Anomalous Bifurcation and Island Formation of the Carotid Artery

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Summary: An anomalous artery directly connecting the common carotid artery and internal carotid artery was discovered on the right side in the cadaver of an 83-year-old Japanese female, and the facial artery, maxillary artery, and superficial temporal artery arose from the common carotid artery by a common trunk. The anomalous artery arose from the posterior aspect of the common carotid artery at the level of the origin of the superior thyroid artery, and joined the posterior aspect of the internal carotid artery. The anomalous artery was covered by the connective tissue surrounding the common carotid artery and the internal carotid artery. The anomalous anastomosis, especially the proximal portion, may have arisen from the second branchial arch artery during development.

The common carotid artery usually bifurcates into the internal carotid artery and the external carotid artery at the level of the space between the 3rd and 4th cervical vertebrae, and the branches that supply the facial area arise from the external carotid artery. Two types of variations in the bifurcation of the carotid artery have been reported. In one type the anomalies are in the height of the bifurcation into the internal carotid artery and the external carotid artery. In the other type the variations are in branching of the common, internal, and external carotid artery. In the course of a routine anatomical dissection we encountered an anomalous anastomosis (island) that directly connected the common carotid artery and the internal carotid artery on the right side. In this case, the superior thyroid artery and lingual artery arose from the common carotid artery, the facial artery, maxillary artery, and superficial temporal artery from the common carotid artery by a common trunk, and the occipital artery from the internal carotid artery. Such an anomalous artery is exceedingly rare, and only three similar cases have ever been reported in the anatomical literature (Adachi 1928; Suzuki 2000; Chiba 2007). Based on our observation of this anomaly, we will discuss the anatomical and embryological aspects of this variation and of island formation of the carotid artery in the present study.

Subject and methods

This report concerns the dissection of the cadaver of an 83-year-old Japanese female in the anatomy laboratory of Tokyo Medical University, Japan, during a routine educational dissection. The cause of the death was renal failure. Gross dissection was performed according to the standard procedure, and the bifurcation of the carotid artery was observed. We found the anomalous anastomosis between the posterior aspect of the common carotid artery wall and the internal carotid artery wall.

Findings

The aortic arch was a normal continuation of the ascending aorta and it continued distally as the thoracic aorta. The brachiocephalic artery and left common carotid artery arose from the aortic arch by a common trunk (Fig. 1).

The right common carotid artery arose 44.4 mm distal to the origin of the brachiocephalic artery. This common carotid artery did not bifurcate into the internal carotid and external carotid artery at the level of the superior margin of the thyroid cartilage (Fig. 2 and 3).
Bifurcation of the common carotid artery

The superior thyroid artery (external diameter at its origin: 2.7 mm) arose from the anterior wall of the common carotid artery at the level of the superior margin of the thyroid cartilage. The lingual artery arose from the common carotid artery 20.7 mm distal to the branch point of the superior thyroid artery. The facial artery (external diameter at its origin: 3.0 mm), superficial temporal artery (external diameter at its origin: 2.8 mm), and the maxillary artery arose as branches of a common trunk.
maxillary artery (external diameter at its origin: 3.7 mm) arose from the common carotid artery by a common trunk 6.0 mm distal to the origin of the lingual artery. The facial artery arose from the common trunk at the same level as the origin of the common trunk. The common trunk bifurcated into the superficial temporal artery and maxillary artery 52.0 mm from the origin of the common trunk (Fig. 2, 4 and 6).

**Branches of the internal carotid artery**

The internal carotid artery bifurcated from the common carotid artery at the upper position of the facial artery, and the level of the bifurcation of the internal carotid artery was higher position than normal. The left internal carotid artery bifurcated below the angle of the mandible.

However, the internal carotid artery on the anomalous side bifurcated above the angle of mandible. The occipital artery (external diameter at its origin: 2.9 mm) originated from the medial aspect of the internal carotid artery 7.0 mm distal to the origin of the internal carotid artery and coursed to the mastoid process along the posterior margin of the posterior belly of the digastric muscle. The internal carotid artery continued to the base of skull along its normal course (Fig. 2, 4 and 6).
The anomalous artery (external diameter at its origin: 1.2 mm) arose from the posterior aspect of the common carotid artery 3.0 mm distal to the origin of the superior thyroid artery, passed obliquely superoposteriorly along the common carotid artery and internal carotid artery, and joined the internal carotid artery 3.4 mm distal to the bifurcation of the occipital artery.

The initial segment of the artery was covered with the connective tissue around the carotid artery. The anomalous artery was observed as an eminence on the posterior aspect of the carotid artery. We prepared the eminence under a stereoscopic microscope, and exposed the entire length of the anomalous artery (Fig. 5 and 6).

**Discussion**

There are many textbook and review articles on the morphology and embryology of the circulatory system (Patten 1968; Moor 1977; Lippert and Pabst 1985; Sadler 1995), but only a few reports have discussed the details of the morphology and embryology. There are high and low types of bifurcation of the common carotid artery (Adachi 1928; Gluncic 2001; Zumre 2005; Ito 2006).

In the high bifurcation type, the intervals between the branches of the external carotid artery are shorter, and in the low bifurcation type, the intervals between the branches are longer (Adachi 1928). Abnormal carotid bifurcations can be classified into 3 types: (1) A type in which the common carotid artery bifurcates into the internal carotid artery and the external carotid artery at a high level and the external carotid artery has normal branches; (2) a type in which a branch that usually arises from the external carotid artery arises from the common carotid artery or the internal carotid artery (Kubota 1950; Matsumoto 1986; Kaneko 1996; Asami 2002, 2004); and (3) a type in which there is an anastomosis (island) between the common carotid artery and the internal carotid artery or between the internal carotid and the external carotid artery.

The results of Ito’s study on the height of the bifurcation of the common carotid artery in 80 cases showed the presence of a high bifurcation in 25 cases (31.2%), a standard bifurcation in 46 cases (57.5%), and a low bifurcation in 9 cases (11.3%) (Ito 2006). Zumre examined 40 carotid bifurcations, 40 external carotid arteries, and the branches of the external carotid artery, bilaterally, and found that, on right side, the level of the bifurcation of the common carotid artery was at the C3 level in 55%, the C4 level in 35%, and the C5 level in 10%, and on left side, at the C3 level in 60% and at the C4 level in 40%.

There are several types of anomalous branches of the external carotid artery. In one type the superior thyroid artery and occipital artery arise from the internal carotid artery (Takenoshita 1983; Aggarwal 2006). In another type the superior thyroid artery and lingual artery arise...
from the common carotid artery; the facial artery, maxillary artery and superficial temporal artery from the common carotid artery by a common trunk (Lemaire 2001). In a third type the superior thyroid artery, lingual artery, and facial artery arise from the common carotid artery, and the superficial temporal artery and maxillary artery arise from the common carotid artery by a common trunk.

Kitagawa (1993) examined the thyroid arteries of 37 Japanese fetuses at 4 months to 9 months of gestation. The patterns of the branches arising from the aortic arch were classified into four types. Type I was the most common type and was found in 91.9%. Anomalous types II–IV were found in only one each (2.7%). In Type I, the arterial distribution to the thyroid gland was as follows; 1) The superior thyroid artery was found to be a single branch from the parent artery in 100% of cases on the right and in 94.1% on the left, in 2 cases it was found to be a thyro-lingual trunk on the left side. 2) The superior thyroid artery arose from the external carotid artery in 61.8% of cases on the right and in 47.0% on the left, from the divergent portion of the internal and external carotid arteries in 26.5% on both sides and from the common carotid artery in 11.7% on the right and in 26.5% on the left.

Anomalous anastomoses between the common carotid artery and the internal carotid artery or external carotid artery are rare. There are very few reports of an anastomosis (island) between the common carotid artery and the internal carotid artery or external carotid artery in the literature. To our knowledge, only 3 somewhat similar cases have been reported, by Adachi (1928), Suzuki (2000), and Chiba (2008) (Fig. 7).

In the case reported by Suzuki, the anomalous artery arose as a branch from the posterior aspect of the external carotid artery, passed obliquely superoposteriorly, and joined the internal carotid artery. In other cases reported, the superior thyroid artery and the lingual artery arose from the common carotid artery, and an arterial island was formed by a slender vessel connecting the common carotid artery and internal carotid artery (Adachi 1928; Chiba 2008).
Suzuki (2000) classified the carotid bifurcations and branching patterns of the main branches of the common, external and internal carotid arteries into 5 types. Type-A is the normal type, and Type-B, the artery corresponding to the Suzuki’s anomalous artery is very slender, Type-C, Suzuki’s case, Type-D, case of Adachi and Chiba. In Type-E the lingual artery and facial artery arise from the common carotid artery.

In the case reported by Chiba, however, it arose from the common carotid artery at the level of the superior thyroid artery. In our case it arose from the common carotid artery at a level below the superior thyroid artery (Fig. 7).

From the standpoint of embryological development, it has been described that the aortic system is formed with the formation and disappearance of 6 pairs of aortic arches. Normally, it has been believed that the internal carotid artery is formed by the 3rd aortic arch and the cranial portion of the primitive dorsal aorta, and the 2nd primitive aortic arch disappears. In the high bifurcation type, however, the internal carotid artery is said to be formed from the 2nd primitive aortic arch.

The anomalous island-type anastomosis may be the result of persistence of both the second and the third branchial arch artery during development (Fig. 8). Island
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Anomalous anastomosis in our case was sheathed in the connective tissue that surrounded the carotid artery. Anastomoses that are surrounded by connective tissue are difficult to detect, and anastomoses in similar cases may have been missed. Consequently, at the Type-E without the island, we need detailed observation of the posterior wall of the common carotid artery and internal carotid artery.

Recently there has been an increase in clinical interest in angiographical anatomy, and diagnosis and surgical techniques depend in part on this anatomical knowledge. The importance of knowledge of the vascular variation, angiographic images and ultrasonic images of the carotid artery for vascular surgery has been pointed out (Glucic 2000; Ozlem 2005; Lo 2006; Ito 2006). Preoperative knowledge of the morphological aspects of the carotid arteries is necessary to prevent vascular injury during the vascular surgical procedures, such as for the treatment of carotid stenosis or occlusion. We believe that our study on these anomalies will provide morphological, embryological, and clinically relevant insights into the mechanisms of the formation of the carotid circulatory system when the branching pattern of a carotid artery is anomalous.

References

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Fig. 8. (8A, 8B) Diagrams of the formation of the carotid circulatory system (modified from Langman’s medical embryology). The internal carotid artery develops from the 3rd aortic arch and parts of the dorsal aorta above the level of the 3rd aortic arch. The external carotid artery is derived from the 3rd aortic arch. In our case, the external carotid artery may have developed form the 2nd aortic arch, which normally disappears, instead of from the 3rd aortic arch. Island formation is thought to be the result of persistence of both of 2nd and 3rd aortic arch.


Key to Abbreviation

AD: arterial duct
BA: brachiocephalic artery
CCA: common carotid artery
DA: dorsal aorta
ECA: external carotid artery
FA: facial artery
HICA: high internal carotid artery
ICA: internal carotid artery
ISA: intersegmental artery
LA: lingual artery
LCCA: left common carotid artery
LITA: left internal thoracic artery
LSA: left subclavian artery
LTT: left thyrocervical trunk
MA: maxillary artery
NICA: normal internal carotid artery
OA: occipital artery
PA: pulmonary artery
RDA: right dorsal aorta
RITA: right internal thoracic artery
RSA: right subclavian artery
SA: subclavian artery
SFTA: superficial temporal artery
STA: superior thyroid artery