

ORIGINAL ARTICLE

Bovine Arch and Laterality of Cardioembolic Stroke

Nosaiba Al-Ryalat^{1*}, Azmy Hadidy¹, Hadeel Younes¹, Rawan Al-suht¹, Dana Shibli¹, Maher Ahmad Tarawneh¹, Akram Kamal Al Hadidi¹, Ali M. Alabbadi¹, Soukaina Ryalat², and Saif Aldeen AlRyalat³

¹Department of Radiology, The University of Jordan, Amman, Jordan

²Faculty of Dentistry, The University of Jordan.

³Department of Special Surgery, The University of Jordan.

*Corresponding author:
nosryalat@yahoo.com

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Abstract

Aims and Objectives: We aimed to find the correlation between cardioembolic and non-cardioembolic stroke incidence with bovine arch anatomical variation.

Materials and Methods: Retrospectively, we identified about 1,500 brain MRI/MRA and neck MRA studies, from which 605 patients were found to have had an acute stroke, with a mean age of 62. Images were reviewed to identify anatomical variations of the aortic arch, particularly bovine configuration, and characterization of anterior and posterior circulation stroke.

Results: Some 60% of patients had had a left-sided stroke. About 17% of patients had had an anterior embolic ischemic stroke, and another 7% had had a posterior embolic stroke. Within the non-embolic stroke, 56% were in the anterior circulation, while 27% were posterior non-embolic ischemic strokes. Some 30% of the patients were found to have bovine arch; from patients with ischemic stroke and bovine arch, about 17% were in the anterior circulation and 5% in the posterior.

Conclusion: the bovine aortic arch may serve as a risk factor for early-onset anterior circulation strokes. Bilateral and left-sided infarcts were more common.

Keywords: Bovine arch, aortic arch congenital variation of arch, normal variant, stroke lateralization

INTRODUCTION

The first branch arising from the normal left arch is the right brachiocephalic (innominate) artery, followed by the left common carotid and left subclavian arteries. This branching pattern represents about 70–80% of the population [1, 2]. The most common arch variant branching pattern occurs when the left common carotid artery commonly shares an origin with, or less often arises from, arises directly from the right brachiocephalic artery [3]. This variant has

been referred to as a bovine-type arch (BA). For the common origin right brachiocephalic trunk (BCT) and left common carotid arteries (LCCA), as well as the direct origin of the left common carotid artery from the right brachiocephalic artery, there is a prevalence of 13% and 9% in the general population, respectively [2] (Figure 1 A). Type 1 (BAT1), or the common ostium variant, is the most common type and occurs when the LCCA and Brachiocephalic trunk originate from the same point (Figure 1 B). Type 2 (BAT2) occurs when the LCCA arises as a branch of the BCT itself (Figure 1 C).

Many clinical implications of bovine arch anatomy variation have been described in the literature. A significant association has been implicated between bovine arch and embolic cerebrovascular accidents [4]. This anatomic variation involves the altered angle of the branching of the great vessels, resulting in increased shear stress, which leads to inflow alterations [4]. One study reported that patients with this configuration have a significant susceptibility to left hemispheric cardioembolic infarcts [5]. The likelihood of developing an ascending aortic aneurysm in this group of patients compared to the general population has also been shown [4]. It is worth mentioning that bovine arch can be a risk factor for technical factors and neurological complications. It can result from ligation of an undetected bovine arch. Increased rates of coarctation are due to short clamping distances when the brachiocephalic trunk is displaced distally and the left common carotid artery is more proximal [6]. Stenting has been affected by bovine arch with a preference for the upper limb approach over the transfemoral to avoid the two tight turns from the aortic arch to the brachiocephalic trunk and then into the left common carotid artery [6]. This warrants the importance of identifying such an anatomic variation due to its influence on the surgical approach. This study aimed to assess the variation in bovine arch in a sample of Jordanian patients and then to determine the impact of bovine arch variation on embolic stroke site.

METHODS

The study was conducted at Jordan University Hospital. Informed consent was waived due to the retrospective study design. We retrospectively identified about 1,500 studies of brain MRI/MRA and neck MRA, with the contrast made between (2018–2021). Exclusion criteria included severe carotid artery stenosis, images degraded by

technical artifacts, and inadequate available clinical data. Inclusion criteria were an acute ischemic infarct, the availability of both brain and neck images, and the availability of clinical data. Images were reviewed for aortic arch anomalies, particularly bovine configuration and the classification of acute stroke as either anterior or posterior circulation. Brain images were also reviewed for characterization of stroke size (lacunar or non-lacunar) and hemispheric laterality (right, left, or bilateral). Image review was conducted by radiology residents trained to identify aortic arch branching patterns and infarct types. Afterwards, the collection of clinical data was performed to identify the embolic and non-embolic acute ischemic infarct. Data collection was conducted by medical students. Equivocal infarct or aortic anomaly categorization was decided by expert radiology consultants, including a neuroradiologist.

Variables

For the purposes of the study, the designation of bovine arch denotes to either a vessel giving rise to both the brachiocephalic and the left common carotid arteries or a common origin of the two vessels. The left vertebral artery variant means that it originates directly from the aortic arch. The aberrant right subclavian artery variant shows four supra-aortic vessels; the right and left common carotid arteries followed by the left subclavian and, as the fourth most distal branch, the right subclavian artery originating on the left side of the body, passing towards the right side. Azygous configuration is a rare variant of a circle of Willis, whereby the two A1 segments join to form a single trunk. A fetal posterior cerebral artery is a common variant in the posterior circulation which occurs when the posterior communicating artery is larger than the P1 segment of the posterior cerebral artery and supplies the bulk of the blood to the PCA. Bi-

carotid trunk means a common origin of both common carotid arteries from the aortic arch. An anterior circulation stroke concerns areas of the brain supplied by the internal carotid artery branches, while a posterior circulation stroke involves areas supplied by vertebral-basilar circulation. Regarding the causes of cardioembolic stroke, there are several mechanisms, especially atrial fibrillation. Other causes include blood stasis in the heart due to congestive heart failure and valvular pathology such as endocarditis.

Statistical analysis

We used IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). in our analysis. We used mean ($\pm$ standard deviation) to describe continuous variables and count (frequency) to describe other nominal variables. We performed an independent sample *t-test* to analyze the frequency of each continuous variable with the presence or absence of bovine arch, for left- and right-sided strokes. A *p-value* of less than 0.05 was considered significant.

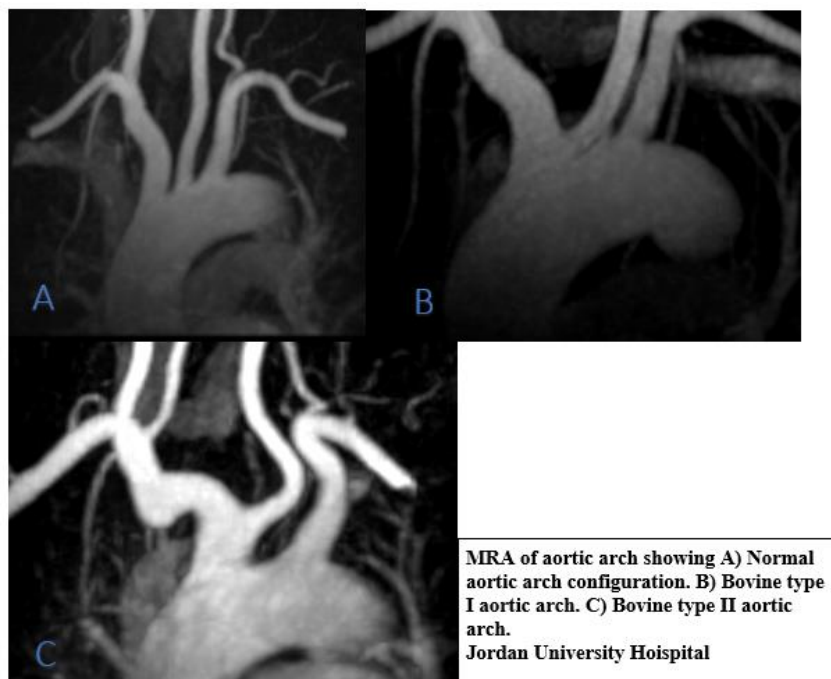


Fig (1): MRA of aortic arch showing: a) Normal aortic arch configuration; b) Bovine type I aortic arch; c) Bovine type II aortic arch.

Source: Jordan University Hospital

RESULTS

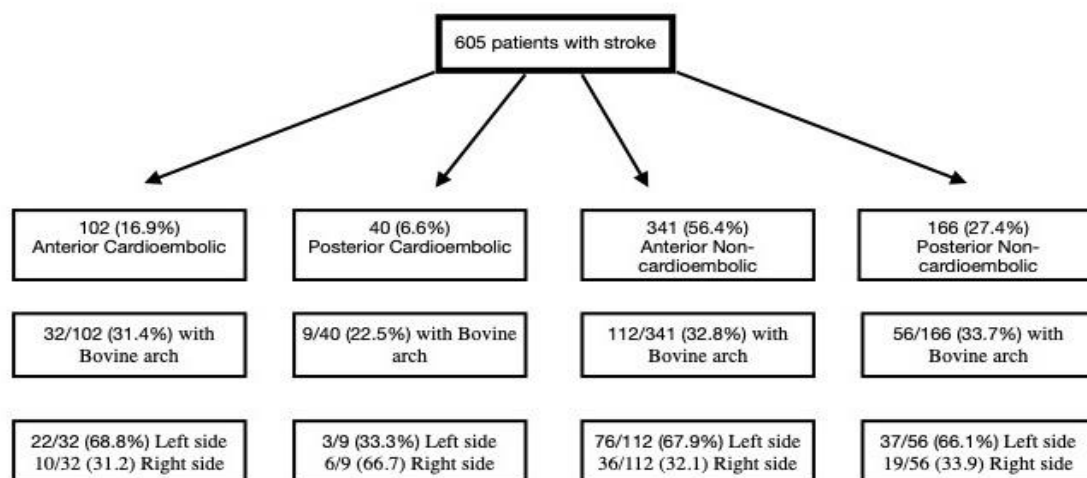
A total of 605 patients were included in this study, with a mean age of 62.61 (± 12.69) years. There were 280 (46.3%) men and 325 (53.7%) women. Some 363 (60%) patients had left-sided strokes, while 333 (55%) had right-sided strokes. Among the 605 patients

with stroke, 102/605 (16.9%) had anterior circulation embolic infarct, and 40/605 (6.6%) had posterior circulation embolic infarct. For non-embolic, 341/605 (56.4%) had anterior non-embolic, while 166/605 (27.4%) had posterior non-embolic. Table 1 details the characteristics of the sample.

Table 1: Details and characteristics of the included sample

		Count	%
B1	No	491	81.2%
	Yes	114	18.8%
Normal	No	190	31.4%
	Yes	415	68.6%
B2	No	529	87.6%
	Yes	75	12.4%
Vertebral artery originating from arch	No	598	98.8%
	Yes	7	1.2%
Apparent right subclavian artery	No	604	99.8%
	Yes	1	0.2%
BiCc tr* ¹	No	605	100.0%
	Yes	0	0.0%
Fetal pca* ²	No	500	82.8%
	Yes	104	17.2%
Azygous	No	593	98.0%
	Yes	12	2.0%
Ant circ* ³ cardioembolic infarct	No	503	83.1%
	Yes	102	16.9%
Post circ* ⁴ cardioembolic infarct	No	565	93.4%
	Yes	40	6.6%
AFib* ⁵	No	530	87.6%
	Yes	75	12.4%
Ant circ* ³ non-cardio embolic	No	264	43.6%
	Yes	341	56.4%
Post circ* ³ non-cardio embolic	No	439	72.6%
	Yes	166	27.4%
Right	No	272	45.0%
	Yes	333	55.0%
Left	No	242	40.0%
	Yes	363	60.0%

*¹BiCc tr: Bi common carotid trunk, *²PCA: posterior cerebral artery, *³Ant circ: Anterior circulation, *⁴Post circ: posterior circulation, *⁵Afib: atrial fibrillation,

**Figure 2: Categorization of patients by laterality of infarct and presence of bovine arch**

Among the included patients, 190 (31.4%) had bovine arch configuration. From the bovine arch with stroke, 32/190 (16.8%) had anterior circulation embolic infarct and 9/190

(4.7%) had post circ embolic infarct. For non-embolic infarcts, 112/190 (58.9%) had anterior non-embolic stroke, while 56/190 (29.5%) had posterior non-embolic (Figure 2).

DISCUSSION

The importance of the identification of this form of anatomic variation in the bovine arch lies in the significant vulnerability to left hemispheric cardioembolic infarcts, the likelihood of developing an ascending aortic aneurysm, the risk factor for technical factors and neurological complications, and the influence on surgical approach (e.g., a preference for the upper limb approach over the transfemoral one in stenting). This study aimed to assess the variation in bovine arch in a sample of Jordanian patients and assess the impact of bovine arch variation on the laterality of the cardioembolic stroke site. Among 605 patients included in this study, anterior circulation infarcts were noted more than posterior circulation in both embolic and non-embolic infarcts. Among those sampled patients with a bovine arch configuration, anterior circulation infarcts were noted more than posterior circulation in both embolic and non-embolic infarcts.

In our study, the number of patients was 605, of whom 114 (18.8%) had bovine arch type 1 and 75 (12.4%) had bovine arch type 2. Most patients (415, 68.6%) had a normal arch. However, we also looked at five associated anomalies in the group: vertebral artery originating from the arch, apparent right subclavian artery, Bi common carotid trunk (BiCc tr), fetal posterior cerebral artery (fetal PCA), and azygous artery. The most commonly associated anomaly we found was fetal PCA, which was seen in 104 (17.2%) patients. This was followed by an azygous artery, artery originating from the arch, and apparent right subclavian artery with 12 patients (2.0%), 7 patients (1.2%), and 1 (0.2%) patient, respectively. We were unable

to find any anomalies of BiCc tr.

For a long time, bovine arches were considered incidental findings of no clinical significance. Recently, more and more studies have been conducted on the effects bovine arch may have on patients [7, 8]. The high percentage of cardioembolic strokes among patients with bovine arches suggests that it may be a risk factor in embolus formation [9–11]. This alone should motivate more prospective studies with the goal of assessing if there is an increased risk of cardioembolism in patients with bovine arch. This study may also illuminate the incidence of bovine arch in Middle Eastern populations.

The main finding of this study was a significantly increased risk of patients with bovine anatomy having left-sided embolic infarct compared to normal. Left-sided strokes tend to have a higher mortality compared to right-sided strokes. considering this study's findings, more research should be conducted on whether patients with bovine anatomy have a worse prognosis compared to the normal population. This may lead to updated guidelines that take arch anatomy into account when prescribing anticoagulants to patients with a higher risk of cardioembolic stroke.

This study had several limitations, among them its retrospective design and reliance on CT imaging for the diagnosis of acute infarcts. Patients with multiple infarcts in separate hemispheres were considered to have both right and left infarcts regardless of relative size, considering that these may arise from distinctive embolic episodes. Patients may have also had extensive aortic arch atheroma, which was not considered. These

patients were not evaluated based on clinical stroke scales, and clinical outcomes were not

assessed as they were beyond the scope of this study.

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القوس الأبهر البقري و جانبية السكتة الدماغية الخثرية

نُسيبة رyalat¹، عزمي الحديدي¹، هديل يونس¹، روان يوسف السحت¹، دانا رضا شبلي¹، أحمد ماهر عماد الطراونة¹،

أكرم كمال الحديدي¹، علي موسى العبادي¹، سكينه الريالات²، سيف الدين الريالات³

الملخص

الخلفية والاهداف : هدفنا هو البحث عن ترابط بين حدوث سكتة دماغية متعلقة بصمي قلبي و غير قلبي مع التباين في تكوين قوس الأبهر البقري.

المنهجية : قمنا بتحديد 1500 صورة دراسية بالرنين المغناطيسي للدماغ و العنق بطريقة استرجاعية، منهم 605 مريضاً وجد لديهم سكتة دماغية حادة مع متوسط العمر 62. قمنا بمراجعة الصور لتحديد التباين في تكوين قوس الأبهر البقري بشكل خاص مع نوع التكوين قوس الأبهر البقري و تميز السكتات الدماغية في الدورة الدموية الامامية و الخلفية.

النتائج: 60% من المرضى وجد لديهم سكتة دماغية في الجانب الايسر. وجد ان حوالي 17% من المرضى لديهم 17% سكتة دماغية افتقار دموي صمي امامي و 7% وجد لديهم سكتة دماغية صمي خلفي. من ضمن السكتة الدماغية غير صمي 56% كانوا في الدورة الدموية الامامية بينما 27% كان لديهم سكتة دماغية غير صمي في الاوعية الدموية الخلفية. 30% من المرضى كان لديهم قوس الأبهر البقري، من مرضى سكتة الدماغ الافتقاري و قوس الأبهر البقري 17% كانوا في الدورة الدموية الامامية و 5% في الدورة الدموية الخلفية.

الاستنتاجات : قوس الأبهر البقري عامل خطورة لحدوث مبكر للسكتات الدماغية في الاوعية الدموية الامامية. الافتقار الدموي ثنائي الطرف و الايسر كانوا اعم.

¹قسم الأشعة، الجامعة الأردنية، عمان، الأردن

²كلية طب الأسنان، الجامعة الأردنية

³قسم الجراحة الخاصة، الجامعة الأردنية

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