Original article

Branching pattern of aortic arch in a kenyan population

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Abstract

Knowledge of the branching pattern of aortic arch is important during supraaortic angiography, aortic instrumentation, thoracic and neck surgery. Variant patterns are often associated with congenital cardiovascular malformations. The branching pattern shows population variation but there are no data for black Kenyans. The purpose of this study was to describe the pattern in a Kenyan population. One hundred and thirteen aortic arches of adult black Kenyans were exposed during cadaver dissection classes in the Department of Human Anatomy, University of Nairobi and their branches examined. All variations were recorded and photographed. The results are presented in macrographs and a table. Seventy six (67.3%) of the aortic arches showed classical 3 branch pattern of brachiocephalic, left common carotid and left subclavian arteries. Six variants were observed. The most common (25.7%) variation was that of two branches namely a common trunk for the brachiocephalic and left common carotid, and the left subclavian artery; followed by direct arch origin of the vertebral artery in 7 cases (6.2%). In 4 (3.5%) cases the arch had four branches. Over 30% of individuals in the Kenyan population may show variant branching pattern of the aortic arch. This should be taken into account during angiography, aortic instrumentation, supraaortic thoracic, head and neck surgery. Evaluation of cardiovascular malformations in the population is recommended.

Keywords: aortic, arch, branching, black Kenyan.

1 Introduction

Variations in branching pattern of the aortic arch are important during supraaortic angiography or aortic instrumentation and may cause misinterpretation of radiological examination and complications during thoracic and neck surgery, some of which may be fatal (SATYAPAL, SINGARAM, PARTAB et al., 2003; GUPTA and SODHI, 2005; NATSIS, TSITOURIDIS, DIDAGELOS et al., 2009). Further, they may be accompanied by congenital malformations of the cardiovascular system (MOSKOWITZ and TOPAZ, 2003). These patterns show population variations depending on genetic and environmental factors (BHATIA, GHABRIEL and HENNEBERG 2005; NATSIS, TSITOURIDIS, DIDAGELOS et al., 2009). Studies in a South African population revealed variation rate of 5.3% with four varieties (SATYAPAL, SINGARAM, PARTAB et al., 2003). There are no figures for Kenya. This study reports the varieties of aortic arch branching in a sample Kenyan population.

2 Material and methods

This was a dissection study, conducted on 113 cadavers at the Department of Human Anatomy, University of Nairobi. The thoracic cavity was opened by cutting through the costochondral junctions and removing the sternum and costal cartilages. The lungs were removed, superior vena cava and brachiocephalic veins cleared and pericardium opened to expose ascending aorta. Fibrofatty tissue and nerves were removed to clarify the branches of the aortic arch. Each of the branches was followed as far distally as possible to establish its distribution. Photographs of the variant anatomy of the aortic arch were taken using digital camera (Sony© - 7.2 megapixel). Descriptive statistics were used to determine frequencies and means. The results are presented using a table and macrographs.

3 Results

Seventy six (67.3%) of the aortic arches showed the classical branching pattern of brachiocephalic, left common carotid and left subclavian arteries. Of the remaining 37 (32.7%), there were 6 different types of variations noted (Table 1). The most common (25.7%) was two branches namely the left subclavian artery and a common stem that gave rise to the brachiocephalic trunk and left common carotid artery (Figure 1a). In four cases (3.5%) the aortic arch gave rise to four branches namely brachiocephalic trunk, left common carotid, left subclavian and left vertebral artery. The vertebral was proximal to left subclavian in three cases (Figure 1b) and distal in one (Figure 1c). In 2 of the cases of common brachiocephalic - left common carotid trunk, the third branch was vertebral (Figure 1d) and in one case it was the suprascapular artery (Figure 1e). In one case the left subclavian and the left vertebral arteries had a common origin from the aortic arch.

4 Discussion

The arch of the aorta usually gives three branches namely the brachiocephalic trunk, left common carotid and

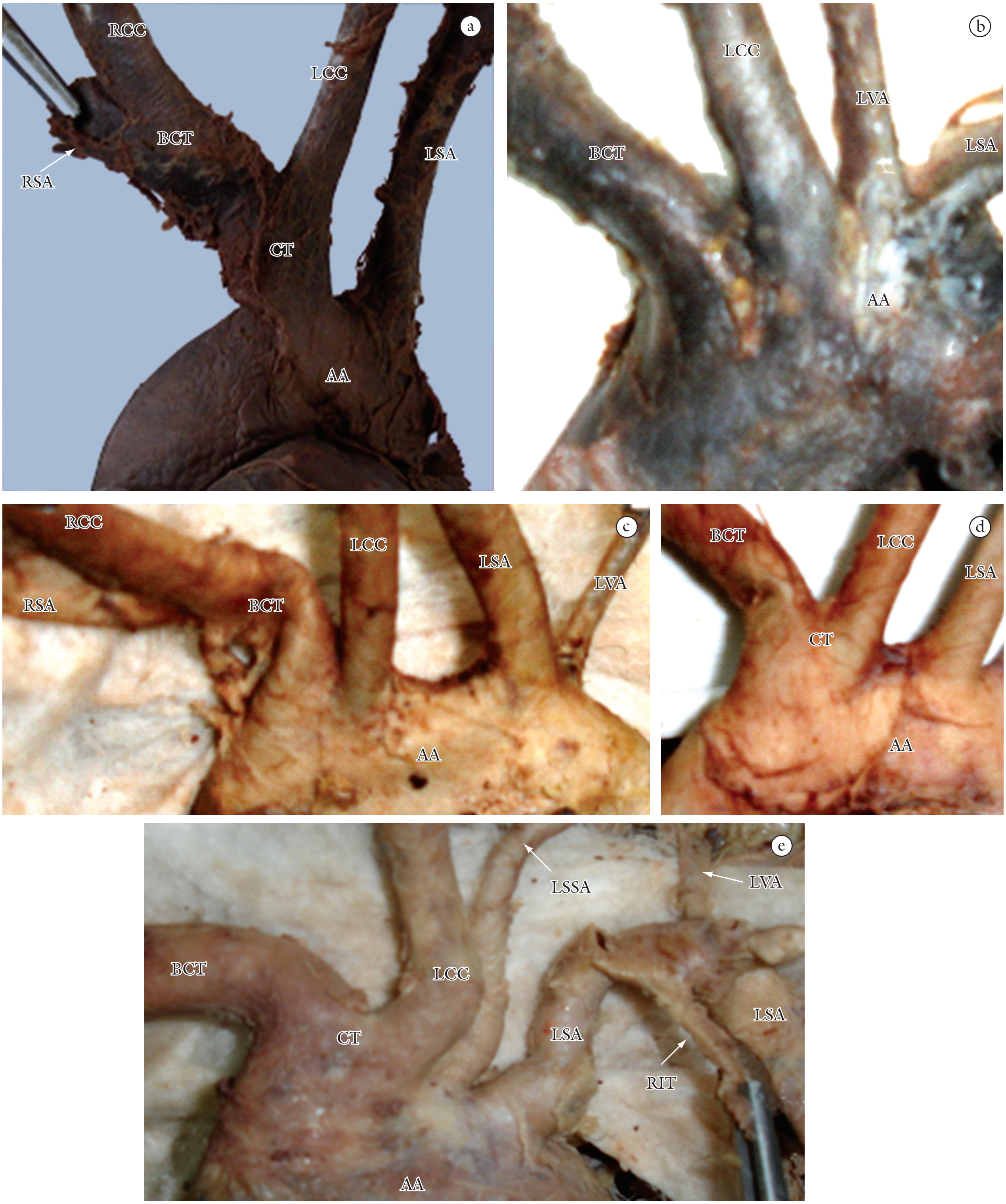

Figure 1. a-e: Variant branching patterns of aortic arch (AA); a) Two branches (i) a common trunk (CT) for brachiocephalic trunk (BCT) and left common carotid (LCC) and (ii) left subclavian artery (LSA); b) Four branches: (i) Brachiocephalic trunk (BCT); (ii) Left common carotid artery (LCC); (iii) Left vertebral artery (LVA) (iv) Left subclavian artery (LSA). Note that LVA originates proximal to LSA; c) Four branches: Pattern in which left vertebral artery (LVA) originates distal to LSA; d) Atypical three branches: (i) Common trunk (CT) for brachiocephalic trunk (BCT) and left common carotid artery (LCC); (ii) Left subclavian artery (LSA) and (iii) Left vertebral artery; e) Atypical three branches: (i) Common trunk (CT) for brachiocephalic trunk (BCT) and left common carotid artery (LCC); (ii) Left suprascapular artery (LSSA); (iii) Left subclavian artery (LSA).

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left subclavian arteries. Observations of the present study reveal that only 67.3% the aortic arches give these three branches and that variation occurs in 32.7%. This is higher than previously reported (Table 2). This supports literature reports that deviation from the conventional branching pattern occurs more commonly in Negroes (MCDONALD and ANSON, 1940). The variant branching pattern is significant to interventional radiologists, anatomists, thoracic and neck surgeons, (NAYAK, PAI, PRABHU et al., 2006) and failure to recognize these patterns may have fatal outcome(SATYAPAL, SINGARAM, PARTAB et al., 2003).

Table 1. Types of aortic arch variations.

Type	Number and description of branches	Frequency	Percentage
I	3: BCT, LCC, LSA	76	67.3
II	2: CT (BCT & LCC), LSA	29	25.7
III	4: BCT, LCC, LSA, LVA	3	2.7
IV	3: CT (BCT & LCC), LSA, LVA	2	1.8
VI	4: BCT, LCC, LVA, LSA	1	0.9
V	3: BCT, LCC, (LVA & LSA)	1	0.9
VII	3: CT (BCT & LCC), LSSA, LSA	1	0.9
	Total	113	100.2

Key: BCT = Brachiocephalic trunk; CT = Common trunk; LCC = Left common carotid; LSA = Left subclavian artery; LVA = Left vertebral artery; LSSA = Left suprascapular artery.

The aortic arch may give a common trunk that gives rise the right subclavian and both common carotid arteries (MCDONALD and ANSON, 1940). Various studies have documented different incidences of this variation (Table 3). In the present study, it constituted 27.5%, which is much higher than most rates reported in literature but comparable to one South African study (MAKHANYA, MAMOGALE and KHAN, 2004). This suggests wide population variation in the branching pattern of the aortic arch. Inadvertent occlusion of this common trunk may have major ischaemic complications given that it supplies both carotids, the right vertebral and subclavian arteries (YAZAR, YALCIN and OZAN, 2003). Further, this variation is associated with cardiac and coronary arterial abnormalities (MOSKOWITZ and TOPAZ, 2003). Understanding the pathophysiological effects of the common trunk is important when planning palliative or corrective procedures and when assessing the potential benefit of surgical repair over the long term (MOSKOWITZ and TOPAZ, 2003).

The third most common variation was that of vertebral artery arising directly from aorta, instead of first part of subclavian artery. Anomalous origins of this artery have been reported in about 5% of the population with a wide range. Majority, however, involve direct origin from the aortic arch (TAKASATO, HAYASHI, KOBAYASHI et al., 1992; YAZAR, YALCIN and OZAN, 2003). Observations of the current study that it arises directly from the aortic arch in 6.2% of the cases are therefore within range (Table 4). As observed in the present study, a vertebral artery from the aortic arch can arise either proximal (28.6%) or distal (71.4%) to the left subclavian artery.

Table 2. Proportion of variant branching of aortic arch in different populations.

Author	Population	N	Proportion of aortic arch with variant branching (%)
Gielecki, Wilk, Syc et al. (2004)	Polish	103	27.2
Grande, Costa, Silva et al. (1995)	Portuguese	33	18
Gupta and Sodhi (2005)	Indian	100	23
Natsis, Tsitouridis, Didagelos et al. (2009)	Greek	633	17
Nayak, Pai, Prabhu et al. (2006)	Indian	61	8.6
Nelson and Sparks (2001)	Japanese	193	5.7
Satyapal, Singaram, Partab et al. (2003)	South African	320	5.3
Shin, Chung, Shin et al. (2008)	Korean	25	16
Current study (2009)	Kenyan	113	32.7

Table 3. Incidence of 2 aortic arch branches in different populations.

Author	Population	N	Proportion of aortic arch with two branches (%)
Gupta and Sodhi (2005)	Indian	100	12
Makhanya, Mamogale, Khan (2004)	South African	60	28.3
Moskowitz and Topaz (2003)	American	1480	3.2
Natsis, Tsitouridis, Didagelos et al. (2009)	Greek	6335	15
Nelson and Sparks (2001)	Japanese	193	01
Satyapal, Singaram, Partab et al. (2003)	South African	320	3.4
Present study	Kenyan	113	25.7

Table 4. Incidence of vertebral artery from aortic arch.

Author	Population	N	Proportion
Bhatia, Ghabriel, Henneberg (2005)	Australian	81	7.41
Gielecki, Wilk, Syc et al. (2004)	Polish	103	6.8
Makhanya, Mamogale, Khan (2004)	South African	60	1.7
Natsis, Tsitouridis, Didagelos et al. (2005)	Greek	633	0.79
Nayak, Pai, Prabhu et al. (2006)	Indian	62	1.6
Nelson and Sparks (2001)	Japanese	193	4.1
Shin, Chung, Shin et al. (2008)	Korean	25	8
Current study (2009)	Kenyan	113	6.2

In one case, similar to literature reports (NELSON and SPARKS, 2001), the vertebral artery shared a common trunk with left subclavian artery. Origin of suprascapular artery as a fourth branch of the aortic arch is, however, hitherto undescribed. Knowledge of variations in origin of the vertebral and suprascapular arteries is important during angiography, thoracic, head and neck surgery (YAZAR, YALCIN and OZAN, 2003). Detailed knowledge of anomalous origin of supraaortic arteries is important for patients who have to undergo four vessel angiography in an emergency, for example, to rule out aneurysm in subarachnoid hemorrhage. If detection of a vertebral artery in the normal position is not possible, presence of these variations must be considered (LEMKE, BENNDORF, LIEBIG et al., 1999)

These variations arise from complex transformation of the embryonic aortic arch system which involves various processes such as regression, absorption, retention or reappearance. For example a common brachiocephalic trunk may be a variant of aortic arch development in which both common carotid arteries and the right subclavian artery originates from a single trunk that arises from the arch (SURESH, ORCHININI and MCRAE, 2006). Origin of vertebral arteries from the aorta suggests that part of the aortic arch arises from the left 7th inter-segmental arteries (BHATIA, GHABRIEL and HENNEBERG, 2005) or there was increased absorption of embryonic tissue of the left subclavian artery between origin of aortic arch and the vertebral artery (SURESH, ORCHININI and MCRAE, 2006). Wide diversity of types and prevalence of variations may be related to environmental (BHATIA, GHABRIEL and HENNEBERG, 2005) and ethnic (NAYAK, PAI, PRABHU et al., 2006) factors. Role of genetic factors is suggested by association of the variations with chromosomal abnormalities (MOMMA, MATSUOKA and TAKAO, 1999).

5 Conclusion

Over 30% of individuals in Kenyan population may show variant branching pattern of the aortic arch. This should be taken into account during angiography, aortic instrumentation, supraaortic thoracic, head and neck surgery. Evaluation of cardiovascular malformations in the population is recommended.

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