Clinical Neurophysiology 125 (2014) 2115–2121

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Misinterpretation of sural nerve conduction studies due to anatomical variation

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ARTICLE INFO

Article history:
Accepted 26 January 2014
Available online 15 February 2014

Keywords:
Anatomical variation
Sural nerve
Nerve conduction studies
Sensory nerve action potential
Polyneuropathy

HIGHLIGHTS

- Sural sensory nerve action potential (SNAP) amplitudes may be falsely interpreted as decreased due to anatomical variation of the nerve.
- A sural nerve formation causing potential technical problems for nerve conduction studies with near-nerve needle technique or surface electrodes was found in 14.4% of 118 subjects with no evidence of polyneuropathy.
- If the sural SNAP amplitude is decreased in discordance to the clinical findings, a normal potential may be obtained by a more lateral or distal electrode placement compared to the traditional electrode placement 12–13 cm above the lateral malleolus.

ABSTRACT

Objective: Anatomical variation of the sural nerve has been documented in numerous cadaver studies. The sural nerve conduction parameters can potentially be influenced by the sural nerve type A formation formed by the union of the medial sural cutaneous nerve (MSCN) and the peroneal communicating branch (PCB) and the type C formation with the sural nerve formed solely by the PCB.
Methods: In 17 out of 240 prospectively examined subjects referred for polyneuropathy a suspicion of an anatomical variation of the sural nerve was raised due to decreased amplitude or substantial side-to-side variation (>50%) of the sensory nerve action potential (SNAP) in disproportion to the clinical findings. To verify the variation the sural nerve was examined further with surface electrodes and near-nerve technique, including extra lateral and distal needle placements.
Results: In all 17 subjects an anatomical variation affecting the sural SNAP was confirmed as a normal sural SNAP could be obtained by changing the electrode placement. The most frequent variation, seen in 15 subjects, was a type A formation with union of the MSCN and the PCB distally at low calf, while a type C formation was seen in 2 subjects.
Conclusions: In case of a decreased sural SNAP amplitude or substantial side-to-side variation in disproportion to the neurologic evaluation, an anatomical variation instead of pathology could be suspected and a different electrode placement be considered.
Significance: Neurophysiologists should be aware of different types of formations of the sural nerve which may cause misinterpretations of nerve conduction studies, especially when needle electrodes are used.
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1. Introduction

Nerve conduction studies are important diagnostic tools to evaluate the integrity and function of the peripheral nervous system. The sural nerve is one of the most commonly examined nerves by nerve conduction studies, mainly for the diagnosis of

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http://dx.doi.org/10.1016/j.clinph.2014.01.030
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polyneuropathy, but it is also useful in the evaluation of focal nerve injury of the lumbosacral plexus and the sciatic and tibial nerves.

The sural nerve is traditionally described by three different formation types, designated A, B, and C (Huelke, 1957). Type A, the most common type, is formed by the union between the medial sural cutaneous nerve (MSCN), which is a branch of the tibial nerve, and the peroneal communicating branch (PCB) of the common peroneal nerve, while type B is the direct continuation of the MSCN with the PCB absent, and type C is formed by the PCB only (Fig. 1). The union in type A may take place anywhere between the popliteal fossa and the lateral malleolus. Numerous cadaver studies have been conducted worldwide documenting the anatomical variations of the sural nerve (Eid and Hegazy, 2011; Huelke, 1957; Madhavi et al., 2005; Mahakkanukrauh and Chomsung, 2002; Pyun and Kwon, 2008; Shankar et al., 2010). In one of these, sural nerve conduction studies from healthy adults were done in addition to the cadaver studies showing highly variable sural nerve formation (Pyun and Kwon, 2008). Recently, an ultrasound study of anatomic variants of the sural nerve has shown similar variations as the cadaver studies (Zhu et al., 2011). These studies have mainly focused on surgical implications such as reconstruction of peripheral nerves, since the sural nerve is commonly used for nerve biopsies as well as a convenient source for nerve grafting.

From a neurophysiological point of view, the type A with a very distal union between MSCN and PCB as well as type C can cause problems, while type A with proximal union and type B show similar nerve conduction studies, probably without giving rise to any technical problems. However, despite the fact that the variability in the formation of the sural nerve may affect the parameters of sural nerve conduction studies, neurophysiologists have in general not paid much attention to the anatomical variation. In this study, we present 17 subjects with anatomical variation of the sural nerve examined electrophysiologically with both surface electrodes and near-nerve needle technique.

2. Material

We examined prospectively 240 consecutive subjects referred on suspicion of polyneuropathy. In all subjects bilateral motor conduction studies in the peroneal and tibial nerves and sensory conduction studies in the sural nerve were performed. The median and ulnar nerves were examined on one side in subjects with either electrophysiological changes in the lower extremities or symptoms in the upper extremities. Surface electrode recording was used for motor conduction studies, while sensory studies were done with orthodromic near-nerve needle recording or antidromic surface recording. All sural nerves were examined with the near-nerve *two-threshold* technique. In all subjects a detailed neurological evaluation including history, examination of force, deep tendon reflexes and sensory modalities of light touch, pain, vibration, and proprioception was performed.

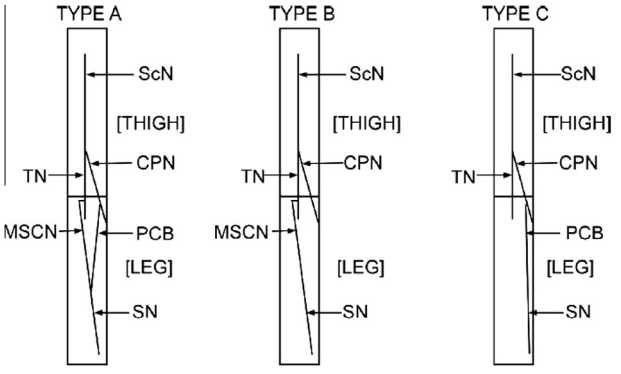

Fig. 1. Schematic diagram showing the different types of formation of the sural nerve as described by Huelke (1957). ScN: Sciatic nerve, TN: Tibial nerve, CPN: Common peroneal nerve, MSCN: Medial sural cutaneous nerve, PCB: Peroneal communicating branch.

In 17 subjects a suspicion of an anatomical variation of the sural nerve was raised as there were no objective clinical signs and the sural sensory nerve action potential (SNAP) was either (1) absent or (2) with an amplitude decreased >2 standard deviations (SD) from mean of controls according to an age-matched reference material, or (3) differed substantially in amplitude (>50%) between sides. The complaints of the 17 subjects (7 males and 10 females; age 32–71 years) were as follows: intermittent sensory disturbances in upper and/or lower extremities (9 subjects), dizziness and/or decreased balance (3 subjects), musculoskeletal pain (2 subjects), feelings of unease in the muscles in the lower extremities (1 subject), tiredness and cramps (1 subject), and decreased force in the legs due to a cervical spinal tumour operation (1 subject). With clinical neurological evaluation, the subject with earlier cervical tumour operation had decreased force in upper and lower extremities and decreased sensation, while all other subjects had normal muscle strength, normal deep tendon reflexes and normal sensory examination for all sensory modalities.

In the remaining 223 subjects, nerve conduction studies and clinical findings confirmed a polyneuropathy in 122, while in 101 subjects all nerve conduction studies were normal. As further examination of the sural nerve would not have added any further diagnostic information in these two groups, this was not done.

3. Methods

The sural nerve was further examined in the 17 subjects with a suspected anatomical variation of the sural nerve in order to exclude pathology of the nerve and confirm the variation and identify its type. These supplementing examinations comprised antidromic surface recordings (Falck et al., 1994) and orthodromic near-nerve needle recordings with both the *one-threshold* (Behse and Buchthal, 1971; Buchthal and Rosenfalck, 1966; Rosenfalck and Rosenfalck, 1975; Trojaborg, 1992) and the *two-threshold* method. For all tests a decrease in SNAP amplitude >2 SD was considered abnormal.

3.1. Antidromic surface recording

Antidromic studies with surface electrodes were done using a bar stimulator (Dantec 13L36) with a distance of 2.3 cm between the cathode and the anode. Recording electrodes were Blue Sensor NF10 electrodes. The recording site was behind the lateral malleolus at the most prominent point of the malleolus, and the stimulation site was 13 cm proximal to the recording electrode just lateral to the edge of the Achilles tendon. The latency was measured from the stimulus onset to the first positive peak for determination of the velocity of the fastest conducting fibres. In case of no clear positive peak, latency was measured to the take-off from the baseline. The amplitude was measured peak-to-peak. Limb temperatures were maintained $\geqslant 32$ °C.

3.2. Orthodromic near-nerve recording

For near-nerve stimulation and recording a 0.7-mm diameter insulated needle with a 3-mm bared tip was placed close to the nerve at the lateral malleolus and at mid calf at the edge of the Achilles tendon 12–13 cm proximal to the lateral malleolus (Fig. 2a). This needle placement often corresponds to the MSCN or the sural nerve after proximal union of the MSCN and PCB.

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