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Positional and Morphometric Anatomy of the Thoracic Aorta of Melanoderms living in Togo: CT Angiographic Study of 53 cases

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ABSTRACT

Background/Aim: The nursing of surgical ailments of the thoracic aorta cannot be carried out without the knowledge of its anatomy. The advent of thoracic aortic surgery in Africa requires us to have local anatomical data on this artery. The aim of this work is to enrich the literature by studying the thoracic artery in melanoderms living in Togo.

Methods: We conducted a cross-sectional, retrospective, single-center, descriptive, and analytical study over six months (July to December 2024) at Nadouvi Lawson-Body Hospital in Lomé, Togo. CT angiographic images from 53 patients were selected and analyzed. The parameters studied were: the morphology of the thoracic aorta, the locations of its origin and termination, the location of the most anterior point of the ascending aorta, the highest point of the aortic arch and then the metric data.

Results: The morphology of the thoracic aorta (TA) was type C in 37.7% (n=20), type B in 32.1% (n=17), and type D in 22.6% (n=12). Morphology varied according to age. Its origin projected at Th8 in 37.7% (n=20) and at Th7 in 22.6% (n=12); its termination was located at Th12 in 58.5% (n=31) and at L1 in 18.9% (n=10). The most anterior point of the ascending aorta was located at the level of the 2EICD, 3PSCD, and 2PSCD in 24.5% (n=13), 22.6% (n=12), and 15.1% (n=8), respectively. The distance from this point to the anterior chest wall was 23.0 ± 9.4 mm and decreased with age. The highest point of the aortic arch projected at Th3 in 52.8% (n = 28) and Th2 in 22.6% (n = 12). The medium diameter of the TA at the origin and termination was 31.4 ± 4.7 mm and 21.9 ± 2.8 mm, respectively. An increase in the various diameters was noted with age.

Conclusion: This study outlines the anatomical bases of certain known clinical concepts and positional variations. These concepts are useful for avoiding interpretation errors in thoracic aortic imaging and also in surgical treatment. It would be desirable to compare these results with those of a study of the thoracic aorta on anatomical subjects later on.

KEYWORDS: Thoracic Aorta, Anatomy, Melanoderm CT Angiography, Lomé-Togo

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INTRODUCTION

The thoracic aorta (TA) is the portion of the aorta between the aortic orifice of the left ventricle and the aortic orifice of the thoraco-abdominal diaphragm. It is classically divided into three parts: the ascending aorta, the aortic arch, and the descending thoracic aorta [1]. It provides arterial blood supply to major organs such as the heart and the encephalon [2]. This shows the extent to which these pathologies, namely those defining acute aortic syndrome, can be life-threatening and rightly constitute extreme medical-surgical-radiological emergencies. The etiological diagnosis and optimal nursing of these pathologies require a good knowledge of the anatomy of the thoracic aorta and its dimensions [3]. The advent of complex surgery of the thoracic aorta in our African countries requires the researcher to study the possible anatomical particularities of this vessel in the melanoderm subject. The anatomical study of the thoracic aorta can be carried out either on anatomical subjects, or if not, by means of medical imaging: transthoracic echocardiogram (TTE) or trans-esophageal ultrasound, aortography, CT or thoracic CT angiography, positron emission tomography associated or not with CT, MRI [4]. In order to enrich the data in the literature on the anatomy of this artery, we are carrying out this study on the thoracic aorta of the melanoderm living in Togo.

METHODS

This was a cross-sectional, retrospective, single-center, descriptive, and analytical study carried out from July to December 2024, over six months, at Nadouvi Lawson-Body Hospital (a private hospital specialized in the management of cardiovascular disease) in Lomé, Togo.

Study Materials

These consisted of CT angiographic images of patients aged 18 and older from 2023. Were excluded from the study, non-contributory images (technical error, aorta not visualized in its entirety), images of subjects with a history of thoracic and/or thoracic aortic surgery, and images of pathological thoracic aorta (congenital or acquired). The scanographic examinations were performed using an Institum 64-barrette scanner, installed in 2020.

CT angiographic examination procedure

The CT angiographic were performed under an appropriate field of vision (according to the patient's morphology) with full longitudinal coverage of the thoracic aorta. The tube rotation time was 0.42 seconds with a tube voltage of 100 to 120 kV and a table movement of 3 mm per rotation. An injection of iodinated contrast agent (Iohexo-M® 50 mg) (80 to 120 ml) was administered using a Seacrown dual-syringe automatic injector, through a venous access (with a flow rate of 2-3 ml/second) at the flexor of the elbow or the wrist. The ROI was positioned in the inferior vena cava and the pulmonary artery trunk, with automatic detection of enhancement in the aortic sinus to initiate the acquisition. The period was often 4 seconds if the access was at the flexor of the elbow and 8 to 10 seconds if the access was at the wrist. Images were acquired during blocked deep inspiration on native axial slices with 10 mm thicknesses. Sagittal and coronal reconstructions were then performed with 1.25 mm thicknesses in the mediastinal and parenchymal window.

The parameters studied

They were represented by: the morphology of the thoracic aorta according to the classification(Figure 1) of Yoshiaki and others [5], the location of its origin, its termination, the location of the most anterior point of the ascending aorta and its distance from the anterior chest wall, the projection of the highest point of the aortic arch, the diameters at the origin and termination, the diameters of the ascending and descending aorta at the bifurcation of the pulmonary artery and the diameter at the level of the aortic arch (between brachiocephalic arterial trunk and left common carotid artery). The diameters were measured in a plane perpendicular to the axis of the vessel at the measurement point and in two directions, ventro-dorsal and transverse (Figures 2 and 3) and at each point the largest measured value was retained. The measurements were carried out manually by two specialists, an anatomist and a radiologist.

Statistical Analyses

Data were entered using Epidata 3.1 software. Analyses were performed using Microsoft Excel 2019 and R 4.0.4 software in the RStudio 1.4 environment. Quantitative variables were described as averages +/- standard deviations with minimum and maximum values; Wilcoxon and Kruskal tests were used for comparisons. Qualitative variables were described in terms of numbers and percentages; and were compared using Chi-square or Fisher tests with a significance level of $p < 0.05$.

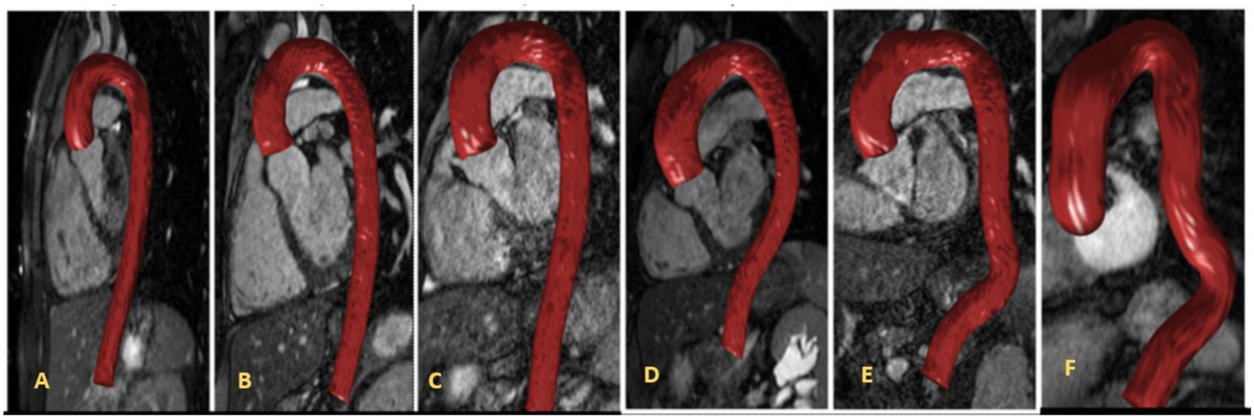

Fig. 1: Variations in the overall morphology of the thoracic aorta

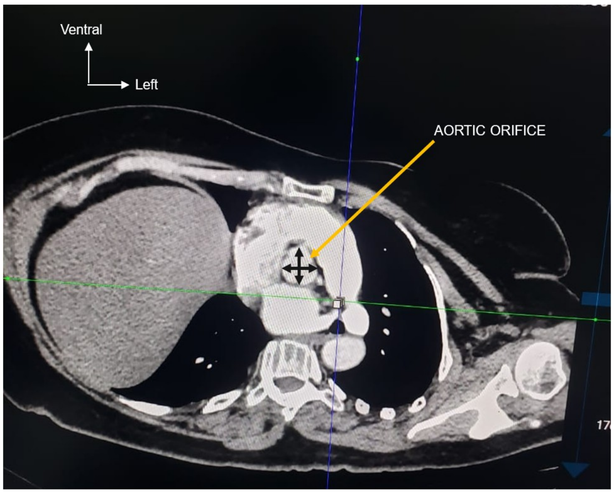

Fig. 2: diameter measurement procedure at the aortic orifice (Black cross arrows).

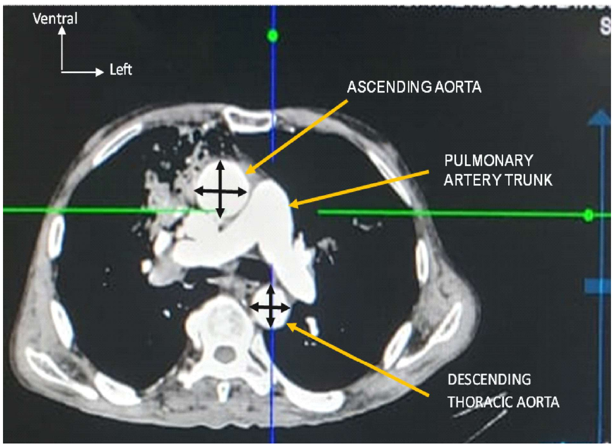

Fig. 3: showing tube diameter measurements of the ascending aorta and descending thoracic aorta at the pulmonary artery bifurcation (Black cross arrows)

RESULTS

In accordance with the exclusion criteria, 53 images were retained (25 men, 28 women); the medium age of patients was 52.6 years ± 17.1, with a range of 24 to 86 years. The age group most represented was 60 and over, in 37.7% or 20 cases.

From a positional perspective, the origin of the thoracic aorta projected at Th8 in 37.7% (n=20) and at Th7 in 22.6% (n=12); origins were noted at Th5 and Th9 in 7.5% (n=4) and 3.8% (n=2), respectively. The termination was located at Th12 in 58.5% (n=31), at L1 in 18.9% (n=10), and at Th11 in 13.2% (n=7). The most anterior point of the ascending aorta was located at the level of 2EICD, 3PSCD and 2PSCD in 24.5% (n=13); 22.6% (n=12) and 15.1% (n=8) respectively. The distance from the most anterior point of the ascending aorta to the internal surface of the anterior chest wall was 23.0 ± 9.4 mm [5.7 and 39.7]. This distance decreased statistically with age with p=0.003 (Table 1); it did not vary statistically with sex (p=0.07). The highest point of the aortic arch projected at Th3 in 52.8% (n=28) and Th2 in 22.6% (n=12). The situation of this point varied neither to age (p=0.4021) nor to sex (p=0.5842)

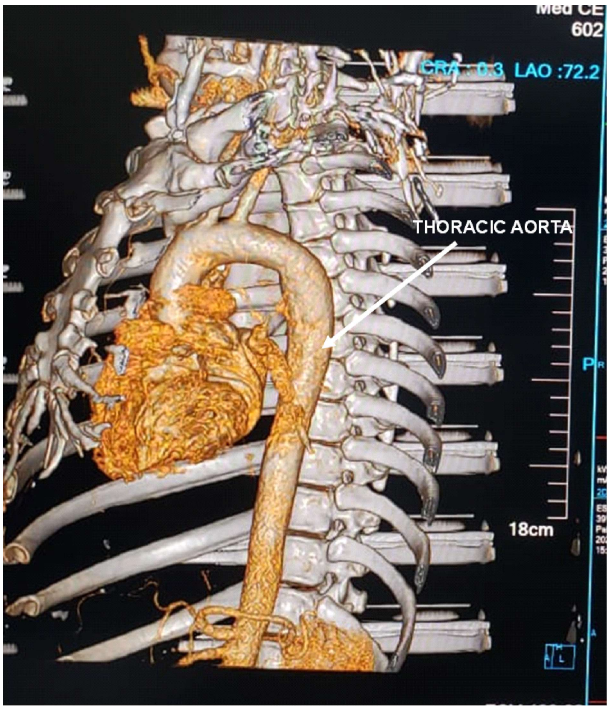

Fig. 4: thoracic aorta type C

Table 1: Distance from MAP to anterior chest wall according to the age

		Distance from MAP to anterior chest wall(mm)	
AGE	[18-40[years (n=14)	Average	29.8
		Sd	6.3
		Min	20.5
		Max	36.6
	[40-60[years (n=19)	Average	21.2
		Sd	9.3
		Min	9.7
		Max	39.3
	60 years and over (n=20)	Average	19.9
		Sd	9.3
		Min	5.7
		Max	39.7
	P-value		*0.003*

Legend: *MAP=Most Anterior Point of ascending aorta; mm= milimeters*

Table 2: Thoracic aorta morphology according to the age

TA Morphology	[18-40] n(%)	[40-60] n(%)	60 and over n(%)	Total n(%)	*P-value*
A	1(7.1)	0(0)	0(0)	1(1.9)	
B	10(71.4)	6(31.6)	1(5)	17(32.1)	
C	3(21.4)	10(52.6)	7(35)	20(37.7)	*7.2.10^{-5}*
D	0(0)	3(15.8)	9(45)	12(22.6)	
E	0(0)	0(0)	3(15)	3(5.7)	
Total	14(100)	19(100)	20(100)	53(100)	

Legend: TA = Thoracic aorta

Table 3: Diameters of thoracic aorta at different points (mm)

	Average	Sd	Min	Max
Origine	31.4	4.7	22.02	47.47
Ascending aorta	33.1	4.6	24.4	47
Aorta arche	29.1	4	20.7	40.3
Descending Aorta	25	3.5	19	35.9
Termination	21.9	2.8	16.7	31

Legend: mm= milimeters

Table 5: Diameters(mm) of thoracic aorta at differents points according to others studies

	Garcier and others [1]	Aronberg and others [19]	Our study
Origine		-	31.4
Ascending aorta	32.8	36	33.1
Aorta arche	29.3	26.3	29.1
Descending aorta	24.3	24.8	25
Termination	-	-	21.9

Legend: *mm= milimeters*

Morphologically, type C thoracic aorta (Figure 4) was the most common in 37.7% (n=20), followed by type B (32.1%; n=17) and type D (22.6%; n=12). The morphology of the thoracic aorta varied according to age; in fact, types D and E were the prerogative of individuals over 40 years of age and types A and B were more common in those under 40 years of age (Table 2). There was no statistically significant morphological difference between the TA of women and men (p=0.9132).

The medium diameter of the TA at the origin and termination was 31.4 ± 4.7 mm [22.02; 47.47] and 21.9 ± 2.8 mm [16.7; 31.0] (Table 3) and we observe on the whole a decrease in the diameter from the origin to the end. Furthermore, we note an increase in the different diameters according to age with statistically significant differences (Table 4); which is not the case when considering the variations according to sex.

Table 4: Diameters(mm) of thoracic aorta at differents points according to the age

	[18-40] years (n=14)				[40-60] years (n=19)				60 years and over (n=20)				*P-value*
	Min	Max	Average	Sd	Min	Max	Average	Sd	Min	Max	Average	Sd	
Origine	22	33.6	28.9	3.4	27.2	43.3	31.8	3.5	25.8	47.5	32.8	5.8	*0.069*
Ascending aorta	24.4	33.3	29.4	2.7	27.6	39.7	33.1	3.4	28.4	47	35.7	5	*0.0003*
Aorta arche	20.7	28.1	25.8	2.6	24.1	37.5	29.6	3.5	26.2	40.3	31	3.9	*3.10^{-5}*
Descending aorta	19	29.8	23	3	20.8	28.5	24.8	2.2	20.7	35.9	26.6	4	*0.007*
Termination	16.7	21.3	19.9	1.4	17.7	23	21.3	1.4	20	31	23.8	3.2	*1.8.10^{-5}*

Legend: mm= milimeters

DISCUSSION

The unavailability of anatomical subjects in our academic contexts forces us to most often conduct our studies using modern imaging techniques. The study of the aorta can be performed using TTE because the results are stackable to those obtained by CT according to James and others in Canada [6, 7]; but their study only concerns the ascending aorta. Indeed, ultrasound can provide a good exploration of the ascending aorta but is not yet the technique of choice for exploring the entire thoracic aorta [4]. MRI provides good resolution, is non-invasive, but its performance is too time-consuming and costly. Among all imaging methods, CT remains the gold standard for exploring the aorta [7-9] by offering good spatial resolution, performance in record time, and appears more accessible in our developing country contexts than MRI. Thanks to CT angiographic scan images, we were able to conduct our study and obtain results on the characteristics of the thoracic aorta in Togolese melanoderm.

The origin of the TA was located at Th8 in 37.7% of cases, these results are stackable with what is usually in anatomy manuals; in fact, according to modal anatomy, the origin of the TA is at Th8; and we know that modal anatomy only concerns about 30% of the population. Furthermore, the termination at Th12 was found in only 52.8%. In the remaining cases, variations were noted for both the origins and the terminations. The existence of these variations confirmed by our investigations constitute fundamental concepts in order to avoid interpretation errors in imaging and iatrogenic complications during thoracic and abdominal surgery. The location of the most anterior point of the ascending aorta around 2EICD in the majority of cases in this study (i.e., 2PSCD, 2EICD, and 3PSCD, or 62.2%) is consistent with the fact that the aortic auscultation focus is at 2EICD. This is indeed the area where the ascending aorta is most superficial and most accessible to auscultation; it is located at this level at 23.0 ± 9.4 mm from the anterior chest wall. This is an important clinical concept: a penetrating wound of the thorax around 2EICD is likely to affect the ascending aorta, which is more superficial there than on the other aortic segments.

The changes in morphology concern the geometry of the arch, and the appearance of tortuosity with age, which we observed, is widely shared by other authors [5, 10 - 12]. These authors agree that the observed changes would be related to several factors including the remodeling of the vascular walls, the modification of circulatory dynamics and the constant effect of cardiac pulsations undergone by the aorta with age.

In comparison to metric values, the largest medium diameter was observed at the level of the ascending aorta measured opposite the bifurcation of the pulmonary artery, i.e. 33.1 mm. Generally, in an adult, the diameter of the thoracic aorta should not exceed 40 mm and decreases towards the termination [4]. However, this value varies according to several factors including age, sex, height, weight, body surface area and blood pressure [13 – 18]. Indeed, the physiological dilation of the aorta is approximately 0.9 mm in men and 0.7 mm in women for each decade of life [18]. This increase in diameter with age was confirmed by our results with $p < 0.05$ except for the values at the origin of the aorta (Table IV). The diameters of the different segments found in our study are stackable with those found in the literature [1,19] (Table 5). We can therefore consider that there are no major differences between the metric values of the thoracic aorta of the melanoderm living in Togo and the data found under foreign skies.

CONCLUSION

Considering the geometry and segmentation of the thoracic aorta first, and its continuous exposure to the physical phenomena of heartbeat and blood circulation on the other hand, it can lead to serious pathologies. The nursing of those pathologies cannot be achieved without mastering its anatomy. Through our results, this study outlines the anatomical bases of certain known clinical concepts, positional variations and metric standards. These concepts are useful for avoiding interpretation errors in thoracic aortic imaging and also in surgery. It would be desirable to compare these results later on with those of a study of the thoracic aorta on anatomical subjects from laboratories in Togo.

ABBREVIATIONS

Th: thoracic vertebra
L1: first lombar vertebra
2EICD: second right intercostal space
3PSCD: third right sternocostal breastplate
2PSCD: second right sternocostal breastplate

Author Contributions

All the authors/co-authors equally contributed for the manuscript right from conception of the study plan to the final drafting for the publication.

Conflicts of Interests: None

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