Effect of aging on the configurational change of the aortic arch

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Abstract

We explored the relationship between aging and the configuration of the aortic arch using computed tomography angiography (CTA).

We retrospectively reviewed CTA obtained in 140 cases. The configuration of the aortic arch was categorized into three types based on the criteria mentioned by Madhwal *et al*., and the relationships between each configuration and patient characteristics were analyzed. Anomalies of the aortic arch were also explored. Twenty patients had a type-1 aortic arch (mean age, 56.1 years), 30 patients had a type-2 aortic arch (mean age, 66.3 years), and 89 patients had a type-3 aortic arch (mean age, 71.7 years). The mean age of patients with a type-3 aortic arch was significantly higher than that of patients with a type-1 aortic arch. No significant correlations between the type of aortic arch and other factors, such as smoking habit, were seen. The configuration of the aortic arch in our study appears to be significantly affected by the age of the patients.

Introduction

The tortuosity of the access route from the puncture site to the target lesion is an important factor in the success of carotid artery stenting (CAS). In particular, a thorough understanding of the aortic arch is of paramount importance because this region can have a wide variety of configurations because of atherosclerotic changes as well as congenital anomalies.[1-3]

Recent advancements in radiological examinations have enabled the configuration of the aortic arch to be evaluated prior to CAS using less-invasive methods. In the present study, we explored the factors causing the configurational change of aortic arches using computed tomography angiography (CTA).

Materials and Methods

Patients

This study was approved by our institutional review board with waiver of patient informed consent. Between March 2010 and March 2015, a total of 148 consecutive patients underwent systemic CTA prior to angiography using the Seldinger technique or endovascular therapy to assess the access route for the catheter. Of these subjects, 8 patients were excluded because of insufficient data. Thus, 140 patients (83 males, 57 females; mean age, 68.0±12.7 years) were included in the present study. All the patients were Japanese. Most of the patients had or were suspected of having cerebrovascular diseases. All the patients provided written informed consent for the CTA examination.

Multi-detector computed tomography

The study was performed using a 64-slice CTA imaging system (Somatom Definition, Siemens AG, Munich, Germany) or a 128-slice CTA imaging system (Somatom Definition Flash, Siemens AG). Image analysis was performed using commercial software (Aquarius NET Viewer, TeraRecon, Tokyo, Japan). The scan field included, at a minimum, the region between the carotid arteries and the abdominal aorta. The optimal scan time was determined using the automatic bolus tracking method. The region of interest was placed over the carotid arteries. The adjustment was made to ensure that the scanning would manually start when the contrast agent was detected in the region of interest. Thereafter, 100 mL of a non-ionic iodine contrast agent was directly administered at a rate of 4-5 mL/s, followed by delivery of 40 mL of saline using an automatic injector. A non-ionic iodine contrast agent (ioversol, 320 mgI/mL, Fuji Farma, Tokyo, Japan; iohexol, 300 mgI/mL, Daiichi Sankyo, Tokyo, Japan; or iopamidol, 300 mgI/mL, Bayer Schering Pharma, Osaka, Japan) was used as the intravenous contrast material. The CTA parameters were as follows: tube voltage, 100-120 kV; tube current, 160-320 mAs; collimation, 38.4 mm; gantry rotation time, 0.33-0.50 s; slice thickness, 1 mm; and slice interval, 0.7 mm.

Image analysis

The branching pattern of the brachiocephalic branch from the aortic arch was categorized into three types based on the vertical distance from the origin of the brachiocephalic branch to the top of the arch, which determined the arch type.[4] This distance was less than 1 diameter of the left common carotid artery (CCA) for a type-1 aortic arch, between 1 and 2 CCA diameters for a type-2 aortic arch, and greater than 2 CCA diameters for a type-3 aortic arch (Figure 1).

The type and percentage of varied branching patterns of the aortic arch were observed. The correlations between patient characteristics, such as age, sex, and atherosclerotic factors, and the type of aortic arch were examined statistically.

Statistical analysis

Categorical factors are described using percentages and frequency of characteristics or events. Continuous variables are presented as the mean±standard deviation. Differences in the ages of the patients among the three branching types were analyzed using a one-way ANOVA followed by the *post-hoc* Student-Newman-Keuls method. The relationships between the type of aortic arch and patient characteristics such as sex, smoking habit, hypertension, and diabetes mellitus were analyzed using the Mann-Whitney U-test. All the statistical analyses were performed using a standard statistical package (StatMate V version 5.01, ATMS Co. Ltd., Tokyo, Japan). P values less than 0.05 were considered significant.

Results

Among 140 patients, 139 patients exhibited the left aortic arch. One patient showed the right aortic arch. Of the 139 patients with the left aortic arch, 20 patients had a type-1 aortic

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arch (14.4%; mean age, 56.1±18.0 years), 30 patients had a type-2 aortic arch (21.6%; mean age, 66.3±11.5 years), and 89 patients had a type-3 aortic arch (64.0%; mean age, 71.7±9.8 years). The mean age of the patients with a type-3 aortic arch was significantly higher than that of the patients with a type-1 aortic arch (Figure 2). The mean age of the patients with a type-2 aortic arch were higher than that of the patients with a type-1 aortic arch, although the difference was not significant. No significant correlations between the branching type and other patient characteristics, such as sex, smoking habit, hypertension, and diabetes mellitus, were observed (Table 1).

Regarding the anatomical variations among the aortic arches, 118 patients (84.3%) had a normal-type aortic arch with three branches (the brachiocephalic trunk, the left CCA, and the left subclavian artery). The bovine aortic arch was present in 20 cases (14.2%). Ten patients showed both a type-3 aortic arch and a bovine aortic arch (7.2%). For some of the patients showing these two characteristics, the navigation of the guiding catheter into the left CCA was difficult (Figure 3).

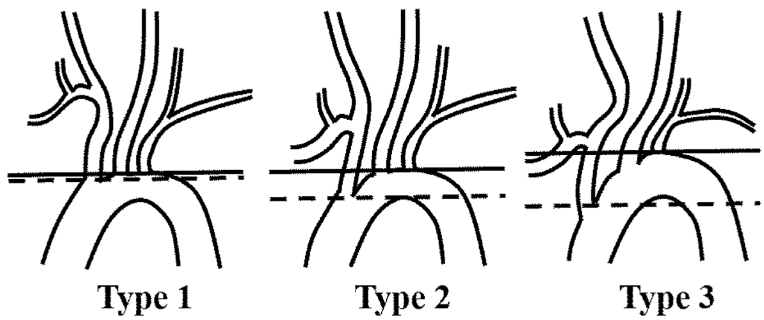

Figure 1. Illustration of the three types of the aortic arch: the line indicates the level of the top of the aortic arch; the dotted line indicates the level of the origin of the bracheiocephalic branch.

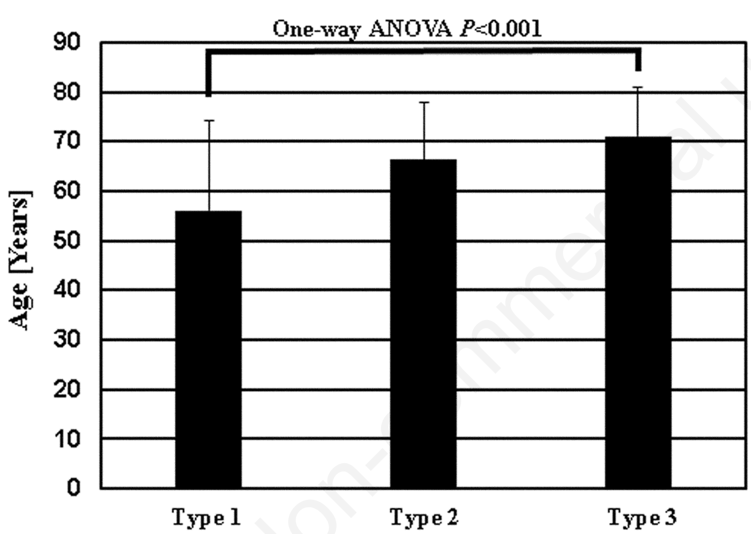

Figure 2. Relationship between the age of the patients and the type of branching pattern of the aortic arch; the mean age of the patients with a type-3 aortic arch was significantly higher than that of patients with a type-1 aortic arch.

Table 1. Relationships between the type of aortic arch and other patient characteristics.

		Type 1 (n=20)	Type 2 (n=30)	Type 3 (n=89)	P
Sex	Male	12	15	55	0.47
	Female	8	15	34	
Smoking habit*	+	7	14	42	0.54
	-	12	16	47	
Hypertension	+	15	14	42	0.11
	-	5	16	47	
Diabetes mellitus	+	16	27	69	0.19
	-	3	3	20	

*As information regarding smoking habits was not obtained from the medical record for one patient, this case was eliminated from the analysis of the relationship between smoking habit and the type of aortic arch.

Discussion

The tortuosity of the access route is a crucial factor in navigating the catheter into the carotid arteries and the vertebral arteries. The aortic arch has long been assessed based on the results of angiography using the Seldinger technique.[5] Today, CTA can be used to facilitate the assessment of the vascular anatomy and to analyze the access route prior to the start of CAS.

Our results show that the type of aortic arch may be related to patient age. Liu *et al.* analyzed the aortic arch in 57 patients and concluded that there was no statistically significant difference in the arch elongation classification, the lesion length, the lesion calcification, or the stenosis severity between patients at an age of over 80 years and those under 80

Figure 3. A 65-year old woman with bilateral internal carotid artery aneurysms: volume-rendering computed tomography angiography shows both a type-3 aortic arch and a bovine aortic arch (arrow). In this case, the navigation of the guiding catheter *via* both the right brachial artery and the femoral artery was unsuccessful.

years.[6] The authors mentioned, however, that the results might have been attributable to the small number of patients. As the number of patients included in our study was larger than that in theirs, our results may be more reliable than their results. The previous report revealed that the tortuosity of the carotid arteries increases in older patients, probably because of the degradation and fragmentation of intramural elastin.[7] The relationship between the tortuosity of the aortic arch and patient age in our study may have been due to similar mechanisms.

In the present results, patient sex, smoking habit, hypertension, and diabetes mellitus were not correlated with the branching type of the aortic arch. Taking this information into account, the age of the patient might have a greater impact on the tortuosity of the aortic arch, compared with other factors.

Aortic arch anomalies have been thoroughly analyzed using CTA.[8-13] The reported frequencies of bovine aortic arch range between 7.8% and 20.8%. The navigation of the catheter to the carotid arteries were especially difficult in the cases with the combination of the bovine aortic arch and the type-3 aortic arch.[14] It is useful to examine the configuration of the aortic arch prior to CAS for the aged patients.

In conclusion, we analyzed the configuration of the aortic arch based on the results of CTA. Age may be correlated with the configuration of the aortic arch, but maybe other factors should be taken into account, *i.e.*, body mass index, body surface area, cardiothoracic index, and age-related increase in kyphosis of the thoracic spine.

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