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Sonographic imaging of the great occipital nerve in the diagnosis and treatment of primary headache disorders

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Abstract. Primary headaches are a type of headache that occurs independently, without any other underlying medical condition or injury. They are a major concern due to their prevalence in the population and their potential to cause significant disruption to daily life. In past years, new techniques have been developed that utilize sonography in diagnosing and treating headache disorders. Some recent publications have appeared on the use of ultrasound in blocks of the greater occipital nerve and the diagnosis of headaches. For a long time, blocks of the nerve have been performed without target visualization, based on exterior landmarks only. New methods may improve the results of performed procedures. Therefore, this study aims to provide an overview of the applications of ultrasound imaging of the greater occipital nerve in clinical practice.

Keywords: greater occipital nerve, primary headache disorders, sonography.

INTRODUCTION

The greater occipital nerve (GON) is a sensory nerve that arises from the medial division of the dorsal ramus of the second cervical nerve. It emerges under the obliquus capitis inferior muscle (OCI) and then courses along the posterior neck, passing between the OCI and the semispinalis capitis (SSC). In the further course, the nerve pierces the SCC and the trapezius muscle (TP) to enter the scalp. Here, it gives rise to branches that provide cutaneous sensory innervation to the occipital region [1]. Studies have shown that the GON may play a key role in primary headaches, such as migraine and tension-type headaches [2], but the pathophysiology is not entirely understood.

Primary headaches are a type of headache that occurs independently, without any other underlying medical condition or injury. According to ICHD-3 (3rd edition of The International Classification of Headache Disorders), primary headaches include migraines, tension-type headaches, trigeminal autonomic cephalalgias, and other primary headache disorders [3]. They are a major concern due to their prevalence in the population and their potential to cause significant disruption to daily life. Estimates suggest that almost three billion individuals suffer migraines or tension-type headaches [4]. Increasing interest in primary headaches has led to the development of new treatment and diagnostic options, some of which involve ultrasound.

The purpose of this article is to provide an overview of the current applications of ultrasound of the GON in the diagnosis and treatment of primary headaches. We concentrate on the sonographic examination technique, changes in the nerve morphology in pathological states, and sonographic guidance in the GON blockade.

SONOGRAPHIC ANATOMY AND EXAMINATION TECHNIQUE

In clinical practice, the GON is usually visualized at the distal location at the height of the superior nuchal line or the proximal location at the level of the C2 spinous process. In both cases, a patient should be in a prone or sitting position with minimal flexion in the cervical spine. To localize the nerve at the proximal location, a linear transducer is placed in a transverse plane beneath the external occipital protuberance (EOP) and then moved downwards until the C2 bifurcated spinous process is seen. The probe is then moved laterally and oriented towards the mastoid process (MP) (see Figure 1). The view of the OCI and the SSC separated by connective tissue should be obtained. The GON will be seen as a hypoechoic oval within the connective tissue surroundings. To localize the nerve at the distal location, the occipital artery (OA) should be identified using Doppler mode at the level of the superior nuchal line. The GON should be visible in close proximity to the OA as a small hypoechoic oval structure. In patients with long hair, using an excess ultrasound gel may help move the hair away from the examined area.

In a study published by Cho JC. et al. [5], the GON was successfully identified at the proximal location in 49 out of 60 examinations in 30 healthy individuals. They reported that the nerve was hypoechogenic, round to oval structure with a mean cross-sectional area of $2mm^2 \pm 1mm^2$ and a mean circumference of 4.8mm ±1.3mm in both males and females. Greher M. et al. performed a study on cadavers, where they examined the GON in proximal and distal locations [6]. In the proximal site, the median depth of the nerve was and the median distance from the C2 spinous process was 27.6mm. In the distal site, the median depth was 8.0mm

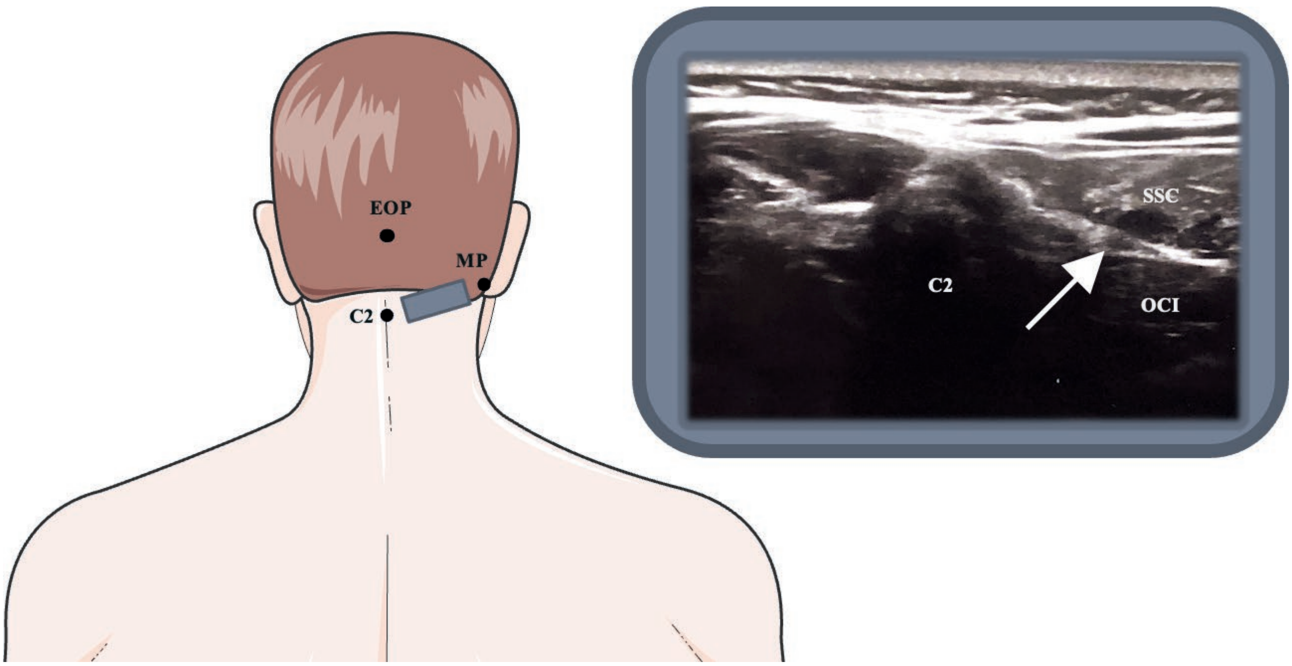

Figure 1. Position of the linear transducer at the proximal location. The GON is indicated by the white arrow. EOP - external occipital protuberance. MP - mastoid process. C2 - the spinous process of C2. OCI - obliquus capitis inferior muscle. SSC - semispinalis capitis muscle. The Figure was partly generated using Servier Medical Art, provided by Servier, licensed under a Creative Commons Attribution 3.0 unported license.

and the median distance from the EOP was 17.4mm. Shim JH. et al. [7] reported that the right nerve was on average 23.1mm away from the EOP, 1.5mm from the OA and 6.8mm from the skin. The left nerve was on average 20.5mm away from the EOP, 1.2mm from the OA and 7.3mm from the skin surface. Measurements were collected in the distal location. They managed to successfully visualize the nerve in 35 out of 40 cases in 20 volunteers. To our knowledge, there are very few publications describing the sonographic anatomy of the GON in the distal location or the position of the nerve in relation to bony landmarks in the proximal location in living patients.

DIAGNOSTIC APPLICATIONS

Sonographic changes in some pathological conditions of peripheral nerves have been well characterized [8]. However, there is still little known about changes in the GON. Cho JC. et al. described a significant increase in cross-sectional area and nerve circumference in patients with occipital neuralgia on the symptomatic sides. The cross-sectional area of the nerve did not depend on the severity of the headaches. Moreover, they showed the correlation of the cross-sectional area with the BMI. Hence, the cross-sectional area and BMI ratio may be more useful in diagnostic applications [5]. A similar mechanism associated with the GON entrapment, as in occipital neuralgia, may have an essential role in the pathogenesis of primary headaches [2]. Therefore, we think similar morphological changes can be seen in sonographic examinations of patients with these conditions. However, we did not find any studies concerning that issue.

THE GON BLOCKADE UNDER SONOGRAPHIC GUIDANCE

The GON block is a procedure of injecting a small dose of local anesthetic (lidocaine, bupivacaine, chirocaine) and/or steroid around the GON.

The GON block is reported to be useful in occipital neuralgia [9]. It has a clinical application in cervicogenic headaches resulting in 2-24 weeks of analgesia depending on the type of block localization [10]. Leinisch-Dahlke E. et al. suggest that this procedure is ineffective in chronic tension-type headaches, but the study was performed on a small sample of 15 patients [11]. The GON block is likely an adequate option for the acute management of migraine headache and proves to be equally effective across different age and gender groups [12].

For a long time, blocks of the GON have been performed without target visualization, based on exterior landmarks only. The ultrasound-guided blockade is likely to be a more effective technique than blind blockade in occipital headache treatment [7]. The conventional visionless technique of GON block just medial to the pulsation of the OA at the level of the superior nuchal line was inadequate due to intramuscular infiltration and blocks of other nearby nerves, such as branches of the lesser and third occipital nerve and even the greater auricular nerve. In patients with diversed anatomy, sightless injection in this area can cause unwanted and alarming complications even such as sudden coma [13]. The base for using a GON block in headache treatment arrives from evidence of the confluence of sensory input to the trigeminal nucleus caudalis neurons from both cervical and trigeminal fibers [14, 15]. There are many ways of GON block under sonographic guidance – the first being a distal block circa ~2–3 cm lateral to the EOP and the second proximal block where GON is superficial to the OCI muscle. In the study published by M. Greher et al., the success rate of a simulated GON block was 80% (95% confidence interval: 58–93%) in the distal and 100% (95% confidence interval: 86–100%) in the proximal approach. The study was carried out on 10 embalmed cadavers placed in a prone position with the head and neck flexed and injected with 0.1 ml of indocyanine green. The imitation block was categorized as successful if it dyed the targeted nerve and this nerve was identified as the GON by anatomical dissection [6]. Other ways include injection into the medial head of the SSC muscle at the C1 level of the cervical vertebra, where both GON and the third occipital nerve enter this muscle, in close proximity, which gives the possibility to block them simultaneously [16]. The study follow-up designed to compare two distinguishable US-guided techniques for blocking the GON demonstrated that both distal and proximal techniques can provide a short-term improvement in headache intensity, reduction in the number of headaches days per week, and an improvement in sleep interruptions. In this study, GON block was performed with bupivacaine and methylprednisolone acetate. The primary outcome was the contrast in the Numerical Rating Score (NRS) for headache intensity at 1 month. There were no significant adverse effects [17]. Another study proved that Ultrasound-guided GON blocks may provide superior pain reduction at 4 weeks when compared with landmark-based GON blocks for patients with occipital neuralgia or cervicogenic headache [18].

CONCLUSION

Primary headaches are an essential issue that should be addressed, as they can severely impact a person's quality of life. In past years new techniques have been developed that utilize sonography. Therefore, the anatomy of the GON has become an important topic. Yet, the sonographic anatomy and variability of the nerve have not been fully explored, especially in the distal location and living patients. Furthermore, to our knowledge, morphological changes in the ultrasound examination of the nerve in primary headaches have not been described in any publications. Evidence of the role of the GON compression in the pathogenesis of primary headaches and the results of the studies on patients with occipital neuralgia suggest that this topic is important.

The GON blocks using anesthetics and/or steroids have been used and are proven to be advantageous in occipital neuralgia, cervicogenic, and migraine headaches resulting in time-limited analgesia, and thus may be used as a medical practice for patients with specific types of headaches. Unfortunately, there is some evidence that GON block is ineffective in chronic tension-type headaches, therefore, other ways to relieve pain must be determined in these patients. Ultrasound-guided block seems to be more advantageous in comparison to the visionless technique primarily due to undesirable complications, among them the most dangerous is a coma. This fact suggests replacing a sightless GON block with an ultrasound-guided block. Furthermore, the topic of ultrasound-guided GON block technique localization should be thoroughly explored. More studies should be performed to determine whether the proximal or distal block is more effective. Likewise, we endorse more research on the intricacies of both ultrasound-guided techniques.

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