9%), D (5%), and E (7%). No type A was encountered. Correlation between preoperative US and intraoperative findings was 100%. During surgery, the LFCN could be identified in all cases. Duration of surgery did not significantly vary for the different anatomical variants.**

CONCLUSIONS: **Preoperative US is reliable in detecting anatomical variations of LFCN. This information can be very helpful in identifying the LFCN more frequently and easily during surgery, especially in more medial variants.**

INTRODUCTION

Meralgia paresthetica is a mononeuropathy of the lateral femoral cutaneous nerve (LFCN) that is often caused by entrapment of this nerve at the site where it runs through the inguinal ligament. Most cases resolve after conservative treatment, but in about 10% of the cases symptoms persist and these patients can be referred for surgical treatment.[1] There are 2 procedures that can be performed in patients with meralgia paresthetica, namely neurolysis and neurectomy of the LFCN.[2]

The start of both procedures is identical: a 5-cm incision is made just below and parallel to the inguinal ligament and the nerve is identified on top of the sartorius muscle, just medial to the anterior superior iliac spine (ASIS). Subsequently, the LFCN is either decompressed by incision of the overlying inguinal ligament and underlying iliac fascia (neurolysis) or the nerve is transected (neurectomy). Sometimes it can be difficult to identify the nerve (in 8.8% of the 148 cases reported by Carai et al.[3]). This may be due to several reasons, as, for example, overweight of the patient or because of the presence of an anatomical variation in the course of the LFCN as it exits the pelvis. Different anatomical variations can be thereby be distinguished in the course of the LFCN.[3-5] Aszmann et al.[5] have categorized these different anatomical variations in type A, B, C, D, and E (**Figure 1**) and investigated the prevalence of these variants in cadavers (respectively 4%, 27%, 23%, 26%, and 20%). Despite this classification, surgical studies on meralgia paresthetica

Key words
- Decompression
- Neurectomy
- Neurolysis
- Sonography

Abbreviations and Acronyms
ASIS: Anterior superior iliac spine
CSA: Cross-sectional surface area
LFCN: Lateral femoral cutaneous nerve
SSEP: Somatosensory-evoked potentials
US: Ultrasound

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frequently do no report if and how frequently anatomical variations are encountered during surgical exploration.[3] In our own experience, type B is the most frequent variation found during surgery, but because in the past also other variants have been encountered (which often complicated and prolonged the surgery), we have started using ultrasound (US) to determine the anatomical variant preoperatively. The aims of this study were to 1) investigate the prevalence of the different anatomical variants of the LFCN in patients with meralgia paresthetica referred for surgical treatment; 2) compare preoperative US data on type of anatomical variation with intraoperative findings; 3) investigate the effect of type of anatomical variation on the duration of surgery; and 4) assess the success rate of localizing the LFCN during surgery with presurgical US data. These aims were investigated in 2 prospective cohorts of patients who underwent either a neurolysis or neurectomy procedure.

METHODS

Between November 2016 and April 2020, a total of 57 consecutive patients with idiopathic meralgia paresthetica (2 bilateral cases) were operated in the Haaglanden Medical Center by the first author (G.d.R.). Three cases were excluded, because in these patients US had already been performed elsewhere and was not repeated to determine the anatomical variant. The diagnosis of meralgia paresthetica was made clinically: a history of a tingling or burning sensation on the anterolateral part of the thigh. In addition, patients had to have at least one of the following: 1) a positive nerve block, 2) an increased cross-sectional surface area on US, and/or 3) a side-to-side difference and/or prolonged latency with somatosensory-evoked potentials (SSEP).

Preoperative Ultrasonographic Analysis

US was performed before the surgery in the outpatient clinic by a well-trained technician with more than 12 years of experience on nerve US (M.W.). Results were evaluated by a physician (M.V.) with expertise in clinical neurophysiology. A high-end US device equipped with a L18–5 MHz (iU22; Philips Medical Systems, Amsterdam, The Netherlands) or eL18–4 MHz (Elite; Philips Medical Systems) transducer was used. Patients were in supine position when LFCN is first visualized in the upper thigh, just lateral of the sartorius muscle below the groin. Here, the nerve is found in a transverse plane between the fascia lata and iliaca. When following the nerve transversally in a proximal direction, the nerve glides over the sartorius muscle inside the lateral femoral cutaneous nerve canal[6] to the medial side and under the inguinal ligament (**Figure 2A**). Here the nerve can be compressed, causing focal thickening of the nerve (**Figure 2B**). The distance from the midpoint of the LFCN to the medial border of the ASIS was measured (**Figure 2A**), and this position in combination with the course of the LFCN over the sartorius muscle was used to determine the anatomical variation according to classification by Aszmann et al.[5] Type B and C have a similar distance from the ASIS (<1.0 cm), but type C usually has a more flattened appearance (**Figure 3A**). Type D variant has a more medial course (1.0–3.0 cm medial to the ASIS, **Figure 3B**) and type E variant is located more medial (>3 cm medial to the ASIS, **Figure 3C**).

The cross-sectional surface area (CSA) at the inguinal ligament was measured at the inner border of the epineural rim using a manual tracing or ellipse method. Presence of a pronounced change in nerve caliber was noted. Intraneural edema was often seen but infrequently documented. The LFCN was investigated bilaterally. A CSA value of >5 mm^2 was considered to be abnormal.[7]

Recording of SSEP

SSEPs were performed bilaterally, elicited by stimulating the skin of the thigh corresponding to the distribution area of dermatome L3. The stimulus was delivered at a rate of 3.13 Hz with an intensity 3 times sensation level. For recordings 10 mm Ag/AgCl

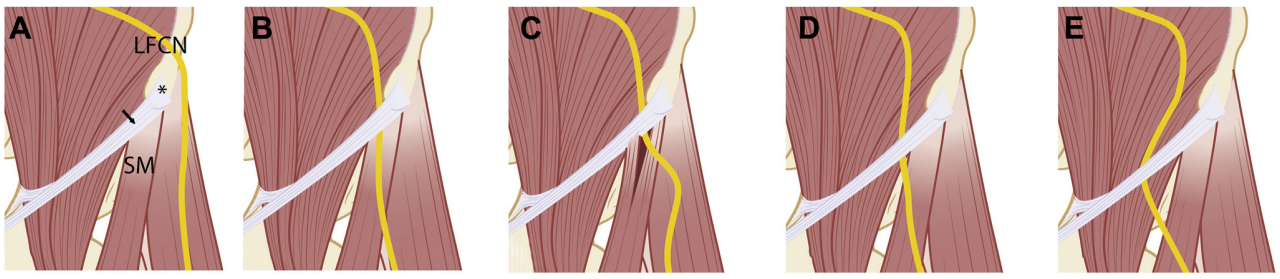

Figure 1. Drawing illustrating the different anatomical variants in the course of the lateral femoral cutaneous nerve (LFCN) around the anterior superior iliac spine (ASIS) according to the classification by Aszmann et al.[5] (**A**) The LFCN runs laterally around the ASIS (*) and does not run through the inguinal ligament (*arrow*). SM, sartorius muscle. This variant was not encountered in the present series. (**B**) The most frequently variant found during surgery for meralgia paresthetica where the LFCN proximally runs through or under the inguinal ligament, just medial (<1 cm) to the ASIS, and distally runs on top of the sartorius muscle. (**C**) The site where the LFCN runs through the ligament is similar to type B, but more distally the nerve runs through a split tendon of the SM. Subsequently the LFCN makes a curve in a lateral direction over the SM through a tight canal where the nerve is often flattened. (**D**) The LFCN runs under the inguinal ligament and has an intermediate medial course in respect to the ASIS at 1.0–3.0 cm. Distally, it has a similar course as type B. (**E**) The most medial course of the LFCN at the inguinal ligament. The LFCN runs through a deeper canal at the level of the inguinal ligament >3 cm medial of the ASIS.

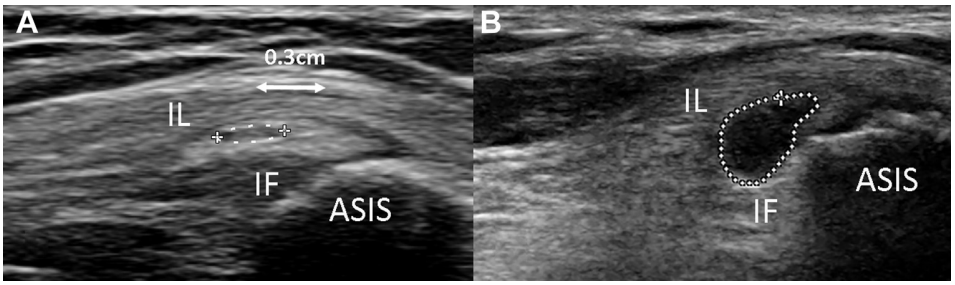

Figure 2. Ultrasound of the lateral femoral cutaneous nerve (LFCN) at the level of the anterior superior iliac spine (ASIS) in a transverse plane, obtained from patients with left-sided meralgia paresthetica. The distance from the midpoint of the LFCN to the medial border of the ASIS was measured. (**A**) normal appearance of a LFCN variant type B, with normal cross-sectional surface area and "honeycomb" architecture, distance 0.3 cm (*white arrow*). (**B**) Focally marked enlargement of a LFCN variant type B with intraneural edema. IL, inguinal ligament; IF, iliac fascia.

surface electrodes were placed on the scalp with Cz' as active and Fz as a reference point (10–20 system). The evoked potentials were recorded with a Nicolet EDX device (Natus Medical Incorporated, Pleasanton, California, USA: 20 ms/div, bandpass 10–1500 Hz). In most cases a typical "W" waveform appears and the first positive peak (P1) was used to determine abnormality. A latency of >39.4 milliseconds for the right side and >40.6 milliseconds for left was considered abnormal.[8] A side-to-side latency difference of >5.4 milliseconds also was considered abnormal.

Neurolysis and Neurectomy Procedures

Surgery was offered after nonresponse to at least 3 months of conservative treatment. Neurolysis and neurectomy were discussed as treatment options.[2] Patients were asked to participate in the STOMP (Surgical Treatment Options for Meralgia Paresthetica) trial if there were no exclusion criteria (in this trial, the effectiveness of the neurolysis and neurectomy procedures are compared[9]). Surgery was performed under general or spinal anesthesia with the patient in a supine position. In case of a type B or C variant, a 5-cm incision was made parallel to the inguinal ligament, just below the ASIS. In case of a type D or E variant, the incision (same size) was made more medially. Correlation between type of anatomical variation on preoperative US with the intraoperative course of the LFCN was noted in the surgical report. During neurolysis, the LFCN was decompressed by both by cutting the overlying inguinal ligament and incising the underlying iliac fascia. The LFCN was subsequently followed proximally into the pelvis up to the site where the deep circumflex iliac artery crosses the nerve. After proximal release, the LFCN was followed for several centimeters into a distal direction, where the LFCN runs under the fascia lata. For neurectomy the same procedure was performed, expect for incision of the underlying iliac fascia and release in distal direction. Proximal release into the pelvis was also performed before neurectomy in order to be able to transect the nerve as far proximally as possible. After transection, a segment of nerve was sent for histopathologic analysis.[10] Finally, complications, blood loss and the duration of the surgery were recorded.

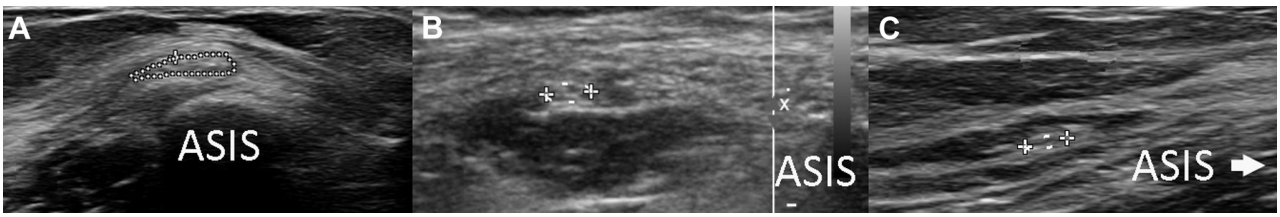

Figure 3. Anatomical variants C, D, and E of the lateral femoral cutaneous nerve (LFCN), all left-sided, demonstrated with US in transverse planes. (**A**) Type C variant. Both type B and C have a similar distance from the anterior superior iliac spine (ASIS; <1.0 cm), but type C usually has a more flattened appearance. (**B**) Type D variant. This variant of the LFCN has a more medial course (1.0–3.0 cm medial of the ASIS), (**C**) Type E variant. This variant runs >3.0 cm medial to the ASIS, where it is not in the same plane as the ASIS. Often the LFCN consist of multiple small branches.

In 33 patients, a neurolysis procedure was performed, in 2 patients bilaterally. The neurolysis procedure was performed as part of the STOMP trial in 6 patients. In 21 patients a neurectomy procedure was performed, in 9 patients as part of the STOMP trial.

Follow-up

First follow-up was 6 weeks after surgery to assess outcome using the 5-point Likert scale; Likert 1: symptoms had resolved completely, Likert 2: almost completely, Likert 3: partially, Likert 4: persistence of symptoms, and Likert 5: worsening of symptoms.

Statistical Analysis

An unpaired t test was used for the comparison of different parameters in the neurolysis and neurectomy groups. One-way analysis of variance was performed for the comparison of the duration of surgery (separately for neurolysis and neurectomy) for the different anatomical variants. The Fisher exact test was performed for comparison successful outcome (Likert 1–3) after neurolysis versus neurectomy. Statistical analysis was performed using Prism 8 (GraphPad Software, Inc., San Diego, California, USA).

RESULTS

The results for the different groups of neurolysis and neurectomy are presented in Table 1. The most common anatomical variant in both groups was type B (79%). Type C, D, and E were present respectively in 9%, 5%, and 7% of the cases. No type A variant was encountered. During surgery, the LFCN could be identified in all cases. There was a 100% correlation between the

Table 1. Patient Characteristics for Surgical Groups of Neurolysis and Neurectomy and Results for US, Duration of Surgery, and Postoperative Likert

	Neurolysis (35), 2 Bilateral	Neurectomy (21)	Percentages	*P* Value
Age, years	51	56		0.5967
Male/female	16/17	10/11	48/52%	
Left/right	17/18	9/12	46/54%	
BMI	29	30		0.0877
Anatomical variant				
A	—	—	0%	
B	27	17	79%	
C	5	—	9%	
D	1	2	5%	
E	2	2	7%	
CSA, mm^2	5.1	5.0		0.5685
Diameter, mm	2.0	2.1		0.8164
Duration surgery, minutes				
All variants	22	17		0.0341
B	22	17		0.02
C	22			*
D	21	15		*
E	19	17		*
Postoperative Likert				0.6960
1	10	5		
2	17	9		
3	2	5		
4	5	1		
5	1	1		

US, ultrasound; BMI, body mass index; CSA, cross-sectional surface area.
*No statistical comparison possible due to small numbers per group.

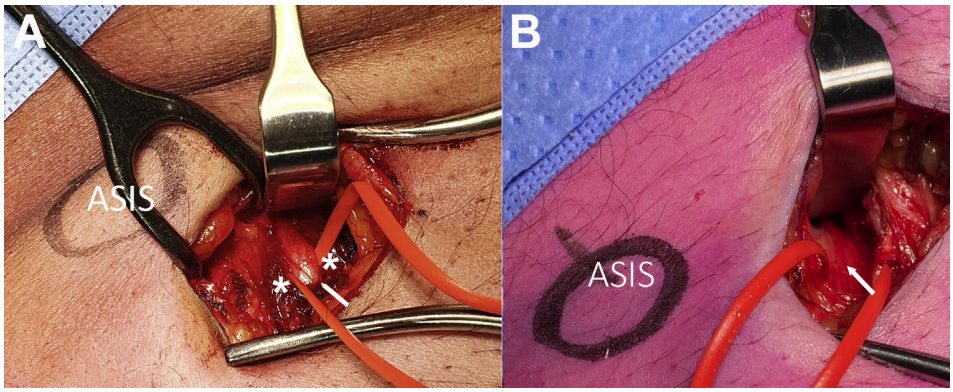

Figure 4. Intraoperative photographs obtained during surgery (directions: *top* = cranial, *right* = medial). (**A**) Case of a right-sided meralgia paresthetica with a type C variant. The lateral femoral cutaneous nerve (LFCN) exits the pelvis just medial to the anterior superior iliac spine (ASIS; *white arrow*). The ASIS was palpated and marked before incision (*black circle*). The incision was placed just below and medial to the ASIS. Asterisks show the two heads of the sartorius muscle where the LFCN runs in between after exiting the pelvis. (**B**) Case of a right-sided type E variant, where the nerve (*arrow*) exits the pelvis 3.5 cm medial to the ASIS. The incision was placed several centimeters medial to the ASIS.

anatomical variant found during surgery and that determined with preoperative US.

The mean CSA and diameter of the LFCN was not significantly different between the 2 groups (5.1 vs. 5.0 mm^2). An enlarged LFCN was seen in type B and C (65.9% and 40% respectively), whereas in none of the patients with type D or E this was the case.

There was no significant difference in SSEP latency between the two groups (39.2 vs. 40.2 milliseconds). In type B and type D (17.1% and 33.0%, respectively) latencies were prolonged. In type C and E there were no prolonged latencies.

The mean duration of surgery was shorter for a neurectomy than for a neurolysis procedure (21.9 vs. 17.1 vs. 21.9 minutes, $P < 0.05$). There was no difference in surgery time for the different anatomical variants (neurolysis analysis of variance groups B-E: $P = 0.9134$, neurectomy $P = 0.6750$). There were no complications. Blood loss was <20 cc in all cases. Histologic analysis confirmed the diagnosis of meralgia paresthetica in all cases after neurectomy.[10] There was no difference in outcome between the 2 groups: Likert 1–3 was found in 83% after neurolysis and 90% after neurectomy ($P > 0.05$).

DISCUSSION

The present study is the first to systematically investigate anatomical variation of the LFCN with preoperative US in a large group of consecutive patients with meralgia paresthetica. We have shown that in our surgical population, type B and C are most prevalent. In addition, we found that correlation between preoperative US data and surgical findings on anatomical variation is 100%.

In our surgical population, type B was encountered most frequently (79%), followed by type C (9%). These percentages are greater compared with those reported by Aszmann et al.[5] in their cadaver study (27% and 23%, respectively). However, this difference is not surprising, since the lateral position of the LFNC (in type B and C) within the inguinal ligament probably makes the nerve more vulnerable to injury[4] and therefore may predispose to developing meralgia paresthetica.

We were able to identify the LFCN during surgery in all patients. In a previous surgical series that reported on anatomical variations of the LFCN intraoperatively, the LFCN could not be identified in 8.8%.[3] The authors of that study suggested that US could be considered to improve nerve identification. Since then, only one case report (in which preoperative US was used to detect a bilateral type A variant preoperatively)[11] and one series of 19 patients in which intraoperative ultrasound wire location was used to detect the LFCN[12] have been published. The fact that we were able to identify the LFCN in all our patients strongly suggests that presurgical US increases the chances of identifying the nerve during surgery, in patients with uncommon variants, but this may also be very useful in patients with obesity in whom nerve identification is often more difficult. The intraoperative technique of ultrasound wire location also can help to identify the LFCN, as shown by Hanna et al.[12] However, performing preoperative US in the outpatient clinic has the advantage that results of US also can be used for clinical decision-making. For example, if the CSA of the LFCN is not increased, we frequently perform an additional nerve block to confirm the diagnosis of meralgia paresthetica.

In our study, a medial variant was present in 14% of patients. In these cases, the incision is placed more medial to the ASIS than is

done during the standard approach for the lateral variants (Figure 4). Preoperative US knowledge about presence of a medial variant (type D or E) is therefore extremely helpful to the surgeon, shortening both surgery time and the length of the incision. Also, the presence of a medial variant makes a surgeon extra alert to distinguish the LFCN from the femoral nerve, which is especially important in case of a neurectomy procedure (we still advise to use neuromonitoring in neurectomy procedures performed in anatomical variants type D or E). In addition to the considerations mentioned previously for medial variants, preoperative workup also is useful in type C. It can be difficult to localize the type C variant of the LFCN, because 1) distally it runs more laterally than in type B (see curve in Figure 1C) and 2) proximally the LFCN runs through a split tendon of the sartorius muscle. Because of the curved course the exploration often has to start more laterally and the nerve is often not identified on top of the sartorius muscle. Interestingly, the type C variant in this study was encountered less frequently than the type B variant (despite similar frequencies in the cadaver study Aszmann et al.[5]). This could mean that the course through the split sartorius tendon somewhat protects the LFCN from compression. For example, in patients with obesity, symptoms may be caused by traction of the fascia of Scarpa (that surrounds the abdominal fat) onto the inguinal ligament, that subsequently compresses the LFNC.[13]

Our study also has a few shortcomings. First, meralgia paresthetica is a clinical diagnosis. Although patients in our study at least had to have 1 of the following (a positive nerve block, an increased CSA on US, and/or a side-to-side difference and/or prolonged latency with SSEP), it can sometimes be difficult to confirm the diagnosis. Interestingly in our study, none of the patients with type D and type E had an enlarged CSA and none with type E had a side-difference in SSEP (all cases conformed by positive nerve block), which could raise doubts about the correct diagnosis. However, in all cases after neurectomy, the typical histopathologic findings of meralgia paresthetica were found.

Second, this study was not set up as study to investigate the diagnostic value of preoperative US in meralgia paresthetica. Other studies have looked at this.[7,14] We noted CSA of the LFCN but did not note other abnormalities as hypo-echogenicity and/or neuroma/neuroma-in-continuity/pseudoneuroma.[14] We also didn't look at the number of LFCN branches (26% more than 1 branch proximal to the inguinal ligament[15]), other anatomical variants such as contribution to genitofemoral nerve,[5] and potential variations in the course of the LFCN in the sagittal plane,[13] because the goal of this study was to determine the position of the LFCN in relation to the ASIS (coronal plane) for surgical identification. Third, although we reported outcome for the different surgical procedures of neurolysis and neurectomy, it is important to realize that the follow-up was short. Interestingly, in this study there was no significant difference in outcome, contrary to what we have previously found in a retrospective and prospective studies.[2,9] Especially the results for the neurolysis procedure in the present study were better than our previously reported results.[2,9] One could argue that this is caused by better preoperative knowledge on potential anatomical variations, but it is too early to conclude this. In the near future, results from the STOMP trial will become available, which will hopefully further clarify this issue.

CONCLUSIONS

We have shown that US is a useful and reliable tool to determine anatomical variations of the LFCN. Preoperative knowledge on anatomical variation can help the surgeon to determine the site of incision, more easily identify the LFCN intraoperatively, and thereby shorten the surgery time, especially in more medial variants.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Godard C.W. de Ruiter: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization, Supervision. **Michel Wesstein:** Investigation, Data curation, Visualization, Writing - review & editing. **Monique H.M. Vlak:** Writing - review & editing, Project administration.

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