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ANATOMIC VARIATIONS

Common left carotid bifurcation at C7–Th1 level: a rare anatomical variant

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Abstract
The left common carotid artery usually bifurcates to the internal and external carotids at or near the superior border of thyroid cartilage. In head and neck surgery, the common carotid arteries are important landmarks, defining the plane of dissection during radical neck surgeries. According to the literature, many variations exist regarding the carotid bifurcation. Anatomical knowledge of these variants is important for surgical approaches in the head and neck regions, to avoid devastating complications that may occur, mainly during anterior neck dissections. We report an interesting case of a 75-year-old male patient with low bifurcation of the left common carotid artery, accidentally found during a routine carotid Doppler ultrasonography. Bifurcation was located at the C7–Th1 intervertebral disc height, approximately 4 cm from the aortic arch.

Keywords Common carotid artery · Carotid bifurcation · Anatomic variation

Introduction

The common (CCA), internal (ICA), and external carotid artery (ECA) are the main arterial supply of the head and neck. Carotid arteries, like other arteries in the vascular system, can become diseased with cholesterol plaque. Plaques typically form in the carotid bifurcation (CB) and extend distally into ICA [6, 10]. Atherosclerotic plaque of the cervical ICA is an important cause of stroke and transient ischemic attack [2].

Injury of the carotid artery is an uncommon but not rare complication of various diagnostic and therapeutic procedures such as carotid endarterectomy, radial neck dissection, central catheterization, etc. [3, 10]. Knowledge of the anatomical variations is very important, reducing the risk of operative morbidity and mortality in patients undergoing vascular surgical procedures.

CB level is subject to individual variations. CCAs may bifurcate higher or lower than usual. In general, carotids bifurcate at or near the superior border of thyroid cartilage (C3–4 junction) [8–11]. Nevertheless, bifurcation may occur as high as C1 or as low as Th2 [8, 11].

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Case report

A 75-year-old, otherwise, healthy, male patient was admitted to our institute for a routine carotid Doppler ultrasonography (DUS). On DUS, a normal carotid arterial system with anatomical variant on the left side was reported. On the right side, carotid bifurcation was found in the expected position, while the left CCA was bifurcated into ECA and ICA at a lower level than usual. DUS findings were confirmed few days later with computed tomography angiography (CTA) and the bifurcation level was determined by the nearby vertebrae between C7 and Th1, approximately 4 cm from the aortic arch (Figs. 1, 2).

Discussion

Common carotid artery (CCA) is the largest artery of the neck originating from the brachiocephalic trunk on the right side and directly from the aortic arch on the left side. Carotid bifurcation (CB) is the natural end of CCA, and the beginning of the two main arteries supplying head with blood, the internal carotid artery (ICA) and external carotid artery (ECA).

Development of aorta is a complex process that takes place during the third week of gestation. Each primitive aorta consists out of a ventral and a dorsal segment that are

Fig. 1 Computed tomography angiography (CTA) volume rendering reconstruction image of the neck. A left common carotid bifurcation of very low level is seen. Carotid bifurcation on the right side is in the expected position

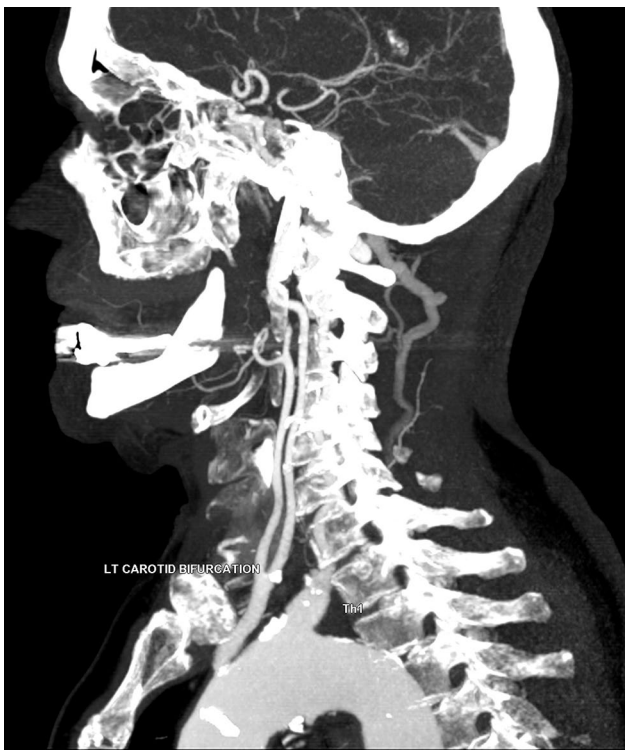

Fig. 2 CTA thick slice in sagittal view shows left carotid bifurcation relation to the spine at C7–Th1 intervertebral disc height, approximately 4 cm from the aortic arch

continuous through the first aortic arch. Six paired embryological vascular structures, "the aortic arches" or "pharyngeal arch arteries", develop between the ventral and dorsal aorta [5]. CCA and the proximal part of ICA arise from the third aortic arch and the remainder of ICA develops from the cranial portion of the dorsal aorta; however, ECA branches from the third aortic arch and unites parts of the first and second aortic arches [4, 6]. The developmental anomalies in the aortic arch's branching and carotid system arise from the unusual patterns of the development of the embryonic aortic arch system. The position of the CB depends on how high or low ECA originates from the third aortic arch and how the ICA takes in the segment of the third aortic arch [4, 6].

Studies show that many variations exist to the level of CB [10]. The CB height may compare to the level of cervical vertebrae, the isthmus of thyroid cartilage, the mandible angle, and the superior thyroid and lingual arteries origin [6]. According to the literature, the CB level revealed with computed tomography angiography (CTA) often differs from that recognized at surgery. This difference between surgical and angiographic views indicated that the CB was positioned lower 1.0–6.6 mm than expected [2]. Radiographically, the standard carotid bifurcation is at or near the superior border of thyroid cartilage (C3–4 junction) [8–11]. Nevertheless, the bifurcation may occur as high as C1 or as low as Th2 [8, 11]. High CB does not cause any problems regarding anterior cervical approach, but should caution surgeons that the hypoglossal nerve lies in closer proximity and is more vulnerable [1, 7, 9]. Low CCA bifurcation may cause problems during anterior neck dissection if not cautious, and surgeons should expect this variation to obviate some manipulations during anterior cervical approach in preventing CCA injury [1, 9].

Several population specific studies report the CB level (Table 1). Ito et al. collect data of 40 Japanese cadavers and classify the height of CB in relation with cervical vertebrae [4]. High CB was reported in 31.2% and includes division of CCA between the C2 and 3 levels or above C2. Standard CB was reported in 57.5% and includes division of CCA at C4 level, while low CB meant that the CCA was divided between C4 and 5 or below C5, as reported for 11.3% of cases. Zumre et al. showed among 40 fetus that CB localization might be at C3 level in 55%, 35% at C4 and 10% at C5 regarding the right side, while for the left side, it was found 60% at C3 and 40% at C4 [11]. Hayashi et al. reported that the mean CB height of 49 Japanese cadavers was most frequently located at the lower third of C3 vertebrae, whereas the highest CB level was found at C2 and the lowest at C4–5 vertebral space [2]. Lo et al. described CB height in 67 specimens using its relation to thyroid cartilage and hyoid bone. They found that CB was at the level of the hyoid bone body in 40%, at the superior border of thyroid cartilage in 39%, at the tip of the greater horn of hyoid bone in 15%, and at

Table 1 Distribution of carotid bifurcation position in studied cases according to cervical vertebrae

Study	Level of carotid bifurcation according to cervical vertebrae		
Ito et al. [4]	C2–3 or above C2 31.2%	C4 57.5%	C4–5 or below C5 11.3%
Zumbre et al. [11]	C3 55% (right side) 60% (left side)	C4 35% (right side) 40% (left side)	C5 10% (right side)
Woldeyes et al. [10]	C2–3 3.85% C3 42.3%	C3–4 15.45% C4 38.4%	
Shivaprakash et al. [9]	C2–3 12% C3 28%	C3–4 38% C4 22%	

Percentage of the position of carotid bifurcation is given

the body of thyroid cartilage in the remaining 6% [7]. Woldeyes et al. collected data from 26 Ethiopian specimens [10]. CB was found high in 46.15%, among which the most common bifurcation level was at C3 (42.3%). In 53.85%, the CB level was standard, most commonly at C4 (38.4%). In this study, low bifurcation was not found. Shivaprakash et al. collected data from 25 south Indian cadavers [9]. CB point was reported at C2–3 junction in 12%, 28% at C3, 38% at C3–4 junction, and 22% at C4 vertebrae. Klosek et al. described CB on 43 Thai cadavers [6] with most of them found at the C3 level, between C3–4 and C4 vertebrae, whereas the lowest CB they described was located at the C5 vertebrae space.

Low carotid bifurcation may cause devastating events during anterior cervical dissection. Knowledge of such variants can be very important for upcoming surgical approach involving the CCA. No clinical signs can predict the level of CCA bifurcation. Therefore, Doppler ultrasonography (DUS) and angiography remain reliant on radiologic imaging to characterize the anatomy to reduce the risk of iatrogenic injury [7].

Our case shows that a very rare low-lying bifurcation located at the level of disc between C7 and Th1 vertebrae nicely revealed on a non-invasive CT-angiographic study.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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