Common carotid artery trifurcation: a potentially dangerous anatomical variant

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Accepted 19 January 2021

DESCRIPTION

A 77-year-old man with a squamous cell carcinoma of the right border of the tongue, clinical stage T2N0, underwent a partial glossectomy and a right supra-omohyoid neck dissection. During neck dissection aberrant branching of the common carotid artery (CCA) was noted consisting on a carotid 'trifurcation' with the internal carotid artery (ICA) coursing posterolaterally, the external carotid coursing anteromedially and an additional anteriorly oriented arterial trunk (figure 1). After a short, ventral course this trunk gave an inferior and medially oriented branch heading towards the right superior lobe of the thyroid gland and turned anterior, superior and medially into the submandibular space to give off two branches. After the identification of these two branches as the lingual and the facial artery, respectively, the lingual artery was dissected and ligated to proceed with a right marginal glossectomy.

After surgery, the patient underwent a CT angiogram to confirm and better understand the intraoperative findings (video 1 and figure 2). The study was performed on a 128-row spiral CT scanner (Siemens Somatom Definition AS plus 128) and included a volumetric acquisition from the level of the aortic arch to the level of the orbital roof after the intravenous administration of 100 mL of non-ionic iodinated contrast medium through an antecubital vein at a rate of 4 mL/s using an automated power injector (Mallinckrodt Optivantage). A bolus tracking technique was used to determine the individual start delay for the arterial phase, placing the region of interest immediately below the carotid bifurcation (CB). Image processing was performed at a dedicated workstation (Philips Intelispace) to obtain multiplanar and tridimensional reconstructions.

This study showed a high CB on the right side (above the thyroid cartilage) compared with the left, confirmed the presence of three main branches coming off the common carotid due to abnormal branching of a thyrolinguofacial trunk from the anterior aspect of the CCA at the level of the CB and showed a hypoplastic external carotid artery (ECA) compared with the contralateral side.

Several anatomical variants of the CCA and CB have been described: some are relatively common while others are quite rare.¹⁻³ Being asymptomatic, they can go unnoticed during lifetime and are usually an incidental imaging or intraoperative finding. Radiologists and surgeons should be well aware of these variants as they can have major

implications during surgical and/or interventional endovascular procedures.⁴⁻⁶

Knowledge of these variants is critical for treatment planning of atherosclerotic carotid artery disease, management of carotid body tumours and carotid body denervation procedures in case of carotid sinus syndrome. In the particular setting of head and neck cancer, they become clinically relevant during oncological surgery, reconstruction of surgical defects, embolisation of hypervascular/haemorrhagic tumours and intra-arterial chemotherapy.^{1,2,6}

Correct identification and ligation of the lingual artery is mandatory during a hemiglossectomy. Whereas this is usually straightforward, abnormal carotid artery branching may become confusing for an inexperienced head and neck surgeon with the risk of identifying and ligating the wrong vessel. Intra-arterial chemotherapy/chemoembolisation has become a valuable treatment option for patients with locally advanced or recurrent head and neck cancers in which surgical resection would lead to an unacceptable functional and cosmetic result.⁷ In this

Figure 1 (A, B) Intraoperative pictures taken during right sided neck dissection and carotid artery exposure. The patient is placed in cervical hyperextension with the neck tilted to the left side. (A) Shows the carotid bifurcation (white arrow) and a ventrally oriented tortuous trunk corresponding to a thyrolinguofacial trunk (dotted arrow). (B) After further exposure of the CCA and CB one can clearly appreciate the emergence of 3 different trunks from the CB, one lying posteromedially corresponding to the ICA (thin white arrow), another lying anteromedially, corresponding to the ECA (thick white arrow) and still another coming off the ventral aspect of the CB corresponding to a thyrolingual trunk (dotted arrow). Also noted is a small branch coursing inferomedially corresponding to the superior thyroid artery (arrowheads). CB, carotid bifurcation; CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery.

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To cite: Borges A, Ramalho S, Ferreira L. *BMJ Case Rep* 2021;**14**:e241104. doi:10.1136/bcr-2020-241104

Video 1 Shows the axial acquisition images from the CT angiogram obtained from the level of the external auditory canal to the level of the posterior cricoid lamina. These sequential images nicely demonstrate a right carotid trifurcation due to the emergence of a thyro-lingual-facial trunk (TLFT) from the anterior aspect of the right carotid bifurcation. It also shows the STA as the first branch of the TLFT and the facial artery coming off the TLFT and coursing anterior and laterally over the submandibular gland and mandibular body. The lingual artery has been ligated during surgery, and therefore, is no longer seen.

setting, correct identification of tumour feeders is mandatory to obtain the desired result while avoiding hazardous delivery of chemotoxic agents to undesired territories.^{1 8} In addition, head and neck reconstructive flaps can require microanastomosis with ECA branches and improper vessel selection may lead to flap necrosis and failure.^{12 8}

Ideally, these vascular variants should be recognised on imaging studies used for tumour staging and treatment planning. In our case, unfortunately, this anatomical variant of the CB was unnoticed on the preoperative contrast-enhanced CT scan, which included images acquired 90s after a single bolus injection technique. While the best contrast between tumours and normal surrounding tissues is obtained at a capillary/venous phase (70–90s after iodinated contrast injection), arterial anatomy is best depicted during a much earlier arterial phase.⁹ In fact, when arterial invasion is in question, a dual injection technique is used to better assess tumour resectability.⁹ Among the various imaging techniques available to depict arterial anatomy (Doppler ultrasound, CT angiography (CTA), MR angiography and conventional angiography), CTA is the modality of choice allowing for multiplanar, tridimensional reconstructions of the vascular tree.^{4 5} Moreover, images can be obtained in predetermined positions mimicking those assumed during a surgical

Figure 2 Sagittal oblique reconstructions of the right (A) and left (B) carotid arteries, showing a higher position of the right CB compared with the left and a carotid trifurcation on the right side compared with a normal carotid bifurcation on the left. (A) Shows the ICA (thin white arrow), ECA (thick white arrow) and an additional arterial trunk oriented ventrally and superiorly (dotted white arrow) coming off the carotid bifurcation corresponding to a thyrolinguofacial trunk. A thin branch can be seen coming off the TLFT, coursing inferiorly corresponding to the superior thyroid artery (arrowheads). Also note that the right ECA is hypoplastic compared with the left. (B) Shows a normal carotid bifurcation with the ICA (thin white arrow) located posterolaterally and the ECA (thick white arrow) anteromedially. (C, D) 3D reconstructions of the carotid bifurcation show a right carotid trifurcation: ICA (thin white arrow), ECA (thick white arrow), a TLFT (dotted white arrow), the STA (arrowheads) and the facial artery (short arrows). The lingual artery has been ligated and is not seen on this postsurgical CT angiogram. 3D, three dimension; CB, carotid bifurcation; ECA, external carotid artery; ICA, internal carotid artery; STA, superior thyroid artery; TLFT, thyro-lingual-facial trunk.

intervention, making recognition of the anatomy much easier for the surgeon.^{1 10 11}

In normal conditions, the CCA bifurcates at the level of the C3–C4 vertebral bodies into two branches: the ICA and ECA.^{1 12} Whereas this posterior landmark is useful when evaluating cross-sectional images, it is of no use during a surgical intervention where, in most instances, the patient is placed in cervical hyperextension and with the neck tilted to the normal contralateral side.^{1 10 11} More useful landmarks lay anteriorly and include the hyoid bone, thyroid cartilage, mandibular angle and the distance between the CB and the mastoid tip.^{1 4 10 11} One should also be aware that asymmetric height of the CB is common.^{1 4 10 11}

High CB is the most common and relevant normal variant of the carotid system with a direct implication on surgical access.^{1 4 6 11} In the most serious end of the spectrum the CB is absent (embryonic arrest of ECA development), ECA branches arise directly from the CCA and the ICA is the continuation of the CCA above the C1–C2 level.¹ In the remainder, the higher the CB the higher the chance of external carotid branches coming off directly from the CCA or from the CB.¹ The lower ECA branches are the most variable, with the superior thyroid artery branching off the CCA or CB in 61% of cases, the ascending pharyngeal artery in 6%–10% of cases and the lingual artery in less than 1%.^{1 13} These vessels can branch off individually or from common trunks with thyrolingual, linguofacial and thyrolinguofacial trunks reported in the literature.^{1 13–18} Therefore, trifurcation, quadrifurcation and even pentafurcation of the CCA have been reported.¹³ In these circumstances the ECA is usually hypoplastic.^{1 13} Abnormal branching of the dorsal ECA branches is rare with only isolated reports of occipitoauricular trunks.^{1 13}

Tortuosity and kinking of the CCA or ICA are common variants with large review studies reporting a straight course of the

CCA in only 63% of patients.^{1 13 19} Severe kinking and coiling are quite relevant for ENT surgeons. They can mimic submucosal masses of the mucosal pharyngeal space and can become a hazard during biopsy or surgical procedures.²⁰

Moreover, these variants have been associated with weakness of the vascular wall (reduction of muscular and elastic fibres) leading to increased susceptibility to surgical damage.^{1 20}

Reversed position of the ICA and ECA is another variant to take into account having been reported in 1.7%–7.5% of individuals.^{12 21}

In summary, surgical anatomy of the CB is complex and important in many clinical and surgical applications. All efforts should be made to identify anatomical variants that can put a patient at risk during surgical or interventional procedures in the head and neck area.

Learning points

- Common carotid artery “trifurcation” with a thyro-linguo-facial trunk originating directly from the CB is a rare anatomical variant.
- Recognition of this variant is crucial to avoid potential hazards during surgical and/or interventional procedures.

Acknowledgements We would like to acknowledge Mrs Sandra Gonçalves from the audiovisual department for her help in compiling the figures and the video included in this manuscript.

Contributors AB: reviewed the subject, conceptualised the manuscript, collected the images, wrote and reviewed the manuscript. SR: responsible for the clinical management of the patient, collected the intraoperative images, reviewed the manuscript. LF: responsible for the surgical management of the patient, depicted the variant and reviewed the manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Next of kin consent obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

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