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The significance of the enlargement of the aortic shadow in adult Nigerians

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Summary

A study of the width of the aortic shadow and of the cardiothoracic ratios in 183 chest radiographs, of persons over the age of 35 years, shows that hypertension produces a constant enlargement of the aortic shadow. The study suggests that gross enlargement, in the absence of disease of the aorta or of the aortic valves, is a result of hypertension. The authors suggest that this enlargement is valuable in delineating a sub-group of cases of myocardial failure in which the primary cause of failure may be hypertension. Cases with gross aortic arch dilatation and no detectable cardiovascular disease often have cardiomegaly. The question of the possibility of remission of untreated hypertension is raised.

Introduction

It has been known for many years that an enlargement of the aortic shadow may be seen in chest radiographs of symptomless negroes. Stuart *et al.* (1962) observed in a study of a Jamaican population that the mean blood pressure was higher in persons with gross dilatation of the aortic arch than in normal controls. The authors suggested that there was a causal relationship between the blood pressure and the diameter of the aortic arch although they believed that widening of the arch may have been aggravated in some of their cases by treponemal infection. Similar changes in the aorta have been observed in the chest radiographs of Nigerians (Ikeme, 1965, unpublished data Igbo-Ora). In 1970, Brockington & Bohrer pointed out that widening of the aortic shadow in chest radiographs may be observed in Nigerian heart muscle disease (idiopathic cardiomegaly—ICM). From this observation, they argued that these cases may, in fact, be cases of 'chronic' hypertensive heart failure. In the study by Stuart *et al.* (1962), the mean increment in the blood pressure over those of normal controls was lowest in cases showing the greatest dilatation of the aorta. We have been led by these observations to seek to establish whether gross dilatation of the aortic arch in the Negro could be an isolated phenomenon unassociated with cardiovascular disease, but one which may be aggravated by hypertension; or whether it is invariably associated with a raised blood pressure. In this study, therefore, we have examined the relationships of the width of the aortic shadow on a chest radiograph, to the age, the mean blood pressure and to the cardiothoracic ratio.

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Materials and methods

Selection of cases

Consecutive chest radiographs of subjects over the age of 35 years taken at the Enugu Specialist Hospital in October and November 1971 were admitted to the study. Cases with obvious valvular disease (aortic or mitral) or severe pulmonary pathology likely to produce mediastinal shift were excluded from the study after a physical examination. Following a chest radiograph, each subject had his blood pressure measured with a standard mercury sphygmomanometer, after 3 min recumbency. The sphygmomanometer readings were taken to the nearest 2 mm. The lower of two measurements of the blood pressure separated by an interval of 1 min, was taken as the casual blood pressure. The diastolic pressure was recorded at phase four. In each subject a cardiovascular examination was performed and the

age, sex, blood pressure, and any cardiovascular abnormalities were recorded. In each case the mean blood pressure was calculated (i.e. diastolic pressure plus one-third the pulse pressure).

Radiographs and measurements

Postero-anterior teleradiographs were done and in any case where the cardiovascular outline was ill-defined in this first radiograph, an additional penetrated view using a grid was done. This usually made it possible, aided by bright illumination occasionally, to define the margins of the aorta. We excluded cases with pulmonary disease causing mediastinal shift, cases with marked scoliosis and excessively rotated cases. For this, we took the criterion of Brockington & Bohrer (1970), of a difference of greater than 1·5 cm between the medial end of the clavicle on each side and the centre of the spinous process.

The width of the aorta was taken as the sum of the maximum extensions of the aortic shadow to the right (A) and to the left (B) of the midline (Rose & Blackburn, 1968). The maximum extension to the left was in most cases at the lateral border of the aortic knuckle, but where this was not the case the most lateral margin above the level of the ascending aorta was taken. Values for A and B were recorded separately as well as the value of their summation. The midline itself was taken at the centre of the spinous process at the level being measured in well centred films; or the mid-point between the costo-transverse joints at the same level in films with some rotation.

We thought the effort of this composite measurement worthwhile because we considered that should the ascending part of the aorta be significantly involved in an enlargement this would not be reflected in any measurement limited to the left side, especially if there was a slight rotation to the right as well.

Cases selected

Altogether 205 chest radiographs were selected after the preliminary physical examination. Of these, twenty-two were rejected after a review of the chest radiographs and 183 were admitted into the study. These 183 cases were made up as follows: normotensive: 137; (males ninety-one, females forty-six); hypertensive: forty-six; (males thirty, females sixteen). Of these 183 cases, a clinical diagnosis of idiopathic cardiomegaly was made in ten (eight males and two females) (Idiopathic cardiomegaly, 1968). All ten had a normal blood pressure. Four males in the series had hypertensive heart failure.

Results

Table 1 shows the mean diameter of the aortic arch related to age and sex in normotensive subjects. In each age group the mean aortic arch diameter is greater in males than in females. In either sex, the aortic arch diameter rises with age.

The mean aortic arch diameter in hypertensive subjects (diastolic pressure greater than 95 mm/Hg and/or systolic pressure greater than 160 mm/Hg) is also shown in Table 1. No consistent difference is observed between the sexes, but the table shows that as in normotensive subjects, the aortic arch width also increases with age. The mean aortic arch

TABLE 1. Aortic arch width related to age and sex

Age	Sex	Normotensive subjects			Hypertensive subjects		
		No. of observations	Mean aortic arch. diam.	s.d.	No. of observations	Mean aortic arch. diam.	s.d.
35–44	M	40	63·04	±8·4	12	65·17	±6·36
	F	19	58·84	±6·01	3	70·67	±10·9
45–54	M	22	66·59	±5·01	13	73·31	±9·46
	F	18	59·94	±5·96	9	72·67	±16·00
55–64	M	17	66·12	±9·27	3	74·00	±9·5
	F	8	66·75	±4·47	4	63·00	±22·8
65+	M	12	69·33	±8·06	2	82·00	—
	F	1	62·0	—	Nil	—	—

TABLE 2. Mean blood pressure related to age in normotensive subjects

Age	Sex	No. of observations	Mean BP mmHg	s.d.
35–44	M	40	91·00	±12·61
	F	19	85·21	±11·38
45–54	M	22	89·22	±9·90
	F	18	87·33	±11·02
55–64	M	17	85·47	±15·33
	F	8	89·75	±15·03
65+	M	12	91·17	±13·0
	F	1	93·0	—

diameter in each age group is greater for hypertensive subjects than for subjects without hypertension.

Table 2 presents the mean blood pressure for the various age groups in normotensive subjects. Neither in males nor in females, is there a constant variation of the mean pressure with age. Increases in the mean blood pressure with age cannot therefore account for the increase in the aortic arch diameter with age observed in normotensive subjects. Table 3 shows aortic arch diameters related to the mean blood pressure in all subjects. In normotensive subjects, there is no constant relationship, while in hypertensive subjects, the aortic arch diameter clearly increases with increasing mean pressure.

In Table 4 the aortic arch diameter is related to the mean blood pressure in three age groups of normotensive subjects; 35–44 years, 45–54 and 55–64 years. Again in each age group, the aortic arch diameter does not appear to be related to the mean blood pressure.

The distribution of the aortic arch diameter in 134 subjects without cardiovascular disease is shown in Fig. 1. The mean aortic arch diameter for males of all ages is 64·25 mm (s.d. ±8·0) and for females 59·5 mm (s.d. ±7·25). Table 5 presents the clinical features of ten males and eight females with aortic arch diameters greater than twice the standard deviation of the mean diameter for each sex. We have chosen this value as representing gross dilatation of the aortic shadow. Only in one male was the unusual enlargement of the aortic shadow not accompanied by cardiomegaly or recognizable cardiovascular disease. (We have defined cardiomegaly in this series as a cardiothoracic ratio of 53% or greater.) Among the women, seven were hypertensive, and one had idiopathic cardiomegaly—the blood pressure in this subject was normal. The cardiothoracic ratio was above normal in all but one hypertensive subject.

TABLE 3. Aortic width related to mean pressure

	Normotensive subjects			Hypertensive subjects		
Mean blood pressure mmHg.	<74	75–95	>95	<129	130–149	>150
No. of subjects	18	65	41	27	15	5
Mean aortic width	64·8	61·2	65·1	68·4	72·9	78·4

TABLE 4. Aortic arch diameter related to BP in three age groups

Mean blood pressure	35–44 years			45–54 years		55–64 years	
	Sex	No. of Obs	Mean diam.	No. of Obs.	Mean diam.	No. of Obs.	Mean diam.
55–74	M	5	64·0	1	66·0	5	68·66
	F	3	60·0	3	64·0	1	64
75–94	M	19	58·89	13	68·69	6	67·17
	F	14	57·21	9	56·78	4	62·0
95–115	M	16	67·75	8	63·25	6	63·0
	F	2	58·50	6	62·27	3	70·06

TABLE 5. Clinical picture of subjects with gross dilatation of the aorta

Clinical Picture	Serial No.	Age	Sex	CTR %	Aortic width (mm)
Hypertension	5	42	F	60	74
Normal	8	49	M	53	80
Hypertension	49	50	F	68	75
ICM	54	60	F	56	78
Hypertension	65	45	M	53	84
Hypertension	68	50	M	54	80
ICM	82	66	M	66	86
Hypertension	87	45	F	69	107
Hypertension	90	38	F	63	79
Hypertension	103	52	F	53	80
ICM	123	60	M	62	89
ICM	130	65	M	69	81
Hypertension	151	40	F	48	76
Hypertension	168	75	M	59	85
Hypertension	171	45	F	54	77
Hypertension	194	58	M	47	87
Hypertensive heart failure	207	45	M	70	87
Normal	210	40	M	50	84

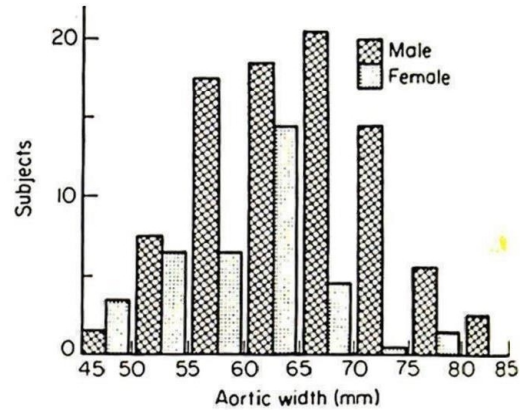

FIG. 1. Distribution of aortic arch width: see text.

Comment

The results clearly indicate that in each age group the aortic arch diameter is greater in males than in females and that it increases with age. This last observation is also true in hypertensive subjects. In persons with a normal blood pressure, the aortic arch diameter is not dependent on the mean blood pressure; we would conclude that age is the important factor in determining the diameter of the aorta in such persons. However, in the presence of an elevated blood pressure, the aortic arch diameter is now related also to the mean blood pressure.

This relationship is emphasized by our observation that the aortic arch diameter for all age groups of normotensive subjects is not significantly different from the mean diameter for all normotensive males; while the mean diameter for the group of hypertensive subjects with the lowest mean pressure, is clearly higher than that of any group of normotensive subjects. (See Table 3.) This suggests that hypertension produces a constant widening of the aortic shadow on chest radiographs and that the degree of this enlargement is related to the severity of the hypertension and to the age of the patient; i.e. possibly the duration of hypertension. It is, however, uncertain, if gross widening of the aortic shadow can occur only as a result of hypertension in the absence of specific disease of the aorta or of the aortic valves.

In this study, forty-six cases had a cardiothoracic ratio equal to or greater than 53%. Cardiomegaly was associated with hypertension in twenty-one cases, with ICM in ten, anaemia in one, thyrotoxicosis in one and a chronic cough in two cases.

In eleven subjects (aged 35–71 years) no detectable cardiovascular abnormality was present. There were nine males and two females. The mean aortic arch diameter for this group was 71·0 and the mean cardiothoracic ratio was 55·5 (72·1 and 55·3 respectively for males; 66·0 and 56·5 respectively for females). Among the hypertensive group, the mean aortic arch width was 75·0 for both sexes and the mean CTR was 59·1 (males: 75·2 and 59·1; females: 74·3 and 58·5 respectively). In the group with idiopathic cardiomegaly, the mean aortic arch diameter was 76·1 and the CTR 62·9 (males 77·8 and 62·9; females 72·3 and 63·7 respectively). It would appear that whatever may have caused cardiomegaly in both the group with hypertension and the group with ICM, has also given rise to dilatation of the aorta.

Similarly, of ten males with gross dilatation of the aorta, all but two had a cardiothoracic ratio 53% or greater. Hypertension was present in five; in three a diagnosis of ICM was made and at that time their blood pressures were normal (134/90, 90/60 and 99/70). Only two persons aged 40 and 49 had no other detectable cardiovascular abnormality; one of these two had a cardiothoracic ratio of 50% (See Table 5). Among the eight females, there was cardiomegaly in seven. There were seven hypertensives and one case of idiopathic cardiomegaly. It would appear that

gross dilatation of the aortic arch is almost invariably associated with cardiomegaly (15/18 or 84%). Conversely, when cardiomegaly occurred in the absence of detectable cardiovascular disease (eleven cases referred to above), some dilatation of the aorta was usually present and the dilatation was proportional to the increase in the CTR. In our cases with gross dilatation of the aorta, cardiomegaly was due to either hypertension (10/14 or 72%) or to ICM (4/14 or 28%). We believe that gross dilatation of the aorta in the absence of disease of the aorta itself or of the aortic valves must be associated with hypertension.

This observation raises the question of the pathogenesis of some cases of ICM seen in Nigeria. It appears that hypertension must play an important part in the pathogenesis of some of the cases of biventricular failure which may be labelled idiopathic cardiomegaly. Of ten cases diagnosed as ICM in our series, four had gross dilatation of the aorta and the mean aortic arch diameter for this group was 76·1. It seems probable, therefore, that sometime in the past all, or at least four of these subjects had been hypertensive. That a raised blood pressure is common in the natural history of the congestive cardiomyopathies is now generally accepted (Hutt *et al.*, 1965; Goodwin, 1970; Goodwin & Oakely, 1972). What is not clear, however, is the role hypertension may play in the aetiology of the disorder (Foster, 1965). It would appear that enlargement of the aortic shadow in chest radiographs could be a useful sign for distinguishing many of those cases of ICM in which hypertension may have been important in the genesis of myocardial failure, from those in which myocardial failure has occurred from other causes.

Enlargement of the aortic shadow would only be an important distinctive feature if a means of quantitating it can be devised. The question of the possible relationship of hypertension to ICM is so important that we would consider essential, further studies of the size of the aortic arch in standard chest radiographs of normal and hypertensive persons. We have shown here that most persons with an aortic arch diameter greater than twice the standard deviation of the mean had cardiovascular disease. We suggest that a more accurate gauge of aortic arch dilatation would be the means in each age group of the aorto-thoracic ratio in normal chest radiographs. From the values of this ratio in normal and hypertensive subjects, a given deviation from the mean could then be taken as abnormal in any particular age group.

We have referred to two males in our series aged 40 and 49 with gross dilatation of the aorta, normal blood pressures and normal cardiothoracic ratios; and to eleven cases with cardiomegaly, some enlargement of the aorta and no cardiovascular disease. Most clinicians have seen cases of aortic arch dilatation in the absence of cardiovascular disease. These subjects pose an important question. What is the natural history of a raised blood pressure in the Nigerian? It is interesting to note that apparent remission of hypertension has also been reported among Nigerian hypertensive subjects during the course of treatment (Carlisle, 1971). Can one assume, therefore, that at some stage in its natural history, the blood pressure may return to normal without treatment leaving behind stigmata of its previous levels, such as a dilated aorta or myocardial failure? Long term prospective studies of the behaviour of the blood pressure in Nigerian communities are needed as well as detailed pathological studies of the aorta in hypertensive and normotensive persons. Further elucidation of the characteristics of persons with gross dilatation of the aorta is obviously indicated.

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