Incidence of Aortic Arch Anomalies in Patients with Thoracic Aortic Dissections

Kelly M. Wanamaker, M.D.,* Chiemezie C. Amadi, M.D., M.A.,† Jeffrey S. Mueller, M.D.,† and Robert J. Moraca, M.D.*

*Department of Thoracic and Cardiovascular Surgery, Allegheny General Hospital, Pittsburgh, Pennsylvania; and †Department of Radiology, Allegheny General Hospital, Pittsburgh, Pennsylvania

ABSTRACT

Background and Aim of Study: Traditionally aortic arch anomalies have been viewed as a normal and clinically insignificant; therefore, they are often overlooked by radiologists and go unreported. Arch anomalies have been reported to occur in 7% to 15% of patients without thoracic aortic aneurysm or dissection. This study aims to define the incidence of aortic arch anomalies in patients with a thoracic aortic dissection (TAD).

Methods: We retrospectively reviewed all patients from 2006 to 2010 with a TAD admitted to a single institution. Thoracic computed tomography images of 176 patients with dissected thoracic aortas and 179 consecutive, unselected age-matched patients without dissection as controls were reviewed to determine the incidence of bovine arch and other arch anomalies. Statistical analysis of demographic data and clinical outcomes was performed to evaluate significant differences between the groups. Results: Arch anomalies occurred in 34% of patients with TAD compared to controls (19%, p = 0.0017). The most common variant was a common origin of the innominate and left common carotid arteries (bovine arch) found in 31% of dissection patients compared to 15% in the control group (p = 0.0004). Overall arch anomalies occurred in 27% of all Type A dissections and 39% (p = 0.1409) of all Type B dissections. The association was statistically significant in patients ages 50 to 79 with TAD (36.4%, p = 0.0011) and in African Americans collectively (43.2%, p = 0.0033). Conclusions: Aortic arch anomalies occur frequently in patients with TAD and therefore may represent a proclivity for this life threatening condition.


METHODS

We retrospectively reviewed all patients from 2006 to 2010 with a TAD admitted to a single tertiary institute. Patients were identified through a systematic review of the Society of Thoracic Surgery Outcomes Database and utilizing admission ICD-9 codes (441.01, 441.03). The Institutional Review Board (IRB) approved the study. A retrospective analysis of prospectively collected demographic and radiographic data was performed. Informed consent was not required for this retrospective review.

Study population

Two hundred and eighty patients with a TAD were admitted and 176 (63%) computed tomography (CT) scans were reviewed for thoracic aortic arch anomalies by two board certified chest radiologists by consensus. The age range of selected dissection subjects was 27 to
97 years. Median age was 68 ± 14 years. There were 104 male patients and 72 (41%) female patients. Our control group consisted of 179 unselected patients without thoracic dissection who underwent chest CT scans for other indications. The control group was selected from sex- and race-matched individuals referred for thoracic CT scans presenting with chest pain to rule out pulmonary embolus. An effort was made to match this group to our study group based on age, sex, and race. All patients with dissection or aneurysm were excluded from this group. The control population was composed of 94 (53%) women and 85 men with a median age of 63 (range, 21 to 89).

**Measured variables**

All variations for aortic arch branching were considered and documented including normal variants, common origin of the brachiocephalic artery (BCA) and left common carotid artery (LCCA; “bovine” arch), direct origin of the left vertebral artery from the aortic arch, aberrant right subclavian artery (RSA). The aortic arch was considered normal if it was left sided and had three branches: the BCA with RSA and right common carotid artery as its branches, LCCA and left subclavian artery (LSA) in succession from right to left. Specific attention was paid to the aortic arch branching pattern. Age, gender, race, and mortality were analyzed in both the dissection and control groups.

**Statistical analysis**

Our prospectively collected database was interrogated to analyze patient characteristics and aortic arch branching variants. They were compared by univariate analysis using Statistical Analysis Systems (SAS Institute, Cary, NC, USA). A p value < 0.05 was considered significant.

**RESULTS**

**Dissection versus control**

Two hundred and eighty (n = 280) patients were admitted with TADs. One hundred and seventy six (n = 176) CT scans were reviewed. There were 66 (n = 66) Type A dissections and 110 (n = 110) Type B dissections. Arch anomalies occurred in 34% (n = 60) of thoracic dissection patients while the incidence in the control group was 19% (n = 34); p = 0.0017. The most common variant was a common origin of the innominate and LCCAs (“bovine” arch) found in 31% (n = 55) of dissection patients compared to 15% (n = 27) in the control group; p = 0.0004 (Table 1).

**Location of dissection**

Patients with thoracic dissection were divided into two subgroups: Type A and Type B dissection. Overall arch anomalies occurred in 27% (n = 18) of all Type A dissections and 39% (n = 42) of all Type B dissections (Table 2); p = 0.1409. In the Type A group, 16 of 66 (24.2%) patients had bovine arches, which was higher than the control group. In the Type B group, 39 of 110 (35.4%) patients had bovine arch which was also higher than the control group.

**Age**

Patients were divided into four subgroups by age: over 80 years, between 66 and 79 years, between 50 and 65, and less than 50 years old. In the TAD group, patients ages 50 to 79 were twice as likely to have a coinciding arch anomaly as compared with those in the control group. This was found to be statistically significant (Table 3). In the under 50 years subgroup, five patients with TAD had anomalous arches (27.7%), compared to eight of 20 in the control group (34.4%); p = 0.5064. In the over 80 years subgroup, eight of 29 (27.6%) patients with TAD had arch anomalies, compared to none in the control group. This also was not statistically significant.

**Gender and race**

Arch anomalies occurred in 36% of female dissection patients and in 33% of male dissection patients compared to 22% and 15%, respectively, in the control group. The gender differences were found to be statistically significant (Table 4). The incidence of bovine arches divided by gender was 33.3% and 28.8% for the female and male dissection group in comparison to 18.1% and 11.8% in the control group.

There were 158 (90%) Caucasian and 18 (10%) African American dissection patients. The incidence of bovine arch was 27.8% and 55.5%, respectively, as compared to 13.1% and 32%, respectively, in the control group. The gender differences were found to be statistically significant (Table 4). Collectively, of the 355 CT scans reviewed, bovine arch occurred two times more frequently in African Americans than in Caucasians: 43.2% versus 20.4%; p = 0.0033.

**Mortality**

Overall in-hospital mortality in 280 dissection patients was 12.5% (n = 35). A difference was not observed with location of dissection (Table 5). Causes for death were multisystem organ failure (n = 8), perioperative refractory cardiac arrest (n = 9), hemorrhagic stroke (n = 2), coagulopathy (n = 3), septic shock (n = 2), unknown (n = 3), and family decision to withdraw care.
There were a total of 22 (12.5%) deaths in the study group (Table 6). Of 176 patients, 10 (5.7%) with coincident anomalous arch anatomy and dissection died (16.7% of all anomalous arches); 12 of 176 patients (6.8%) with normal aortic arch anatomy and TAD died; p = 0.2383.

**DISCUSSION**

More than 20 different aortic arch configurations have been described. The most common configuration occurs in approximately 80% of the population and consists of three separate origins for the BCA, LCCA,
and LSA. A common origin of the BCA and LCCA (also known as bovine arch) is the second most common variation occurring in 6.7% to 20% of patients without TAA or dissection. The third most common is the left vertebral artery arising directly from the aortic arch in 4% to 6% of the general population. The present study shows that thoracic aortic branching patterns, specifically the bovine arch are more common in patients with aortic dissection than in the general population.

The mechanism linking an anomalous branching pattern of the aorta with dissection has yet to be determined. Hornick et al. reviewed thoracic CT and/or MRI scans of 175 patients with known TAs. Of patients with TAA, 20.7% had concomitant bovine arch variant, compared to 6.7% of patients without TAA (p < 0.0001). Malone et al. found bovine arch in 62 of 191 (26.2%) patients with TAA in comparison to a control group without pathologic features (20.5%). They proposed two mechanisms of this association suggestive of a focal process: during fetal development bovine arch results from the slow growth of the ventral aortic roots resulting in fusion of the LCCAs and BCA. The branch vessels and aorta are thought to weaken from altered neural crest cell migration. Aortic dissection may be the result of changes in blood flow across vessel origins of increased size in the bovine arch. This hemodynamic mechanism suggests that the relatively larger common origin of the BCA and LCCA may lead to marginalized high velocity blood flow leading to escalated shear wall stress and injury. A third explanation may implicate a genetic component. It is well documented that a deletion in chromosome 22q11 results in bovine arch in concordance with other structural heart defects such as VSD, ASD, and coarctation.

The most important predisposing factor for TAD is systemic hypertension, Others are older age, male gender, and other atherosclerotic risk factors. Bovine arch tends to be correlated with TAA, particularly in the descending aorta. These findings parallel our study that bovine arch is significantly higher in the dissection group. In cadaveric studies, race appears to be a significant factor in bovine arch (25% vs. 8% found in Whites). Our study showed a similar relationship occurring more frequently in Blacks (56%) versus Whites (29%) in the dissection group and in 43.2% versus 20.4%, respectively, overall.

Over 20 aortic arch branching variations exist in the general population. With the exception of an aberrant RSA, which is known to cause dysphagia, the more commonly found variations usually do not cause symptoms and are typically coincidental findings during diagnostic procedures. In our study, we found a higher incidence of arch anomalies associated with TAD as compared to an unselected control group. Therefore, this should be considered an additional risk factor for a proclivity to aortic dissection particularly in the descending aorta. For that reason we propose routine reporting of arch anomalies by radiologists and more strict hypertensive control in these patients.

**Limitations of the study**

The retrospective, case–control design was the major limitation of the present study. Other limitations include: the study was completed at a single center and the control population was selected in a non–randomized fashion. Another limitation is that only 63% of the dissection scans were reviewed due to their limited accessibility. All patient scans were not available as some were performed at outside institutions and follow-up imaging was not available for review. We have proposed a correlation between bovine arch and other arch anomalies with TAD. That some patients with aortic anomalies dissect, while others do not, remains inadequately explained. A review of medical records may help to reveal less common or well–characterized predisposing factors for dissection which may have been missed.

**REFERENCES**
