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Anatomical variations of aortic arch vessels in Japanese patients with aortic arch disease

Yuki Ikeno[1] · Yutaka Koide[2] · Takashi Matsueda[1] · Katsuhiro Yamanaka[1] · Takeshi Inoue[1] · Satoshi Ishihara[3] ·
Shinichi Nakayama[3] · Hiroshi Tanaka[1] · Koji Sugimoto[2] · Yutaka Okita[1]

Abstract
Objectives The present study analyzed the prevalence of variations of the aortic arch branching in Japanese population, comparing patients with aortic arch disease with healthy controls.
Methods Between from October 1999 and December 2015, 815 Japanese patients with aortic arch disease defined as aortic arch aneurysm (diameter ≥ 45 mm) and aortic dissection (group A) underwent aortic arch surgery in our institution. As a control group, 1506 traumatic screened patients were enrolled (group C).
Results Aortic arch anomaly was diagnosed in 140 patients (17.2%) in the group A and in 222 patients (14.7%) in the group C ($p = 0.125$). Significant differences were found in the incidence of aberrant subclavian artery (A: 14 patients, 1.7%, vs. C: 8 patients, 0.5%, $p = 0.006$). Significantly more patients with aortic arch aneurysm in the group A had anomalies of the aortic arch compared with the group C ($p = 0.009$), including bovine aortic arch ($p = 0.049$) and aberrant subclavian artery ($p < 0.001$). In term of aneurysm location, bovine arch was detected in more patients with proximal arch aneurysm (15.7%, $p = 0.043$), whereas aberrant subclavian artery was in more patients with distal location (3.7%, $p < 0.001$). No difference was found in aortic arch anomaly in patients with acute or chronic dissection.
Conclusion Aberrant subclavian artery was a significant maker of aortic arch disease in Japanese populations. Bovine arch was a risk maker of proximal arch aneurysm, and aberrant subclavian artery was a risk factor of distal arch aneurysm.

Keywords Aortic arch anomaly · Bovine aortic arch · Aberrant subclavian artery · Common carotid trunk · Cervical high arch

Introduction

Recent dramatic advances in aortic arch surgery might determine an increasing number of patients with anomalous patterns of the aortic arch [1]. Numerous anatomic variations of

✉ Yuki Ikeno
 yu80piase@gmail.com

1 Division of Cardiovascular Surgery, Department of Surgery, Kobe University Graduate School of Medicine, 7-5-2 Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan

2 Division of Radiology, Kobe University, Kobe, Japan

3 Division of Emergency, Hyogo Emergency Medical Center, Kobe, Japan

the vessels arising from the aortic arch have been reported. Several studies showed that the three most frequent variations account for more than 95% of populations [2–5]. These are described as "normal aortic arch", "bovine aortic arch", and "isolated left vertebral artery arising from aortic arch". The most common type of the normal aortic arch is that with three branches: the brachiocephalic trunk (BT), the left common carotid artery (LC), and the left subclavian artery (LS). The second common type is bovine aortic arch, defined as common origin of the left BT and LC at the aortic arch. The third common type is isolated left vertebral artery arising directly from aortic arch. Moreover, several computed tomographic (CT) studies found that other variations, including aberrant subclavian artery with or without Kommerell's diverticulum, were identified in 0.8–2.0% of patients [3–7].

The relationship between anomalous aortic arch variations and the prevalence of aortic arch disease remains controversial. Recently, Dumfarth et al. [8] reported that

aortic arch variations including bovine arch, isolated left vertebral artery, and aberrant subclavian artery were significantly more common in patients with thoracic aortic disease than in the general population acquired from the review of large imaging studies. Moorehead et al. [9] demonstrated that bovine arch occurred more frequently in patients with thoracic aortopathy than in controls. However, these studies included multiple aortic pathologies, anatomic locations, and ethnic groups. Several authors found that there were significant difference in the incidence of anomalous variations of the aortic arch in each ethnic group [10–14].

The aim of this study was to evaluate the prevalence of variations of aortic arch branching in Japanese patients, and to compare patients with and without aortic arch disease. In addition, we analyzed the surgical outcomes of the aortic arch replacement for patients with and without anomalous variations.

Methods

Between October 1999 and December 2015, 1114 patients underwent aortic arch surgery in our institution. All patient records were queried retrospectively to determine patient inclusion vs. exclusion for the study. Inclusion criteria were aortic arch surgery (composed of hemiarch, partial or total arch replacement, descending/thoracoabdominal aortic replacement under circulatory arrest or cross clamping between aortic arch, and debranching endovascular aortic repair) for aortic arch disease (defined as aortic arch aneurysm diameter ≥ 45 mm and/or aortic dissection), analyzed by appropriate preoperative enhanced CT imaging. Of 1114 patients, 921 patients had appropriate enhanced CT imaging. In addition, the following exclusion criteria were applied: Marfan syndrome, aortitis, infectious aortic aneurysm, aortic trauma, coarctation, porcelain aorta, iatrogenic aortic dissection, non-Japanese, and repeated aortic arch surgery for

the same patient. After excluding 106 patients, 815 Japanese patients (group A: age 70.4 ± 11.0 years; male 65.0%) were finally enrolled as the group of aortic arch disease (Fig. 1).

As a control group, between August 2010 and August 2015, 1593 patients (aged 18–96 years) who underwent CT screening for trauma in Hyogo Emergency Medical Center were enrolled. We excluding 87 non-Japanese patients without appropriate enhanced CT images, with aortic aneurysm (≥ 45 mm), Marfan syndrome, previous cardiac surgery, or coarctation. In the final analysis, 1506 patients were included (group C: age 49.9 ± 19.8 years; male 74.2%). The work was reviewed and approved by the institutional Review Board, and additional informed consent was not required.

Image analysis

All included patients (815 patients of aortic arch disease and 1509 patients of control group) underwent enhanced CT screening. Axial images were used to assess the anatomy of the arch and its branches. When axial images were equivocal, multiplanar reconstruction was performed on ZIO station 2 (Ziosoft Inc., Tokyo, Japan) and the local picture archiving and communication system (PACS). To minimize the error of each analyzer, two trained observers (a cardiothoracic surgeon and a radiologist) performed all the measurements. Bovine aortic arch was defined as a common trunk of BT and LC in at least one CT slice, and the common carotid trunk was defined as a common trunk of LC and the right common carotid artery (RC) in at least one CT slice (Fig. 2). The aberrant subclavian artery was defined as left or right subclavian artery emerging from the distal arch and crossing to the posterior mediastinum toward contralateral side. The location of the aortic arch in the neck above the thoracic cage was defined as cervical aortic arch [15] (Supplemental Fig. 2). The right aortic arch was defined as the aortic arch located in the right part of the trachea. Proximal arch aneurysm was defined as the aortic aneurysm, with the
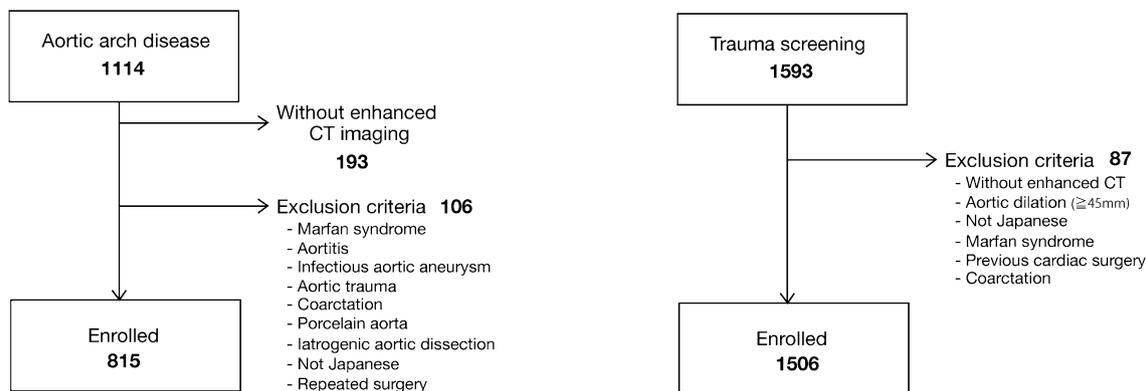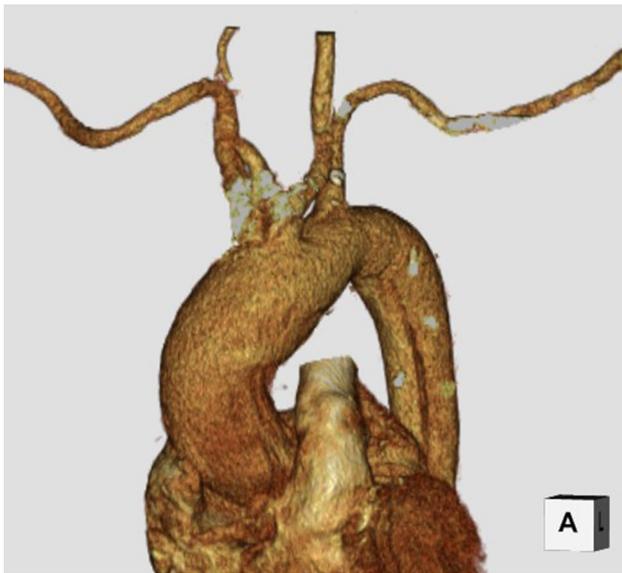

Fig. 1 Study design

Fig. 2 Common carotid trunk. The first branch is the right subclavian artery directly arising from the aorta, the second branch is the common carotid trunk, and the third branch is the left subclavian artery

considered to be statistically significant. The actuarial survival rate was analyzed using the Kaplan–Meier technique. The cumulative survival rate of Japanese people was calculated using national census. The analysis was performed using JMP 11.0 software (SAS Institute, Cary, NC, USA).

Results

Prevalence of the aortic arch branch variations

The prevalence of normal aortic arch was 85.3% ($n = 1284$,) in group C and 82.7% ($n = 674$) in group A (Odds ratio [OR] 0.83, 95% confidence interval [CI] 0.66–1.05, $p = 0.107$) (Table 1). Bovine aortic arch was emerged as the second frequent branching pattern in both groups (C: 9.0%, $n = 135$ vs. A: 10.1%, $n = 82$, OR 1.16, 95% CI 0.87–1.55, $p = 0.389$). Isolated left vertebral artery prevalence ratio was similar (C: 5.4%, $n = 81$ vs. A: 5.2%, $n = 42$, OR 1.00, 95% CI 0.68–1.47, $p = 0.817$). However, aberrant subclavian artery prevalence was identified in higher prevalence in group A than in group C (C: 0.5%, $n = 8$, vs. A: 1.7%, $n = 14$, OR 3.33, 95% CI 1.39–7.99, $p = 0.006$). Aberrant inferior thyroidal artery (A: 0.6%, $n = 5$, vs. C: 0.3%, $n = 4$, OR 2.38, 95% CI 0.64–8.90, $p = 0.211$), common carotid trunk (A: 0.4%, $n = 3$ vs. C: 0.2%, $n = 3$, OR 1.91, 95% CI 0.64–8.90, $p = 0.455$), and cervical arch (A: 0.4%, $n = 3$ vs. C: 0.1%, $n = 1$, OR 5.72, 95% CI 0.38–55.0, $p = 0.104$) had similar prevalence in both groups. The right aortic arch was detected only in group A (1.1%, $n = 9$, $p < 0.001$).

Aortic arch aneurysm

Patients with aortic arch disease were classified into two subgroups: aortic arch aneurysm ($n = 416$) and aortic dissection ($n = 411$), including 12 patients with both pathologies (Table 2). In patients with aortic aneurysm, 112 patients had proximal arch aneurysms, whereas 304 patients had distal arch aneurysms. The prevalence of each variation is shown in Tables 1, 2, 3, and 4. Compared with the control group,

maximum diameter located between the aortic root and the subclavian artery, whereas distal arch aneurysm was the aortic aneurysm, which had maximum diameter located more distal than subclavian artery.

Statistical analysis

All continuous variables were expressed as the mean ± SD. A comparison of the clinical characteristics was performed using the Chi-square analysis for categorical variables and Student's *t* test for continuous variables. Non-parametrically analysis using a Mann–Whitney *U* test was performed for continuous variables. Sixteen patients with overlapping pattern (5 patients with aortic arch disease and 11 control patients) were included in each variation. In addition, 12 patients with aortic aneurysm and aortic dissection were also classified in both pathologies. *p* value of less than 0.05 was

Table 1 Prevalence of aortic arch variations (whole patients)

Variations	Control	Aortic arch disease			
	($N = 1506$), n (%)	($N = 815$), n (%)	OR	95% CI	*p* value
Normal aortic arch	1284 (85.3)	674 (82.7)	0.83	0.66–1.05	0.107
Bovine aortic arch	135 (9.0)	82 (10.1)	1.16	0.87–1.55	0.389
Isolated left vertebral artery	81 (5.4)	42 (5.2)	1.00	0.68–1.47	0.817
Aberrant subclavian artery	8 (0.5)	14 (1.7)	3.33	1.39–7.99	0.006*
Aberrant inferior thyroidal artery	4 (0.3)	5 (0.6)	2.38	0.64–8.90	0.211
Common carotid trunk	3 (0.2)	3 (0.4)	1.91	0.38–9.46	0.455
Cervical arch	1 (0.1)	3 (0.4)	5.72	0.59-55.0	0.104

OR odds ratio, *CI* confidence interval

Table 2 Prevalence of aortic arch variations in patients with non-dissection aneurysm

Variations	Control	Arch aneurysm			
	(N = 1506), n (%)	(N = 416), n (%)	OR	95% CI	p value
Normal aortic arch	1284 (85.3)	331 (79.8)	0.67	0.51–0.89	0.006*
Bovine aortic arch	135 (9.0)	51 (12.3)	1.47	1.04–2.07	0.049*
Isolated left vertebral artery	81 (5.4)	22 (5.3)	1.07	0.66–1.74	0.942
Aberrant subclavian artery	8 (0.5)	11 (2.6)	5.33	2.12–13.4	<0.001*
Aberrant inferior thyroidal artery	4 (0.3)	2 (0.5)	1.94	0.35–10.6	0.501
Common carotid trunk	3 (0.2)	1 (0.2)	1.29	0.13–12.5	0.873
Cervical arch	1 (0.1)	2 (0.5)	7.76	0.70–85.8	0.095

OR odds ratio, *CI* confidence interval

Table 3 Prevalence of aortic arch variations in patients with proximal arch aneurysm

Variations	Control	Proximal arch aneurysm			
	(N = 1506), n (%)	(N = 112), n (%)	OR	95% CI	p value
Normal aortic arch	1284 (85.3)	86 (76.8)	0.57	0.36–0.91	0.023*
Bovine aortic arch	135 (9.0)	17 (15.2)	1.88	1.09–3.26	0.043*
Isolated left vertebral artery	81 (5.4)	8 (7.1)	1.49	0.70–3.19	0.448
Aberrant subclavian artery	8 (0.5)	0 (0)	0	–	0.283
Aberrant inferior thyroidal artery	4 (0.3)	1 (0.9)	3.73	0.41–33.8	0.339
Common carotid trunk	3 (0.2)	0 (0)	0	–	0.512
Cervical arch	1 (0.1)	0 (0)	0	–	0.705

OR odds ratio, *CI* confidence interval

Table 4 Prevalence of aortic arch variations in patients with distal arch aneurysm

Variations	Control	Distal arch aneurysm			
	(N = 1506), n (%)	(N = 304), n (%)	OR	95% CI	p value
Normal aortic arch	1284 (85.3)	245 (80.6)	0.71	0.52–0.99	0.046*
Bovine aortic arch	135 (9.0)	34 (11.2)	1.32	0.88–1.97	0.235
Isolated left vertebral artery	81 (5.4)	14 (4.6)	0.92	0.51–1.64	0.575
Aberrant subclavian artery	8 (0.5)	11 (3.7)	7.21	2.87–18.1	<0.001*
Aberrant inferior thyroidal artery	4 (0.3)	1 (0.3)	1.31	0.15–11.8	0.851
Common carotid trunk	3 (0.2)	1 (0.3)	1.75	0.18–16.9	0.677
Cervical arch	1 (0.1)	2 (0.7)	10.5	0.95–116.0	0.055

OR odds ratio, *CI* confidence interval

normal aortic arch pattern occurred with significantly lower frequency in patients with aortic arch aneurysm (79.8%, n = 331, OR 0.67, 95% CI 0.51–0.89, p = 0.006). On the other hand, bovine aortic arch (12.3%, n = 51, OR 1.47, 95% CI 1.04–2.07, p = 0.049) and aberrant subclavian artery (2.6%, n = 11, OR 5.33, 95% CI 2.12–13.4, p < 0.001) were detected in significantly higher prevalence in these patients.

In patients with proximal arch aneurysm, normal arch configuration had significantly lower prevalence (76.8%, n = 86, OR 0.57, 95% CI 0.36–0.91, p = 0.023) (Table 3). The prevalence of bovine aortic arch was significantly higher (15.2%, n = 17, OR 1.88, 95% CI 1.09–3.26, p = 0.043) in this group. All other patterns, including aberrant subclavian artery, had similar frequency.

In patients with distal arch aneurysm, normal arch pattern was also detected in significantly lower ratio (80.6%, n = 245, OR 0.71, 95% CI 0.52–0.99, p = 0.046) (Table 4). However, no significant difference in the prevalence of bovine aortic arch was found (11.2%, n = 34, OR 1.32, 95% CI 0.88–1.97, p = 0.235) and more patients in this group had aberrant subclavian artery compared with control group (3.7%, n = 11, OR 7.21, 95% CI 2.87–18.1, p < 0.001). Seven of eleven patients underwent surgical repair due to Kommerell's diverticulum enlargement.

Aortic dissection

The prevalence of each variation is shown in Table 5. Stanford type A aortic dissection occurred in 321 of 411 patients, and 259 of 321 patients experienced acute type A aortic dissection. In patients with aortic dissection, no significant difference was detected in the prevalence of variations of aortic arch branching. Compared with control group, distribution of branching pattern did not differ in Stanford type A aortic dissection including acute type A dissection, including the occurrence of brain malperfusion.

Patient characteristics

Patient characteristics are shown in Table 6. Age, gender, dyslipidemia, diabetes mellitus, bicuspid aortic valve, and urgency of surgical repair were similar in different variants of arch branching. However, in patients with anomalous variations, significantly smaller number had family history of

aortic disease (5.5%, $n = 6$) than in patients without anomalous variations (12.0%, $n = 60$, $p = 0.031$). Similar trend was detected in patients with isolated left vertebral artery (0%, $n = 0$, $p < 0.001$). In patients with aberrant subclavian artery, the prevalence of hypertension (57.1%, $n = 8$, $p = 0.026$) and smoking history (28.6%, $n = 4$, $p = 0.013$) was significantly lower than in patients with normal arch configuration.

Surgical procedures and outcomes

Details of surgical procedures and surgical outcomes are shown in Supplemental Table. In patients with normal arch pattern, 30-day mortality and in-hospital mortality rates were 3.4 and 6.4%, respectively. These rates were similar in patients with anomalous variations of aortic arch branching. Except for patients with isolated left vertebral artery (no hospital mortality, $p = 0.021$), no significant differences were found in the early mortality rate in each anomalous variation.

Table 5 Prevalence of aortic arch variations in pathology of aortic dissection

Variations	Control	Aortic dissection		Type A dissection		Acute type A dissection		Type B dissection	
	($N = 1506$), n (%)	($N = 411$), n (%)	p value	($N = 321$), n (%)	p value	($N = 259$), n (%)	p value	($N = 90$), n (%)	p value
Normal aortic arch	1284 (85.3)	352 (85.6)	0.844	277 (86.3)	0.631	227 (87.6)	0.304	75 (83.3)	0.623
Bovine aortic arch	135 (9.0)	33 (8.0)	0.549	25 (7.8)	0.492	18 (7.0)	0.274	8 (8.9)	0.981
Isolated left vertebral artery	81 (5.4)	21 (5.1)	0.829	17 (5.3)	0.952	13 (5.0)	0.811	4 (4.4)	0.694
Aberrant subclavian artery	8 (0.5)	3 (0.7)	0.646	1 (0.3)	0.589	2 (0.8)	0.648	2 (2.2)	0.118
Aberrant inferior thyroidal artery	4 (0.3)	3 (0.7)	0.204	1 (0.3)	0.888	0 (0)	0.260	2 (2.2)	0.037*
Common carotid trunk	3 (0.2)	2 (0.5)	0.348	2 (0.6)	0.238	2 (0.8)	0.167	0 (0)	0.555
Cervical arch	1 (0.1)	1 (0.2)	0.374	1 (0.3)	0.296	0 (0)	0.573	0 (0)	0.733

Table 6 Patient characteristics

Variables	Normal	Whole anomalous		Bovine arch		Isolated left vertebra		Aberrant subclavian	
	($N = 674$), n (%)	($N = 141$), n (%)	p value	($N = 82$), n (%)	p value	($N = 42$), n (%)	p value	($N = 14$), n (%)	p value
Age (years)	70.3 ± 10.9	70.9 ± 11.3	0.556	71.7 ± 10.8	0.259	70.7 ± 11.8	0.796	67.1 ± 14.3	0.295
Male gender	441 (65.4)	89 (63.1)	0.602	54 (65.9)	0.939	24 (57.1)	0.281	9 (64.3)	0.929
Hypertension	504 (83.0)	111 (83.5)	0.905	64 (83.1)	0.985	34 (87.2)	0.487	8 (57.1)	0.026*
Dyslipidemia	171 (29.0)	37 (28.9)	0.977	22 (29.7)	0.901	11 (29.7)	0.928	2 (14.3)	0.198
Diabetes mellitus	76 (12.7)	19 (14.3)	0.624	14 (18.4)	0.184	4 (10.0)	0.609	2 (14.3)	0.862
Smoking	356 (61.9)	68 (54.0)	0.101	44 (59.5)	0.684	17 (48.6)	0.121	4 (28.6)	0.013*
Family history	60 (12.0)	6 (5.5)	0.031*	6 (10.0)	0.639	0 (0)	0.004*	1 (7.1)	0.552
Bicuspid aortic valve	21 (3.1)	4 (2.8)	0.858	2 (2.4)	0.727	1 (2.4)	0.780	0 (0)	0.349
Emergent/urgent surgery	269 (39.9)	45 (31.9)	0.073	25 (30.5)	0.094	18 (42.9)	0.706	3 (21.4)	0.145

Permanent neurologic deficit (PND) occurred in similar ratio in both groups (normal arch: 7.6% vs. anomalous variations: 8.1%, $p = 0.832$). In addition, transient neurologic deficit (TND) also occurred in similar ratio (Normal arch: 8.7% vs. anomalous variations: 8.8%, $p = 0.948$). Subgroup analysis showed no significant difference between the groups.

In 38.1 ± 39.2 months of the follow-up, 5-year survival rate was $89.4 \pm 3.2\%$ in patients with anomalous variations and $82.1 \pm 1.9\%$ in normal arch configuration ($p = 0.694$) (Supplemental Fig. 1A). No significant differences in other variations (bovine arch $88.4 \pm 4.3\%$, isolated vertebral artery $91.8 \pm 5.9\%$, aberrant subclavian artery $92.3 \pm 7.4\%$, and other variations 100%, $p = 0.745$) (Supplemental Fig. 1B).

Discussion

In humans, the aortic arch and its branch formation occurs within the first few weeks of the fetal life. The great vessels arises from six pairs of aortic arches, and the anomalies of the aortic arch result from some failures of regression of arches regression [16, 17].

A recent CT analysis showed that bovine arch, which is considered the second most common variation, was observed in 7.5–20% of population [3–6]. Several authors found that the incidence of bovine arch was higher in African Americans and Caucasians compared to Asian population [6]. This type of branching pattern was generally considered a benign anomaly. However, recently, the association of bovine arch and thoracic aortic disease was established [8, 9, 18, 19]. These reports showed that bovine arch was significantly more common in patients with thoracic aortic disease. Hornick et al. [18] reported that aortic expanding rate was significantly larger in patients with bovine arch. Malone et al. [19] revealed the relationship between bovine arch and aortic arch dilatation. Wanamaker et al. reported that the prevalence of bovine arch was significantly higher in patients with aortic dissection [20]. Although the mechanism linking an bovine arch and aortic disease has not been full determined, three suggestive hypotheses were proposed. During fatal development, bovine arch results from the slow growth of the ventral aortic roots resulting in fusion of the LC and BT. The branch vessels and aorta were thought to weaken from altered neural crest cell migration [21]. Second, the common origin of LC and BT may lead to escalated shear wall stress and injury [20]. Third, the genetic factor that a depletion in chromosome 22q11 resulted in bovine arch with other structural heart disease such as ventricular septal deficit, atrial septal deficit, and coarctation [22]. These hypotheses supported our results that bovine arch was a significant maker of aortic arch aneurysm, especially in proximal arch aneurysm.

Isolated left vertebral artery was observed in 3.7–6.0% in the CT analysis [3–6]. Dumfarth et al. [8] reported that isolated left vertebral artery was a significant risk factor of thoracic aortic disease. However, the present study showed no significant association of aortic arch disease. We accomplish acceptable surgical outcomes including prevention of neurologic complication.

Regarding the aberrant subclavian artery, Tanaka et al. reported in their review of Kommerell's diverticulum that nearly 20–60% of individuals with aberrant subclavian arteries are associated with Kommerell's diverticulum and the rupture and/or dissection rate of Kommerell's diverticulum was 19–44% [23]. Some authors reported that aberrant subclavian artery was a significant maker of thoracic aortic disease [8]. Kim et al. suggested that resected diverticulum specimens had medial degeneration accompanied by the presence of atherosclerotic changes [24]. These changes may brought the results that aberrant subclavian artery was a significant risk factor of aortic arch disease (1.7%) in particular in the distal arch aneurysm group (3.7%). Because of small number of patients, the association of this anomaly with aortic dissection was not proved.

Regarding the carotid trunk, although only a few cases of successful surgical repair were reported, the association with the aortic arch disease was not established [25, 26]. We had three surgical cases of this anomaly, and two of them were acute type A dissection. One emergent case with common carotid trunk and without aberrant subclavian artery required caution [27]. Because three orifices of arch vessels were present as in the normal pattern, the patient experienced large stroke due to failure of antegrade cerebral perfusion of RC. This aspect is important from surgical perspective. Even for emergency cases, it is important to evaluate the aortic arch vessels preoperatively, to recognize this anomaly.

Shuford et al. [15] reported 12 cases of cervical aortic arch in 1972. A recent CT analysis showed interesting configuration of this anomaly [28, 29]. We experienced three cases of this anomaly; two of them underwent total arch replacement (Supplemental Fig. 2). The division and reconstruction of dislocated arch vessels must be performed cautiously in each case.

In our study, patients with aortic dissection did not show a significant difference across the variations of aortic arch. Dumfarth et al. [8] reported that no significant differences were found in frequency of aortic arch anomaly in patients with aortic aneurysms or acute aortic dissection. On the other hand, Wanamaker et al. demonstrated that bovine arch was a significant risk factor of aortic dissection [20]. The thinning of tunica media was considered as a reason of high frequency of aortic dissection in patients with bovine aortic arch [30].

Although our study is a large study of aortic arch anomaly comparing narrower lesion of aortic arch disease with

single-race normal control population, it had some limitations. First, this was a single-center retrospective study. Second, as patients with aortic arch disease, we did not included those who were not surgical candidates. Most of acute type B dissection and acute type A dissection with intramural hematoma were not included. This may influence the result that relatively many patients with aberrant SCA (1.7%) were included in group A, although, in recent reports, aberrant SCA was found at most 2.0%. Third, we adopted patients with traumatic screening CT as the control group, and patient background, such as age or gender, was different. We also excluded 9 patients with aortic aneurysm larger than 4.5 cm from the control group (1 patient with bovine arch and 2 patients with isolated left vertebral artery). This may effect on the prevalence rate of aortic anomaly in control group. We demonstrated the significant difference of frequency using univariate analysis. Ideally, multivariate analysis was more suitable to remove several confounding. However, our cohort included so many kinds of arch variations that it was difficult to set a model. In addition, the fact that we did not have enough clinical except age and sex in control group brought us more difficulty to analyze. Fourth, although we could demonstrate that bovine arch and aberrant subclavian artery were significant makers of arch aneurysm, we did not perform histologic or flow analysis data to prove the results. Fifth, although we presented relatively larger number of patients with aberrant subclavian artery in comparison to the recent literature [8], the number of 14 patients with aberrant subclavian artery was so small that we could not exclude the possibility of other confounding factors. Sixth, though we excluded the influence of etiology on the prevalence of aortic arch disease as much as possible, we cannot exclude all of predisposing factors, such as familial aortic dissection without Marfan syndrome. Thus, further analysis is needed.

Conclusions

In Japanese populations, aberrant subclavian artery was a significant maker of aortic arch disease. Bovine arch occurred more frequently in patients with proximal aortic aneurysm, and aberrant subclavian artery was detected in more patients with distal aortic aneurysm than in those without pathology.

Compliance with ethical standards

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