Dual Roots of Origin of Inferior Alveolar Nerve and "Vagal Ansa" Cervicalis: Surgical and Anaesthetic Implications

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Abstract: During routine cadaveric dissection for undergraduate medical teaching, we observed dual roots of origin of the inferior alveolar nerve (IAN) on the right infratemporal fossa in an elderly male cadaver. The IAN originated by two roots encircling the second part of the maxillary artery (MA). The superior root of the ansa cervicalis (AC) originated from the ipsilateral vagus nerve and two independent muscular branches of the right vagus provided additional innervations to the anterior neck muscles. Awareness about the dual roots of origin of IAN is imperative for anaesthesiologists and dentists, while administering local anaesthesia. A prior knowledge about the vagal origin of AC is essential to prevent iatrogenic damage during surgeries.

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Introduction

The anatomy of the infratemporal fossa (ITF) is of tremendous clinical relevance as a number of important neurovascular structures are located in the compact region that too amidst the masticatory muscles (Anil et al., 2003). The branches of the maxillary artery (MA) and mandibular nerve (MN) are notable structures in the ITF. The inferior alveolar nerve (IAN) arises from the posterior division of the MN deep to the lateral pterygoid muscle and then descends over the medial pterygoid muscle to enter into the mandibular foramen. The nerve terminates as incisive and the mental branches and supplies the lower jaw (Wolf et al., 2016). The nerve to mylohyoid arises from the IAN and courses medial to the main IAN and supplies the mylohyoid muscle. The MA is usually found lateral to the IAN, lingual and the buccal nerves in the ITF. Anatomic variations of the IAN such as accessory IAN, split IAN and aberrant communication of IAN with other branches of the MN are known. However, there are very few reports of IAN arising by two roots and encircling the 2nd part of the MA in the ITF (Nayak et al., 2020). The ansa cervicalis (AC) is a nerve loop formed by the first three cervical spinal nerves i.e. C1 to C3 spinal nerves over the carotid sheath. The nerve loop consists of two roots: the superior and the inferior root. The superior root is formed by C1 spinal nerve fibres that travels along the hypoglossal nerve and descends to join the inferior root which in turn is formed from the C2 and C3 spinal nerve fibres. AC innervates usually all the infrahyoid muscles (except thyrohyoid) which act as depressor of the hyoid bone and thus are involved in the important functions of stabilization of neck, swallowing and vocalization (Shvedavchenko et al., 2019).

Case report

During routine dissections of the head and neck region for undergraduate teaching, we found anatomical variation in the origin of the IAN and in the formation of AC on the right side of a 74-year-old male cadaver. The IAN originated by two roots from the posterior division of the MN which encircled the second part of the MA. The MA was deep to the buccal nerve and superficial to the lingual nerve. The length of the deep and the superficial roots were 1.35 cm and 1.41 cm respectively. The main IAN thus formed further descended for 3.15 cm and entered into the mandibular foramen (Figure 1A and B). The nerve to mylohyoid originated from the IAN 1.50 cm inferior to its formation.

On the right anterior triangle of the neck, the AC is formed over the bifurcation of the common carotid artery whose superior root originated from the right vagus nerve and the inferior root was formed by the C2 and C3 spinal nerves. The AC loop supplied the

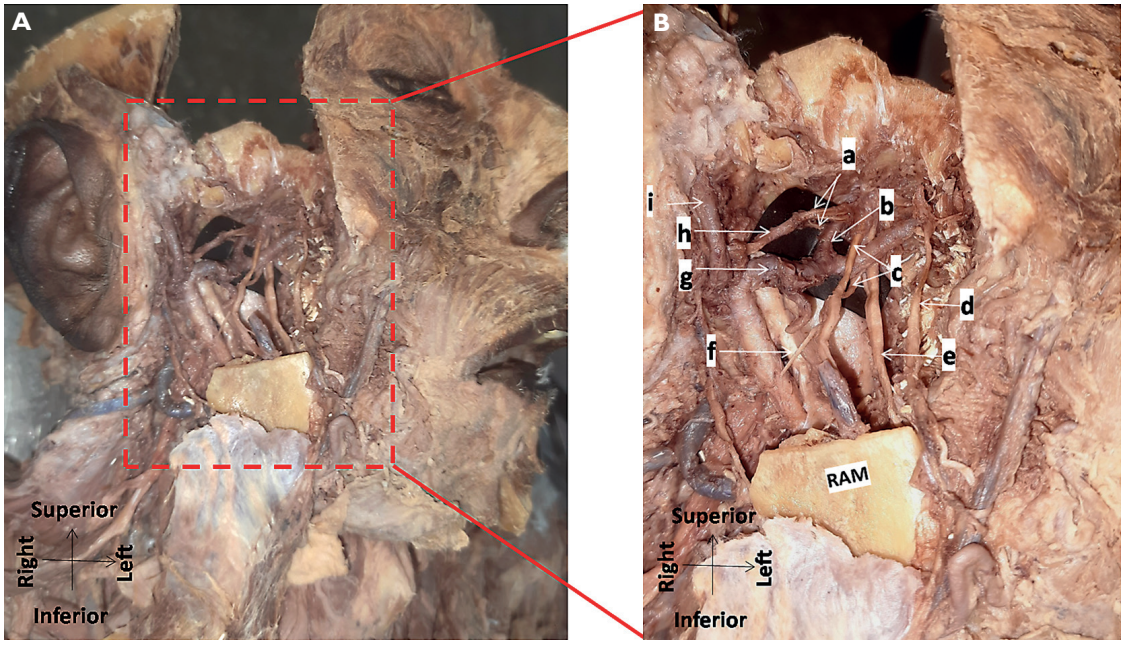

Figure 1: A) Photograph of the part of dissected infratemporal fossa on the right side showing the two roots of origin of the inferior alveolar nerve. B) The same region in close up view. a – two roots of the auriculotemporal nerve; b – middle meningeal artery arising from the maxillary artery; c – the two roots of the inferior alveolar nerve; d – buccal nerve; e – lingual nerve; f – nerve to mylohyoid; g – 2nd part of the maxillary artery; h – auriculotemporal nerve; i – superficial temporal artery; RAM – ramus of the mandible.

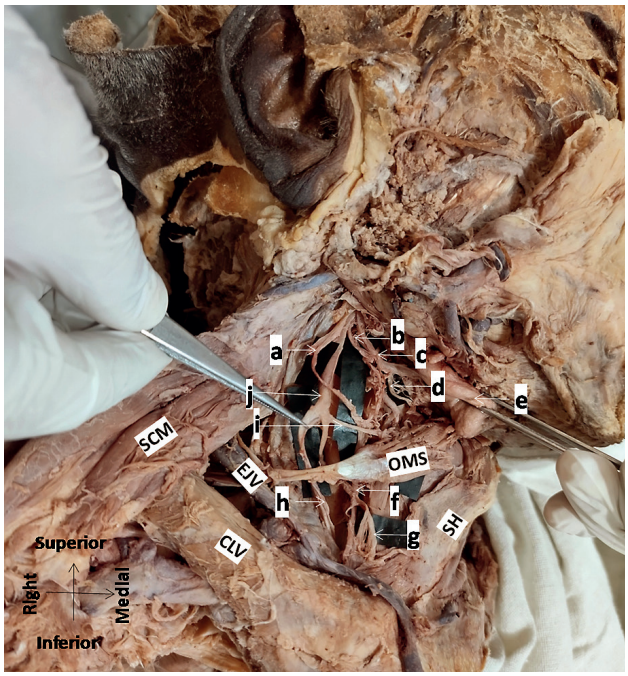

Figure 2: Photograph of the part of the dissected anterior triangle of the neck on the right side showing ansa cervicalis and its formation by the vagus nerve. a – inferior root of the ansa cervicalis; b – superior root of the ansa cervicalis; c – hypoglossal nerve; d – C1 fibre passing with the hypoglossal nerve supplying the thyrohyoid muscle; e – submandibular gland; f – muscular branches arising from ansa cervicalis to the sternohyoid and sternothyroid; g – muscular branches arising from the vagus nerve to the sternohyoid and sternothyroid; h – continuation of the vagus nerve to the thorax; i – muscular branch of the vagus to superior belly of omohyoid; j – vagus nerve within the carotid sheath; SCM – sternocleidomastoid; EJV – external jugular vein; OMS – superior belly of omohyoid; CLV – clavicle; SH – sternohyoid.

sternohyoid, sternothyroid and omohyoid muscles. In addition to that, two independent medial branches were seen arising from the right vagus which supplied the superior belly of omohyoid, sternohyoid and the sternothyroid muscle (Figure 2). The remainder of the vagus nerve descended and entered the thorax following its normal course.

Discussion

One of the common causes for failure to achieve adequate local anaesthesia for routine dental procedures in spite of correct technique is anatomical variations of the MN. These variations are also important as they are prone for iatrogenic injuries (Anil et al., 2003). The ITF is a site for lateral approach during skull base surgeries, which can be challenging in the presence of anatomical variation of IAN (Roy et al., 2002). Bifid IAN is reported where one of the branches enters the mandible through the accessory mandibular foramen. During the local anaesthetic block of IAN, one of the branches can get skipped leading to insufficient anaesthesia. Connection between the IAN and the lingual or auriculotemporal nerve has been reported in the ITF (Wolf et al., 2016). The other notable variation of IAN is MA piercing the IAN (Nayak et al., 2020). Furthermore, the two roots of the IAN encircling the MA mimic the two roots of the auriculotemporal nerve encircling the middle meningeal artery and can confuse surgeons. The 2nd part of the MA may get compressed between the two roots of the IAN. The sensory fibres of the IAN if compressed and irritated by the pulsating MA might give symptoms of mandibular neuralgia (Roy et al., 2002). The origin of the IAN by two roots encircling the MA might necessitate adopting an alternate method for administering local anaesthetic drugs for IAN blocks. Additionally, this type of anatomic variation when undergoing entrapment can present with symptoms similar to mandibular neuralgia.

Table 1: Prevalence of "vagal ansa" cervicalis observed in recent studies

Authors	Population, study type and samples studied	Findings of the study
Jelev (2013)	Bulgarian, cadaveric, 20 cases	2 cases of aberrant formation of AC were observed. In the first case, 3 separate roots of origin of AC from vagus, hypoglossal and cervical ventral rami forming two neural loops. In the second, 2 anterior branches of vagus supplied the anterior neck muscles bilaterally.
Pillay et al. (2012)	South Africa, cadaveric, 40 foetuses	Formation of the superior root of AC from the vagus and the hypoglossal nerve and it was termed vago-hypoglossal-AC.
Kikuta et al. (2019)	American, cadaveric case	Superior root of the AC arose from the vagus and the hypoglossal nerves on the right side.
Gopalakrishnan et al. (2015)	Canadian, clinical case	Superior root of the AC originated from the vagus nerve which also supplied the sternocleidomastoid muscle via separate muscular branches.
Sonne (2019)	American, cadaveric case	Non looping superior root of the AC originated from the vagus nerve and aberrant innervation of the omohyoid muscle by the spinal accessory nerve.

AC – ansa cervicalis

The superior root of AC can arise from the vagus or the spinal accessory nerve instead of the normal hypoglossal nerve and sometimes the superior root can have dual roots of origin from vagus and hypoglossal (Jelev, 2013). The "vagal AC" as found in our case resembles closely with some of the recently reported studies presented in Table 1. The AC in the present case is thus termed as "vagal AC" as coined by several authors and matches with type-IV variety according to Jelev's classification system (Jelev, 2013). However, in our case two additional anterior branches of the right vagus were observed which innervated anterior neck muscles. The reported prevalence of "vagal AC" in foetuses was around 3% (Pillay et al., 2012). Branches of AC are an ideal choice for non-selective reinnervation of the recurrent laryngeal nerve (RLN) by direct end-to-end anastomosis and/or neurorrhaphy procedure. RLN palsy is a clinical condition characterized by denervation of the laryngeal muscles and results in immobilization of the vocal cord, lateralization or inadequate approximation of the vocal cords, impaired phonation, aspirations, breathlessness, dysphagia etc. (Yeole et al., 2024). RLN palsy usually occurs following radical neck dissections, penetrating trauma to the neck etc. The important surgical procedures that commonly lead to RLN injury are thyroid surgery and oesophageal cancer surgery in adults (Kikuta et al., 2019) and patent ductus arteriosus (PDA) closure operation in children. It has been observed that non selective reinnervation of the laryngeal muscles by AC effectively restores voice quality (Zhou et al., 2024). The branches of "vagal AC" may be another excellent alternative for laryngeal reinnervation and hence becomes clinically relevant.

Conclusion

This case highlights rare anatomical variations presenting dual roots of the inferior alveolar nerve encircling the maxillary artery, and a "vagal ansa" cervicalis supplying the anterior neck muscles. Such variations have important implications in dental anaesthesia and neck surgeries. Awareness of these anomalies can help avoid failed nerve blocks, misdiagnosis of neuralgia, and iatrogenic nerve injuries during surgical procedures.

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