

REGIONAL TOPOGRAPHY OF THE INTERNAL CAROTID ARTERY

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ABSTRACT

We studied the extra cranial portion of the internal carotid artery and structures associated with it, which are vulnerable to iatrogenic injury during surgical approach to the neck region in 18 individuals. Distances from the origin of the artery to hypoglossal nerve and posterior belly of digastric muscle were measured. The mastoid process and the hyoid bone were also used as landmarks in locating the nerve and respective distances measured. Hypoglossal nerve and posterior belly of digastric muscle crossed the ICA at variable positions with a mean distance of 10.1mm and 17.9mm respectively from the common carotid bifurcation. From the mastoid process, the internal carotid artery ascends underneath the posterior belly of the digastric muscle a third the distance to the hyoid bone. The external carotid artery is located lateral to the internal carotid artery in 63.8% of the cases, posterior in 16.7% and anterior in 19.4%. The posterior belly of digastric muscle and its attachments are key landmarks in identifying the internal carotid artery and thus avoiding injury to vital neurovascular structures which may help structures, which may help, improve clinical outcomes during surgery.

Keywords: internal carotid, topography, landmarks

INTRODUCTION

The internal carotid artery (ICA) begins at the level of the upper border of the thyroid cartilage at C3/C4 junction after bifurcation of the common carotid artery (CCA). It supplies most of the ipsilateral cerebral hemisphere, the eye, forehead and parts of nose (Standring et al., 2008). During its course in the neck, the ICA related to neurovascular structures that may be of importance to a surgeon operating in this region.

The hypoglossal nerve (HN) crosses the ICA superior to the common carotid bifurcation, although its exact location has been shown to vary between individuals (Fortes et al., 2012). Stab wounds to the neck are a major cause of HN palsy (Hui et al., 2009) although damage during surgical procedures such as carotid endarterectomy and carotid body

tumor excision has been implicated (Sajid et al., 2007).

The external carotid artery (ECA), in its course, lies close to the ICA whereby it is normally antero-medial to the ICA at its origin and becomes lateral during its ascent in the neck (Standring et al., 2008). Their relative positions have been shown to vary and pose a risk of ligating the wrong vessel.

The posterior belly of the digastric muscle (PBDM) is a useful landmark in distal approach to the ICA (Mock et al., 1991). Its attachments, the mastoid process and the hyoid bone, are structures, which may help in locating the artery.

In addition describing the relationship of the ICA to HN and the ECA, the study aimed at

providing relevant palpable landmarks that would be useful in locating the artery.

MATERIALS AND METHODS

Internal carotid arteries from 36 individuals were randomly studied at autopsy in a Nairobi morgue. A skin incision was made in the neck along the anterior border of the sternocleidomastoid (SCM) from the angle of the mandible to the sternoclavicular joint.

The skin and investing fascia were retracted to expose the carotid sheath. The bifurcation point of the common carotid artery (CCA) was identified and the ICA is followed cranially identifying the HN, posterior belly of

digastric (PBD) and the ECA. The distance from the bifurcation to the level of crossing of the HN (p) and PBD (q) were measured. The mastoid process (MP) and hyoid were also identified.

The distances from the MP to the ICA (X) and from the MP to the hyoid (Y) were recorded (Figure 1 & 2). The positional relationship of the ECA in relation to the course of the ICA was recorded and photographs taken.

RESULTS

HN crossed the ICA at variable positions. This crossing has been noted to be relative to the CCB since the position of the HN was observed to almost constant just at the level of the superior border of the angle of the mandible (Figure 3A&B). The mean distance of level of crossing (P) for the 36 samples dissected was $10.06 \pm 6.2\text{mm}$ [range- 0-30.8mm] (Table 1). The HN was located superficial to the ICA and at the level of crossing; it was within the carotid sheath. At approximately the lower level of the C2 the ICA is crossed by the PBDM, which passed superficial to it in all specimen (Figure 3C). From the 36 samples dissected, the mean vertical distance of this crossing from the carotid bifurcation was $17.9 \pm 6.9\text{mm}$ [range: 7.8 – 32.1mm] (Table 1). Various levels of

crossing of the HN across ICA is shown in figure 3. From the MP the artery crosses the muscle at a distance of $29.7 \pm 5.4\text{mm}$ (range: 21.6 – 43mm). The length of the PBDM from the MP to the lateral border of the hyoid bone was $80.3 \pm 8.6\text{mm}$ (62.1 – 99.6mm). This gives a ratio of 1: 2.7. Initially the ECA courses antero-medial to the ICA. More cranially, after passing underneath the digastric tendon, ECA crosses the ICA at variable points to become lateral to it. This crossing was noted in 29 of the 36 dissected hemi-sections. Of the 29, 6 looped to become posterior to the ICA (Figure 3D). In the remaining 7, the ECA was located anterior to ICA throughout its course. Crossing was common superior to upper border of the mandibular angle (Figure 4).

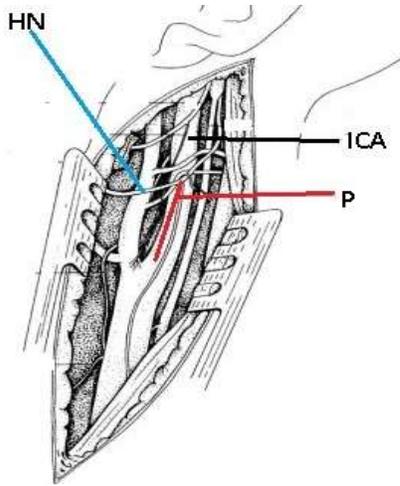


Figure 1: Photograph of the hypoglossal nerve (HN) in relation to the internal carotid artery (ICA). P is the distance from the carotid bifurcation to HN crossing.

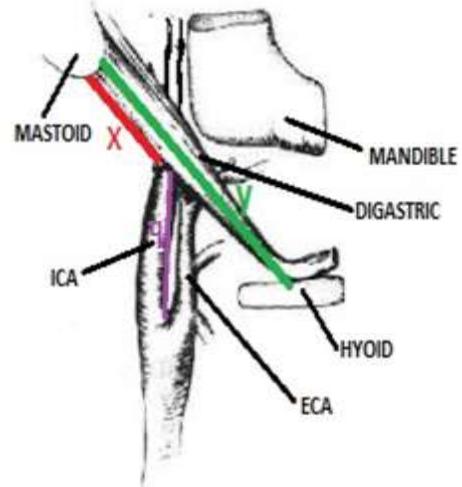


Figure 2: Photograph of the relationship between the ICA and digastric. Mastoid and hyoid form attachments of the muscle and palpable landmarks. X is the distance from the mastoid to the crossing of the ICA. Y is the whole length from the mastoid to hyoid

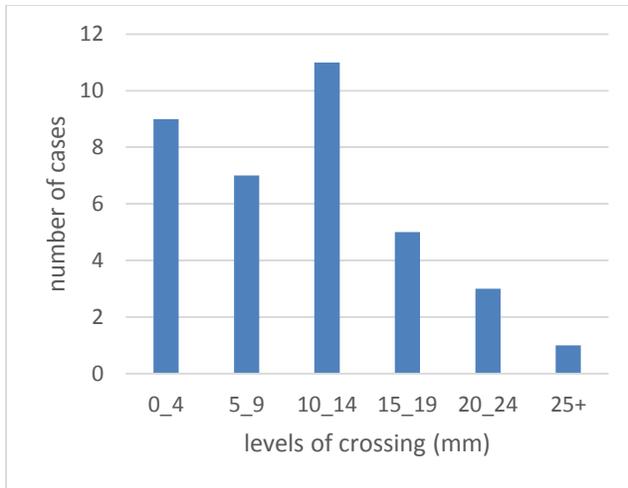


Figure 3: Histogram showing frequency of cases at various levels of crossing (grouped)

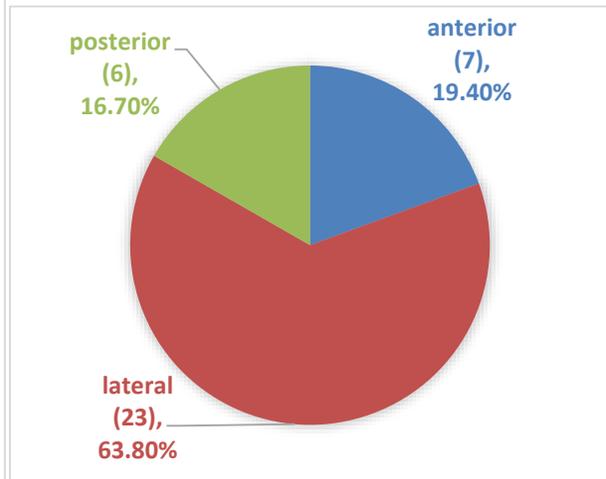


Figure 4: A pie chart showing the frequency of positions of the ECA relative to the ICA

Table 1: A table showing distances from the cervical relations the ICA

	HN (p)	DIGASTRIC (q)	X(MASTOID-ICA)	Y(MASTOID-HYOID)
Mean(mm)	10.1	17.9	29.7	80.3
Sd(mm)	6.2	6.9	5.4	8.6
Range(mm)	0-30.8	7.8-32.1	21.6-43	62.1-99.6



Figure 3: **A**, Photograph depicting a high crossing of the HN relative to the ICA. Other structures in the vicinity i.e. internal jugular vein (IJV), vagus nerve (VN) and external carotid artery (ECA) are shown. **B**, Photograph showing a low crossing of the HN just immediately above the carotid bifurcation. **C**, Photograph showing the ICA relative to the posterior belly of the digastric. Mastoid and hyoid, which are digastric attachment points are shown. The HN is seen just below the muscle. ICA (internal carotid artery) and ECA (external carotid artery) are shown. **D**, Photograph showing the position of the ECA relative to the ICA. The vessel is initially antero-medial. It becomes lateral then posterior to ICA. Looping is at the level of the mandibular condyle, which has been cut.

DISCUSSION

The position of HN is imperative during surgical approach to the neck (Thompson and Smoker, 1994). Present study found position of the HN to be highly variable in the

neck in relation to the ICA in that lowest crossing of the HN was at the CCB whereas the highest crossing was 30mm with a mean distance of 10.1mm. Fortes et al., (2002)

found a mean distance of 21mm with a range of 5 to 43mm. This difference can be accounted by sample sizes used. However, the position of the HN was more or less constant at the level just superior to the angle of the mandible, therefore variation of HN crossing may be influenced by the level of CCB which shown to vary between individuals (Anangwe et al., 2008). The location of the HN within the carotid sheath may limit exposure of the ICA during surgery. This necessitates retraction of the nerve, which poses risk of damage to the superior root of ansa cervicalis. Schmidt, (1983) reported of ipsilateral HN injury in patients undergoing reconstruction of the ICA following atherosclerotic stenosis. With increasing prophylactic carotid endarterectomy for patients at risk of stroke (Imparato et al., 1972) and other neck procedures as branchial cyst surgery (Mukherjee et al., 2012) and carotid tumor resection (Sayed et al., 2011), incidence of HN injury may rise. The surgeon is better equipped with the knowledge that the position of HN varies greatly in the neck within the ranges provided.

The ICA was found to traverse beneath the muscle at a mean distance of 17.9mm (range 7.8 – 32.1mm). Major variants of the ICA relative to the digastric tendon are rare although variations have been reported. Avadhani et al., (2012) found the ICA above the DM in one case during routine dissection. HN was located just inferior or beneath the PBDM at the point of crossing. The muscle may therefore be useful in identification of

the HN during surgery. The MP and the hyoid are palpable landmarks on which the posterior belly of the PBDM attaches. From the present study, the position of the ICA a third way down the line joining the MP and the hyoid may serve as a useful surface landmark in locating the ICA.

From the present study, the posterior and anterior position of the ECA relative to ICA were common. Few studies have attempted to study the course of the ECA with most studying the relative position of the ECA at its origin. Prendes et al., (1980) found the posterior location of the ICA in 5.3% of the patients. Bussaka et al., (1990) found lateral position of the vessel in 4.3% of the cases. The difference observed from previous studies and in the present one may be due to the fact that the former observed the ECA at the CCB whereas the latter at its course. The lateral position of the ECA has been implicated in HN palsy (Ueda et al., 1984). There is also a risk of ligating the ICA during bleeding of ECA or one of its branches (Sayfa et al., 2008).

Conclusion: The PBDM is a key landmark in identifying the ICA and thus avoiding injury to HN and ECA.

Acknowledgements: The authors appreciate the constant input and guidance from Prof. Hassanali, Prof. Saidi and Dr. Odula. The technical and moral support from Sarah, Esther, Maggie, Murunga and Ng'ang'a is deeply appreciated.

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