Landmarks for the Identification of the Cutaneous Nerves of the Occiput and Nuchal Regions

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Although surgical procedures are often performed over the posterior head and neck, surgical landmarks for avoiding the cutaneous nerves in this region are surprisingly lacking in the literature. Twelve adult cadaveric specimens underwent dissection of the cutaneous nerves overlying the posterior head and neck, and mensuration was made between these structures and easily identifiable surrounding bony landmarks. All specimens were found to have a third occipital nerve (TON), lesser occipital nerve (LON), and greater occipital nerve (GON), and we found that the TON was, on average, 3 mm lateral to the external occipital protuberance (EOP). Small branches were found to cross the midline and communicate with the contralateral TON inferior to the EOP in the majority of sides. The mean diameter of the main TON trunk was 1.3 mm. This trunk became subcutaneous at a mean of 6 cm inferior to the EOP. The GON was found to lie at a mean distance of 4 cm lateral to the EOP. On all but three sides, a small medial branch was found that ran medially from the GON to the TON ~1 cm superior to a horizontal line drawn through the EOP. The GON was found to pierce the semispinalis capitis muscle on average 2 cm superior to the intermastoid line. The mean diameter of the GON was 3.5 mm. The GON was found to branch into medial and lateral branches on average 0.5 cm superior to the EOP. The LON was found to branch into a medial and lateral component at approximately the midpoint between a horizontal line drawn through the EOP and the intermastoid line. The main LON trunk was found on average 7 cm lateral to the EOP. In specimens with a mastoid branch of the great auricular nerve (GAN), this branch was found at a mean of 9 cm lateral to the EOP. The main trunk of this branch of the GAN was found to lie on average 1 cm superior to the mastoid tip. Easily identifiable bony landmarks for identification of the cutaneous nerves over the posterior head and neck can aid the surgeon in more precisely identifying these structures and avoiding complications. Although the occipital nerves were found to freely communicate with one another, avoiding the main nerve trunks could lessen postoperative or postprocedural morbidity. Moreover, clinicians who need to localize the occipital nerves for the treatment of occipital neuralgia could do so more reliably with better external landmarks. Clin. Anat. 20:235–238, 2007.

Key words: neck; head; skin; iatrogenic; injury; anatomy

INTRODUCTION

The posterior head and neck is an area where neurosurgical intervention often occurs (e.g., approaches to the foramen magnum, cerebellopontine angle, and upper cervical spine). In addition to these surgical approaches, procedures
such as halo pin and Mayfield pin placement and nerve blocks for occipital neuralgia necessitate a good working knowledge of the cutaneous nerves in this region so as to minimize complications such as severe dysesthesias following their injury (Sindou and Mertens, 1994). Bogduk (1982) has pointed out the risk of inducing anesthesia dolorosa by cutting these nerves with incisions over the posterior head and neck. Likewise, Ebraheim et al. (1996) have stressed complications of halo pin placement, such as traumatic neuroma formation. Additionally, locating the nerves over the posterior head and neck for the surgical treatment of occipital neuralgia requires a thorough knowledge of their anatomy, which is not adequately addressed in standard anatomical textbooks. The nerves of this area from lateral to medial are the lesser occipital nerve (LON), the greater occipital nerve (GON) (Arnold’s nerve), and the third occipital nerve (TON) (least occipital nerve) (Barna and Hashmi, 2004). Most lateral, the great auricular nerve (GAN) may have a mastoid branch (McKinney and Gottlieb, 1985). Rarely, the suboccipital nerve (dorsal ramus of C1) which normally innervates primarily the muscles of the suboccipital triangle sends a small cutaneous filament to the occiput (Bogduk, 1982). At a submuscular level, the suboccipital nerve and branches of the second and third dorsal rami intercommunicate to form the posterior cervical plexus of Cruveilhier (Pick and Howden, 1974) (Fig. 1).

The LON is derived from the second and third cervical ventral rami and ascends toward the occiput by running parallel to the posterior border of the sternocleidomastoid muscle. Near the cranium it perforates the deep fascia, and is continued superiorly over the occiput where it supplies the integument and communicates with the GON medially (Lucas et al., 1994) (Fig. 1).

The medial branch of the dorsal ramus of the second cervical nerve is referred to as the GON. Gawel and Rothbart (1992) have suggested that this nerve may also have fibers derived from the dorsal ramus of C3. This nerve passes between the inferior capitis oblique and semispinalis capitis muscles and ascends to pierce this latter muscle and the trapezius. At this point, it travels with the occipital artery to supply the integument of the scalp as far anterior as the vertex of the skull. Medially and over the occiput, this nerve communicates with the TON and laterally with the LON (Fig. 1).

The TON arises deep to the trapezius from the medial branch of the dorsal ramus of the third cervical nerve. This nerve ascends medial to the GON and is connected to it both over the occiput and as the GON rounds the inferior edge of the inferior capitis oblique (Bogduk, 1982). The medial terminal branch of the TON supplies the skin over the rostral end of the neck and the occiput near the external occipital protuberance (EOP). More lateral branches of this nerve are directed toward the mastoid process.

The GAN arises from the ventral rami of cervical nerves two and three, and ascends toward the posterior cranium by curving from around the posterior border of the sternocleidomastoid. This nerve is mainly distributed to the auricle and parotid regions but may have a mastoid branch that communicates with the LON posteriorly (Fig. 1).

**MATERIALS AND METHODS**

In the prone position, 12 adult formalin-fixed cadavers (aged 50–89 years, mean 75 years) underwent dissection of the cutaneous nerves (great auricular, lesser occipital, greater occipital, and third occipital) of the posterior head and neck, and measurements were made between these nerves and surrounding superficial bony landmarks. Five males and seven females were used in this study. All measurements were made with calipers. Measurements included the diameters of the LON, GON, and TON as they were found over the occiput and adjacent cranium. Measured distances were made from superior to the intermastoid line (a line connecting the inferior tips of the mastoid processes) (Fig. 1) and distances superior to a horizontal line drawn through the EOP and lateral to this bony landmark. Statistical analysis was made between left and right sides and genders using Student’s t-tests.

**RESULTS**

All specimens were found to have a LON, GON, and TON. We were unable to locate a mastoid branch of the GAN on...
eight sides. A cutaneous branch of the suboccipital nerve was not found in any specimen. No surgical scars were found over the posterior head and neck in any specimen. We found that the TON was 0–4 mm (mean 3 mm) lateral to the EOP and that in all but two sides (one left and one right in separate specimens) that this nerve had a lateral small communicating branch to the GON that branched just inferior to the EOP. Additionally, very small branches were found to cross the midline and communicate with the contralateral TON inferior to the EOP in the majority of sides (n = 7). These branches were always less than 0.5 mm in diameter. The mean diameter of the main TON trunk was 1.3 mm (range 0.5–2 mm). This trunk became subcutaneous at a mean of 6 cm inferior to the plane of the EOP (range 4–7.5 cm) (mean of 3 cm inferior to the intermastoid line) and this most often occurred in the lateral aspect of the nuchal ligament. The GON was found to lie at a mean distance of 4 cm lateral to the EOP (range 3.5–6.5 cm). On all but three sides, a small medial branch was found that ran medially from the GON to the TON ~1 cm superior to a horizontal line drawn through the EOP (Fig. 1). These medial branches when present coursed at approximately 30° toward the midline. The GON was found to pierce the semispinalis capitis muscle on average 2 cm (range 1.5–3.3 cm) superior to the intermastoid line (Fig. 1). One right side demonstrated two branches of the GON as it pierced the semispinalis capitis muscle that reunited into a single trunk 2 cm inferior to the EOP. The mean diameter of the GON was 3.5 mm (range 2.8–4.1 mm). The GON was found to branch into medial and lateral branches on average 0.5 cm superior to the EOP (range 0.2–2.5 cm). The LON was found to branch into a medial and lateral component at approximately the midpoint between a horizontal line drawn through the EOP and the intermastoid line.

The main LON trunk was found on average 7 cm lateral to the EOP (range 6–9 cm) and this nerve was found to lie at a mean of 3 cm medial to the tip of the mastoid process. In specimens with a mastoid branch of the GAN, this branch was found at a mean of 9 cm lateral to the EOP (range 8–11 cm). The main trunk of this branch of the GAN was found on average to lie 1 cm superior to the mastoid tip. Overall, we found that the areas of the posterior head and neck that were less concentrated with these nerve trunks were the midline and a midpoint between a line drawn between the EOP and mastoid tip. No significant differences were found between left or right sides or genders (Student’s t-test; P > 0.05).

DISCUSSION

Greater occipital neuralgia (Arnold’s neuralgia) is characterized by a lancinating pain extending from the suboccipital region up to the cranial vertex. This pathology may be idiopathic or may appear following a history of cervical trauma (e.g., whiplash injury) (Stechison and Mullin, 1994), osteophyte formation on the C2 vertebrae (Clavel and Clavel, 1996), arthritis of the C2 vertebrae (Ward, 2003), cervical cord tumors (Clavel and Clavel, 1996), Chiari I malformation (cerebellar tonsillar ectopia inferior to the foramen magnum) (Gille et al., 2004), or muscle entrapment (Magnusson et al., 1996; Mosser et al., 2004) (e.g., inferior capitis oblique, semispinalis capitis, or trapezius muscles). Invasive treatments for this disorder include nerve blocks, neurolytic injections, C2 dorsal rhizotomy, neuromectomy, decompression of the C2 dorsal root ganglion, gangliectomy, occipital nerve stimulator placement, and radiofrequency lesions of the C2 dorsal root (Stechison and Mullin, 1994; Barna and Hashmi, 2004).

The GON was found to lie at a mean distance of 4 cm lateral to the EOP and this nerve was found to pierce the semispinalis capitis muscle on average 2 cm superior to the intermastoid line (Fig. 1). Stechison and Mullin (1994) have found that the dorsal root ganglion of C2 is located approximately 2 mm from the inferior aspect of the posterior arch of C1 and that this ganglion was 15 mm from the midline. Mosser et al. (2004) have found that the GON emerges from the semispinalis capitis muscle ~14 mm from the midline and that this site was roughly 30 mm inferior to the EOP. However, Bovim et al. (1991) have written that in routine clinical work, they have had success in blocking this nerve 2 cm inferior to the EOP and 2 cm lateral to the midline.

The GON was found to branch into medial and lateral branches on average 0.5 cm superior to the EOP. Bogduk (1982) has stated that the GON divides into its terminal branches just inferior to the superior nuchal line. In contrast, Ebraheim et al. (1996) have described this nerve as dividing into medial, middle, and lateral branches 1 cm inferior to the EOP with the lateral branch ascending at a mean angle of 38°. These authors also found that the lateral branch is most often found ~5 cm lateral to the midline. We did not appreciate three such distinct branches but rather a medial and lateral branch with the medial branch often providing a sizable lateral branch. Sindou and Mertens (1994) have found the portion of the GON adjacent to the EOP between the medial and middle one thirds of a line connecting this bony process to the mastoid tip. Incidentally, the occipital artery is normally found just lateral to the GON in the proximity of the EOP. Schmidt and Adelmann (2001) have noted that the occipital artery travels at a mean distance of 3.92 cm on the right side and 4.4 cm on the left side from the midline.

Pain in the region of the LON is a frequent component of cervicogenic headache often brought about by physical exertion (Okuda et al., 2001). Raffaeelli et al. (1987) have stated that injection of the LON can be performed inferior to the medial groove of the mastoid tip and 1 cm superior to its tip. Becser et al. (1998) reported that this nerve most frequently first branched inferior to the superior nuchal line in their specimens. However, this line is often difficult to palpate and thus is not as useful a landmark as the EOP or mastoid process. Barna and Hashmi (2004) have stated that the LON is about 2.5 cm lateral to the occipital artery over the occiput. We found that the LON branched into a medial and lateral component at approximately the midpoint between a horizontal line drawn through the EOP and the intermastoid line. The main LON trunk was found on average 7 cm lateral to the EOP, and this nerve was found to lie at a mean of 3 cm medial to the tip of the mastoid process.

Lord et al. (1994) have reported a 27% (95% confidence interval) incidence of TON headache in post whiplash patients. Third occipital neuromy has been performed for patients with this neuralgia (Govind et al., 2003). Lang (1993) has reported that this nerve becomes subcutaneous ~5 cm inferior to the EOP and ~7 mm lateral to the midline. We found the TON was 0–4 mm lateral to the EOP.
The mean diameter of the main TON trunk was 1.3 mm. This trunk became subcutaneous at a mean of 6 cm inferior to the EOP and a mean of 3 cm inferior to the intermastoid line and this most often occurred in the lateral aspect of the nuchal ligament.

Although we were unable to find reports of injury to the mastoid branch of the GAN it is possible that this nerve injury occurs especially with procedures such as retromastoid approaches to the posterior cranial fossa. This nerve may be duplicated (Pantaloni and Sullivan, 2000). Although of an unclear etiology, some have found that the GAN may be involved in some cases of tic douloureux (Wyburn-Mason, 1953; Pantaloni and Sullivan, 2000). This branch was not found in the majority of our specimens.

CONCLUSIONS

Our study has documented potentially useful superficial bony landmarks for the identification of the cutaneous nerves of the posterior head and neck. We found that the areas of the posterior head and neck that were less concentrated with these nerve trunks were the midline and a mid-point between a line drawn between the EOP and mastoid tip. It is our hope that these data will aid the surgeon and clinician in avoiding complications in this region.

REFERENCES