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ANATOMY AND PATHOLOGY OF CORONARY ARTERY IN ADULT BLACK KENYANS

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ABSTRACT

Objective: To determine the pattern of coronary arterial anatomy and prevalence of postmortem coronary pathology in adult Kenyan Africans.

Design: Cross-sectional study.

Setting: The Nairobi City Mortuary and the Department of Human Anatomy, University of Nairobi.

Method: One hundred hearts were retrieved during consecutive autopsies over a three month duration and systematically dissected. Details on coronary ramification, dominance, atherosclerosis, tunnelling and hypoplastic segments were obtained and statistically analysed.

Results: Seven patterns of left coronary ramifications were identified. The right coronary artery anomalously exited from the left coronary sinus in one situation. There were separate ostia for the coronary artery branches in 2% and 31 % of cases on the left and right coronary systems respectively. The right coronary artery was dominant in 82% of the hearts. Coronary ostial sizes and luminal dimensions showed wide variations. Only two of the hearts had atheromatous luminal narrowing greater than 75% of the cross-sectional area. Muscle bridges of average depths of 1.1-2mm were demonstrable in 29% of the autopsies. Diminutive left anterior descending artery was present in four cases. The right coronary artery was diminutive in one case.

Conclusion: Coronary atherosclerosis is still a rarity in the setting within which the study was undertaken. The diverse patterns of ramifications of the coronary tree begs for caution during coronary investigations and interventional procedures. Coronary arterial anomalies, myocardial bridges, atheroma and diminutive arteries should be considered in cases of sudden cardiac death in the absence of other pathologies.

INTRODUCTION

Coronary atherosclerosis is the most common cause of death in Western countries. It is responsible for over 14 million cases of myocardial infarction and 700,000 deaths due to ischaemic heart disease every year. Over 200,000 cases of coronary bypass surgery and a similar number of coronary angioplasties are recorded every year in the USA(1). Coronary artery disease is responsible for over 70% of sudden cardiac deaths. In the young, the primary cause of the death is non-atherosclerotic coronary abnormalities(2). In the older patient, the most prevalent cause is atherosclerotic coronary disease. Among athletes, the occurrence of sudden death is calculated at 0.46 deaths per 100,000 athletes per year(3). The incidence of coronary anomalies as detected angiographically is less than 1%(4). Although most of these are incidental with little clinical relevance, a number do present with cardiac symptoms and tragic sudden death. Additionally, the abnormal arterial anatomy can be a source of great angiographic anxiety.

Studies from Africa on the nature and prevalence of occlusive coronary artery disease are limited. It is however generally accepted that it is rare in this part of the world. But, risk factors for coronary atherosclerosis like hypertension, diabetes, cigarette smoking and high cholesterol diets are sharply rising in the developing world(5). The current study attempts to determine the pattern of coronary arterial anatomy and postmortem pathology in a sample of 100 consecutive hearts from patients dying of diverse causes and arriving at the Nairobi City Mortuary during the study period. It is hoped that the study results will provide the impetus for further local work in the area of heart diseases.

MATERIALS AND METHODS

One hundred and one hearts were collected from adult Kenyan Africans during consecutive autopsies. These were obtained within three days of their deaths during which time the bodies were stored in cold rooms. Selection of the first donor was randomised. After a 2-7 days' period of fixation

in formalin, the hearts were studied by systematic dissection. A hundred hearts were studied and one discarded due to evidence of myocardial tear. The visual identification of the coronary sinuses, coronary arteries and their branches and muscle bridges were based on standard anatomical knowledge(6). In cases where the arteries were deep in the sub-epicardial fat or taking an intra-mural course, a series of transverse incisions 0.5 – 1mm apart were made across the long axis of the arteries' courses to enable visual confirmation of the lumen.

Ostial sizes, vessel lengths and diameters, lengths and depths of muscular bridges were all measured to the nearest 0.5 mm and recorded in millimeters. The luminal diameters were directly measured using metal calipers and rulers. The lengths were obtained by measuring the entire course of the arteries from origin to the last point of naked eye identification. The lengths and depths of myocardial bridges (MB), as well as the extent of hypoplastic segments (HS - defined in this study as section of an artery distal to a point whereby the luminal diameter declined suddenly by more than 75%, instead of a gradual reduction in diameter), were measured on the same principle.

The shapes of the orifices of origin of the vessels were described as round, oval, elliptical, crescent-shaped, semi-circular or slit based on the closest visible geometrical orientation. For better visualization of the coronary orifices, the postero-median walls of the ascending aortae and the non-coronary sinuses were divided then reflected aside. The degree of atherosclerosis was taken as a percentage of the cross-sectional area of occlusion of the lumen at the maximum point of occlusion of the respective artery. The branching pattern for the left coronary artery (LCA) was documented based on its major (1st order) epicardial branches - the left anterior descending (LAD) also referred to as the anterior interventricular artery, the circumflex (CX) and the left diagonal artery (LDA) - which were followed to termination and the geographic pattern of branching determined. The 2nd and 3rd order branches were not considered in determining the branching patterns. Based on similarity of ramification, seven major patterns were established and named as I-VII.

The 1st order branches of the right coronary artery (RCA) were determined visually and carefully by following the main RCA trunk through its entire course to the inferior interventricular artery (IIVA). The coronary artery was considered dominant if it gave the IIVA (Posterior interventricular artery). Co-dominance occurred as situations whereby both coronary arteries gave IIVA.

The data were recorded in pre-typed sheets for each individual heart then subsequently transferred to a common spreadsheet. Frequency tables were prepared using the raw data from the spreadsheets and also the values of mean, range, and mode calculated.

RESULTS

A total of 100 hearts were studied and evaluated for the following specific anatomical and pathological characteristics.

Left coronary artery: The origin of the LCA was typical in 98% of the hearts, as a single common stem from an ostium in the left posterior aortic sinus (LPAS). In the remaining 2%, there were separate ostia for CX

branch, both ostia being from the LPAS.

The average size of the orifice was 3.9mm with a range of 1.0-7 mm and a mode of 4.0mm. The shapes of the orifice were round, elliptical or oval in 80% of the hearts and crescent, semi-circular or slit shaped in the remaining 20%.

The proximal luminal diameter of the common stem ranged from 1.5-8.0mm with a mean of 3.3mm and a mode of 3.0mm. The length of the common stem ranged from 0.5-22.0mm with a mean of 8.8mm and a mode of 8.0mm. The dimensions of the major branches (1st order) of the parent LCA are detailed in Table 1.

Thirty one per cent of the hearts had type 1 ramification pattern. Here, a common left stem gave LAD and CX arteries. The CX deviated before reaching the crux without giving the IIVA. Left diagonal artery (LDA) arose as a secondary branch from LAD. In 24 hearts (type II), the common stem trifurcated into LDA, LDA and CX. The CX ran within the coronary sulcus terminating deep into the sulcus without an IIVA. The third prevalent branching type involved 17 hearts. Here the common stem gave LAD and CX. The latter ran all the way to the crux without giving off an IIVA while LDA arose as a branch of CX. In type IV ramification (11 %), the common stem branched into LAD, LDA and CX with the CX reaching the crux without giving off IIVA. In the fifth pattern (5%), the common stem gives LAD, LDA and CX, the CX runs within the coronary sulcus all the way to the crux and gives off IIVA. In the sixth type of ramification, the common stem gives LAD and CX, with the CX deviating before reaching the crux, giving LDA and not IIVA. The last group (type VII) comprised miscellaneous patterns including absence of LDA (2 cases) or origin of a nodal artery from CX (2 cases).

Right coronary artery: The RCA originated from the anterior aortic sinus (AAS) in 99% of the hearts while anomalously originated from the LPAS in 1%. The parent trunk originated from the AAS singly in 79% of the hearts. In 17%, there were two separate ostia one being for the right conal artery (commonly a branch of the RCA). In 3% of the hearts there were three separate ostia: one for the right conal artery, one for the main RCA trunk and a third for the sino-atrial node artery arranged in that order from left to right. The average size of the orifices was 3.0mm with the range being 1.0-6.5mm and a mode of 3.0mm. In 82% of the hearts, the orifices were oval or round, while in the remaining 18% they were crescent-shaped, semi-circular or slit shaped.

The major branches observed were the right conal branch (C), the SAN branch (A), the right marginal artery (M), and the IIVA (P), which were jointly present in 57% of the hearts. C was observed in 65%, M in 100%, P in 92% and A in 88%. Other branches observed but not documented included the atrio-ventricular node (AVN) artery as well as numerous

non-specific infundibular, right and left ventricular as well as other right atrial branches besides A.

The dimensions of main RCA trunk (excluding the terminal IIVA) are detailed in Table 1.

Atherosclerosis: Eighty four hearts had no evidence of atherosclerosis (AS) visible to the naked eye (0% AS). Table 2 shows the distribution of AS in each artery. The arterial trunks were each considered separately giving total frequencies of AS per artery. Over 50% luminal narrowing was observed in 12

vessels with the majority in LAD. Only two vessels had over 75% narrowing.

Myocardial Bridges: A total of 29 hearts (29%) had muscle bridges (MB). Twenty six of these hearts had MB in the Left coronary arterial system: One in the LDA and 25 in the LAD main trunk. No MB was observed in the CX. There were six MB in the right coronary artery. The dimensions of these MB are shown in Figure 2.

Table 1

Coronary arterial dimensions and ostial geometry

Characteristic		CS	LAD	CX	LDA	RCA
Ostial Size(mm)	Range	1-7	-	-	-	1-6.5
	Mean	3.9	-	-	-	3.0
	Mode	4.0	-	-	-	3.0
Ostial shape (%)	Oval. Round	80	-	-	-	82
	Crescent slit	20	-	-	-	18
Length (mm)	Range	0.5-22	65-187	24-154	14-115	65-179
	Mean	8.8	126.1	68.7	56.6	110
	Mode	8.0	-	-	-	108
Luminal Diameter (mm)	Range	1.5-8.0	1.0-4.5	1.0-5.5	0.5-3	1-4.0
	Mean	3.3	2.7	2.1	1.3	2.4
	Mode		3.0	2.0	1.0	2.0

CS = left common stem, LAD = left anterior descending artery, LDA = left diagonal artery, Cx = left circumflex artery, RCA = right coronary artery.

Table 2

Degree of luminal obstruction by atheroma and dimensions of coronary muscle bridges

Feature	CS	LAD	CX	LDA	RCA
Atheroma					
<5%	87	81	83	84	83
6-25%	9	6	10	7	9
26-50%	4	8	4	3	5
51-75%	0	5	3	2	2
>75%	0	0	0	1	1
Muscle Bridges					
Number present	0	25	1	0	6
Length (mm)					
Range	-	3-56	63	-	16-32
Mean	-	21.2	63	-	15.9
Depth (mm)					
Range	-	1-3	2	-	1-25
Mean	-	1.1	2	-	1.1

NB: LDA was absent in three hearts. (CS = left coronary stem, LAD = left anterior descending, LDA = left diagonal artery, Cx = left circumflex, RCA = right coronary artery)

Luminal course: In two hearts (2%), the LAD was intraluminal (within the cavity of the left ventricle) after following an intramural course.

Hypoplastic segments: There were four hearts (4%) with HS in the LAD branch of the LCA, which extended the entire course distal to the respective MB. A single case of a 1.9 mm long HS in the RCA, 78mm from the origin was also demonstrated.

Dissecting aneurysm and thrombosis: No case of dissecting aneurysm or that of thrombosis was identified in the study.

DISCUSSION

The results of this preliminary study demonstrate an anomalous origin of the right coronary artery from the contralateral left coronary ostium. The quoted incidence of coronary artery anomalies in general autopsy series is 2.85 cases per 1,000 autopsies(7) and less than 1 % in patients undergoing angiography (4). Most of these anomalies involve origins from the aorta. Their significance lies in the fact that they are implicated in the aetiology of sudden cardiac death (SCD). The relationship between coronary arterial anomaly and sudden death is however not a simple one. The patient outcomes are highly variable. The first reported case of sudden death due to anomalous origin of the right coronary artery from the left sinus of Valsava was in 1983(8). This abnormal course is presumed to alter the dynamics of the coronary artery leading to myocardial ischaemia especially during physical strain. The vessel is compressed and its ostium occluded between the aorta and pulmonary arteries during systole. A similar mechanism is operational in anomalous left coronary artery origin from the right coronary sinus. Up to 27% of patients with this left coronary anomaly may die suddenly(9-11).

In a blinded analysis of 30 consecutive cases of anomalous right coronary artery from the contralateral sinus to assess features that might aid in risk stratification for sudden death, only age above or equal to 30 years was found to be associated with increased incidence of sudden death(2). Ostial size, degree of vessel displacement nor angle of coronary take off did not seem to add to the risk of death.

The commonest and most lethal congenital coronary anomaly is that in which the left coronary artery originates from the pulmonary trunk(4). Only a minority of patients with this anomaly survive beyond infancy. Our data did not capture this anomaly presumably because these were adult autopsies and not stratified to those who died suddenly.

Whereas the left coronary artery exited from the left sinus in 100% of the cases in this study, there were separate ostia for the circumflex and left anterior descending artery in two cases. On the right, there was a single ostium from the anterior aortic sinus in 79 hearts, two separate ostia (right coronary and right

conal) in 17 cases and, three separate ostia (right conal, right coronary, right sinoatrial) in three hearts. These results are in concordance with previous studies(6). The exact significance of the patterns awaits to be elucidated. Such information is however vital in angiographic studies of the coronary circulation as they may be a source of great anxiety in interpretation. Routine angiography is often inconclusive in these cases necessitating additional and more specialised techniques including magnetic resonance angiography (12).

The mean left coronary ostial diameter was 3.9mm while that for the right was 3.0mm. The respective mean proximal luminal diameters for the left main stem, left anterior descending, left circumflex and right coronary arteries were 3.3mm, 2.7mm, 2.1mm and 2.4mm millimeters. Baroldi and Scmazoni gave mean luminal dimensions of 4.0 and 3.2mm for the left and right coronary vessels at their origins(13). The left coronary artery dimensions usually exceed those of the right in 60% of cases, smaller than the right in 17% and equal to the right system in 23% of the cases(6). The value of the variations in the luminal diameters demonstrated here and in previous studies is contentious(6). The post-mortem state and the effects of preservation must impact on the dimensions. In life, the relationship between vascular calibre and the thickness of the myocardium determines the barrier to nutrient transport. Additionally, the vessels are under the influence of diverse autonomic and other mediators whose distribution may as well be the driving theme of another study.

The right coronary artery was dominant in 82% of cases. This is the commonest pattern in the literature. The right coronary artery usually reaches the crux in 60% of cases, terminate before it in 10% of cases and terminates beyond it replacing the left circumflex artery in 20%(6). The definition of coronary dominance used here is contested by some workers who contend that the left coronary artery serves a larger heart volume and should be the dominant vessel(6). Eighty four per cent of the hearts had no naked eye evidence of atherosclerosis. In no case did the left coronary stem have over 50% luminal obstruction by atheroma. Significant atheromatous coronary narrowing refers to loss of more than 75% of the cross-sectional area of the lumen of at least one epicardial coronary artery(14). In the current study, two coincidental hearts had over 75% luminal cross-sectional blockage involving the left descending and right coronary arteries. These results confirm the rarity of atherosclerotic heart disease in this part of the World. At the Open Heart Unit at the Kenyatta National Hospital, Nairobi, valvular disorders comprise the bulk of indications for surgery(15). The converse is true elsewhere. Ischaemic heart disease is the commonest cause of death in the Western world. With the changing lifestyles in terms of diet and smoking, and the rising prevalence of hypertension, we may soon be confronted by increasing burden of

coronary artery disease. Studies in India and China show an alarming rise in the prevalence of cardiovascular risk factors and with it the rise in the shift of the burden of disease from infections to cardiovascular aetiology(5).

Muscle bridges were demonstrable in 29% of the hearts. The mean lengths of these bridges ranged from 15.9mm to 21.2mm with a depth of 1.1 to 2mm. The depths dimensions are similar to those reported by Morales and his colleagues(16). The quoted incidence of these intramural coronary vessels is 17-78%(16). The exact role of bridging is contentious. Some workers consider them anatomical variants(17). The bridges are found in all age groups. Presumably, they represent a congenital developmental lesion due to incomplete exteriorisation of the primitive intratrabecular arterial network during intrauterine life(18). Is it possible that the bridged segment is constricted during systole and cause ischaemic sudden death. This is true when the variation occurs around a significant portion of a dominant left main coronary artery in which instances it may be the cause of sudden death during the course of strenuous exercise(18). The perfect combination for this outcome seems to be a deep intramural course, vigorous myocardial contraction and a rapid heart rate(16).

Four hypoplastic segments were demonstrated in the left anterior descending artery and one in the right coronary artery. Few reports of the significance of the diminutive coronary artery abound in the literature(19,20). A diminutive vessel in a person who pursues athletic activities cannot adequately supply metabolic demands due to lack of compensatory mechanism(20).

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