

## Pattern of atherosclerosis in a Ghanaian adult population: an autopsy study

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### Summary

A qualitative assessment of the degree of atherosclerotic involvement of six major arteries in 310 autopsies of Ghanaian adults revealed that atherosclerosis is less severe in Ghanaians compared to Caucasians. Atherosclerosis increases with age, more so in hypertensives, but severe lesions are not common in cerebral vessels in spite of the high mortality from haemorrhagic stroke in the adult Ghanaian. Severe atherosclerosis is, therefore, not important in the causation of cerebral haemorrhage. The small number of cerebral infarcts (six) is in keeping with the absence of severe atherosclerotic lesions in both extra cranial and intracranial large arteries. Absence of severe coronary lesions also parallels the low incidence of myocardial infarction and ischaemic heart disease in Ghanaians. Diabetes mellitus in combination with hypertension results in more severe atherosclerosis of the aorta and coronary arteries but the effect of diabetes mellitus alone requires further study.

### Résumé

Une évaluation qualitative du degré d'implication athérosclérotique reliée du fonctionnement de six principales artères, sur un échantillon de 310 autopsies d'adultes Ghanéens, a révélé que: L'athérosclérose est moins sévère chez les gens de race Ghanéenne que chez les gens de race blanche. L'athérosclérose progresse avec l'âge, surtout chez les hypertendus et bien que le taux de mortalité dû à l'hémorragie cérébrale chez

l'adulte Ghanéen soit élevé, le taux de lésions sévères dans les vaisseaux cérébraux est comparativement bas. Par conséquent, l'athérosclérose sévère n'est donc pas un facteur important dans la cause de l'hémorragie cérébrale. Le petit nombre d'incidence d'infarctus cérébrale (six au total), corrobore ce fait ainsi que l'absence de lésions d'athérosclérose sévère à la fois dans les grandes artères extracranien- nées et intracranien- nées. De plus, l'absence de lésions coronaires sévères est en concordance avec le taux bas d'incidence de formation d'infarctus myocardique et de maladie du cœur de type ischémique chez les Ghanéens. Le diabète mellitus combiné à l'hypertension, produit un athérosclérose plus sévère de l'aorte et des artères coronaires. Cependant il est à noter l'effet du diabète mellitus, requière à lui seul, une étude plus approfondie encore à venir.

### Introduction

The pattern of atherosclerosis among different populations in the world has been studied (Gore *et al.*, 1960; Florentin *et al.*, 1963; Tejada *et al.*, 1968; Resch *et al.*, 1970) and the International Atherosclerosis Project has collated information on the geographical variations in its presentation. African populations studied include the South African Bantu, Nigerians (Williams, Resch & Loewenson, 1969; Resch *et al.*, 1970; Williams, Loewenson & Lippert, 1975) and Ugandans (Davies, 1948; Ikeme, Bennet & Somers, 1973). No such study has been carried out among Ghanaians although clinical observations on cardiovascular complications of hypertension have been made (Haddock 1970; Pobee *et al.*, 1977).

There are ethnic similarities between Nigerians and Ghanaians to support the assumption

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that similar patterns of atherosclerosis would be found in the two countries. However, in view of the increasing importance of the disease in developing countries, this assumption should be tested by an objective study in Ghanaians also. This study aims at providing basic information on atherosclerosis in the Ghanaian adult and how it relates to (a) hypertension, (b) the high mortality rate from cerebrovascular accident and (c) diabetes mellitus.

### Subjects and methods

The study was carried out in the Pathology Department of the Korle Bu Teaching Hospital, Ghana. Consecutive autopsies of 310 Ghanaian adults ( $\geq 20$  years old) of both sexes were performed. These were cases that were also studied by post-mortem arteriography, the results of which have been reported elsewhere (Anim & Kofi, 1984). Major arteries examined for atherosclerosis were the aorta, cerebral, carotid (bifurcations), vertebral (origins), renal and coronary.

Each vessel or group of vessels was opened with a pair of coronary artery scissors and qualitatively assessed. The atherosclerotic lesions were graded using the following format, the final grade being based on the most advanced lesion: grade 0 — normal intima, fatty streaks; grade 1 — fibrous plaques (discrete and isolated); grade 2 — confluent plaques; grade 3 — complicated lesions (ulcerated, necrotic, haemorrhagic or calcified lesions).

Normal arteries and fatty streaks were grouped together under grade 0 because not all fatty streaks progress to true atherosclerosis, and the lesions are common in large arteries in young Ghanaians (W. N. Laing and E. C. Christian, personal communication). Ulcerated, necrotic, or haemorrhagic lesions were grouped together with calcified lesions in grade 3 because there is no basis for considering one lesion more significant than the other, as shown by Gore and Tejada (1957) in their quantitative method of assessing the degree of atherosclerosis. Our scheme of grading, although perhaps less detailed, offers a quick and reproducible assessment of the severity of atherosclerosis.

Intracranial vessels were graded by taking the highest grade after examining the basilar and

the communicating arteries and all the branches of the internal carotids. A similar procedure was used for the aorta, carotid bifurcations, renal arteries and origins of the vertebral arteries as well as the coronary arteries.

### Results

There were 181 hypertensives and 129 normotensives. The hypertensives were either known (i.e., clinically diagnosed using parameters outlined by Pobee *et al.*, 1977) or those diagnosed at autopsy using heart weight (300 g for females and 350 g for males) in conjunction with granular kidneys as evidence of pre-existing hypertension. The distribution of atherosclerosis for the different vessels in various age groups is shown in Tables 1–6 and Fig. 1. Table 7 and Fig. 2 show a comparison of atherosclerosis in the various arteries between hypertensives and normotensives.

There were sixty-eight cases of cerebral haemorrhage (all hypertensives) and six cases of cerebral infarction. Table 8 and Fig. 2b show the grades of atherosclerosis in the various vessels in hypertensives with cerebral haemorrhage compared to all hypertensives. There is no significant difference between the severity of atherosclerosis in the two groups except for slightly higher grades in the aorta and cerebral vessels (grade 2). Two of the six cases with cerebral infarction had grade 3, the remaining showed lower grades.

Of the 310 cases studied, twenty-eight were known diabetics comprising sixteen males, twelve females, ranging in age between 32 years and 77 years old. There is a significant increase in grades 2 and 3 lesions in the aorta of diabetics when compared to all hypertensives. Similarly, there is a slight increase in grade 2 atherosclerosis of the coronary arteries in the diabetics (Table 9).

### Discussion

The inherent bias in autopsy samples is well recognized, and findings from such studies cannot be indiscriminately applied to the general population. However, meaningful conclusions have been drawn from such results by other workers. Mainland, 1953; McMahon, 1960, Strong & Restrepo, 1978). Our qualita-

**Table 1.** Atherosclerosis of the aorta in normotensives and hypertensives of various age groups in 310 Ghanaian adults

Age groups (years)	Normotensives					Hypertensives				
	Total	Grade				Total	Grade			
		0	1	2	3		0	1	2	3
20-29	23	19	4	0	0	13	6	5	2	0
30-39	28	9	18	1	0	25	5	11	9	0
40-49	26	6	16	4	0	37	3	15	16	3
50-59	24	2	7	12	3	53	1	9	32	11
60-69	13	0	3	7	3	17	1	5	16	10
70-79	11	3	2	1	5	32	0	2	10	5
80-89	3	0	1	0	2	3	0	0	2	1
90-99	1	0	0	1	0	1	0	0	1	0
Total	129	39	51	26	13	181	16	47	88	30

**Table 2.** Atherosclerosis of the cerebral vessels in normotensives and hypertensives of various age groups in 310 Ghanaian adults

Age groups (years)	Normotensives					Hypertensives				
	Total	Grade				Total	Grade			
		0	1	2	3		0	1	2	3
20-29	23	20	3	0	0	13	12	0	1	0
30-39	28	27	1	0	0	25	18	3	4	0
40-49	26	18	4	3	1	37	18	9	8	2
50-59	24	14	5	4	1	53	8	14	26	5
60-69	13	4	6	3	0	32	3	10	12	7
70-79	11	5	4	2	0	17	0	3	8	6
80-89	3	0	1	1	1	3	0	2	1	0
90-99	1	0	0	1	0	1	0	1	0	0
Total	129	88	24	14	3	181	59	42	60	20

tive method of study of atherosclerotic lesions should not be directly compared to the quantitative studies of workers in other populations (Gore & Tejada, 1957; Gore *et al.*, 1960; Florentin *et al.*, 1963; McGill *et al.*, 1963; Tejada *et al.*, 1968; Resch *et al.*, 1970; Strong, Restrepo & Guzman, 1978). Nevertheless, useful inferences can be drawn from such comparisons.

#### *Effect of age and hypertension*

Atherosclerosis of all the vessels studied increases with age (Tables 1-6, Fig. 1). There is

progressive increase in the severity of atherosclerosis with age in the normotensives, but this increase is greater in the hypertensives, thus confirming the conclusions of other workers (Ackerman, Dry & Edwards, 1950; Baker & Resch, 1964; Baker, Resch & Lowenson, 1969; Chobanian, 1983) that hypertension increases atherogenesis and contributes to the progression of the disease. A comparison of atherosclerosis in each vessel between hypertensives and normotensives is shown in Table 7 and Fig. 2. This shows a variation among the different arteries.



**Table 3.** Atherosclerosis of the renal arteries in normotensives and hypertensives of various age groups in 310 Ghanaian adults

Age groups (years)	Normotensives					Hypertensives				
	Total	Grade				Total	Grade			
		0	1	2	3		0	1	2	3
20-29	23	23	0	0	0	13	11	1	1	0
30-39	28	25	3	0	0	25	19	4	2	0
40-49	26	22	3	1	0	37	25	6	5	1
50-59	24	17	4	2	1	53	29	14	10	0
60-69	13	9	0	4	0	32	17	9	5	1
70-79	11	6	4	0	1	17	9	5	3	0
80-89	3	1	0	2	0	3	2	0	1	0
90-99	1	0	0	1	0	1	1	0	0	0
Total	129	103	14	10	2	181	113	39	27	2

**Table 4.** Atherosclerosis of the vertebral arteries in normotensives and hypertensives of various age groups in 310 Ghanaian adults

Age groups (years)	Normotensives					Hypertensives				
	Total	Grade				Total	Grade			
		0	1	2	3		0	1	2	3
20-29	23	23	0	0	0	13	12	0	1	0
30-39	28	28	0	0	0	25	21	3	1	0
40-49	26	25	1	0	0	37	30	3	4	0
50-59	24	24	0	0	0	53	29	15	9	0
60-69	13	10	2	1	0	32	22	4	5	1
70-79	11	8	3	0	0	17	8	5	4	0
80-89	3	2	0	1	0	3	1	1	0	1
90-99	1	0	1	0	0	1	1	0	0	0
Total	129	120	7	2	0	181	124	31	24	2

### Geographical variation

The degree of atherosclerosis generally shows geographical variation because of important environmental factors such as dietary habits, which are important in atherogenesis. In this study, there are fewer cases of advanced atherosclerosis (grade 3) in all vessels. Some vessels do not show grade 3 lesions in either normotensives or hypertensives. These findings generally confirm findings of other studies done on Africans, that atherosclerosis is less severe

in the African compared to the Caucasian (Edington, 1954; Walker, 1966; Williams *et al.*, 1969; Resch *et al.*, 1970; Ikeme *et al.*, 1973).

The reasons for these apparent differences between Africans and Caucasians is not clear but the more aggressive nature of hypertension in blacks is documented (Williams *et al.*, 1975; Anim & Kofi, 1984). This contributes to the short natural history of hypertension and curtails the development of severe atherosclerotic lesions before the subjects die of other com-



**Table 5.** Atherosclerosis of the carotid arteries in normotensives and hypertensives of various age groups in 310 Ghanaian adults

Age groups (years)	Normotensives					Hypertensives				
	Total	Grade				Total	Grade			
		0	1	2	3		0	1	2	3
20-29	23	23	0	0	0	13	12	0	1	0
30-39	28	24	4	0	0	25	16	6	3	0
40-49	26	19	3	4	0	37	13	16	8	0
50-59	24	9	9	6	0	53	15	28	10	0
60-69	13	3	8	2	0	32	6	19	7	0
70-79	11	6	2	2	1	17	4	7	6	0
80-89	3	0	2	1	0	3	0	3	0	0
90-99	1	0	1	0	0	1	1	0	0	0
Total	129	84	29	15	1	181	67	79	35	0

**Table 6.** Atherosclerosis of the coronary vessels in normotensives and hypertensives of various age groups in 310 Ghanaian adults

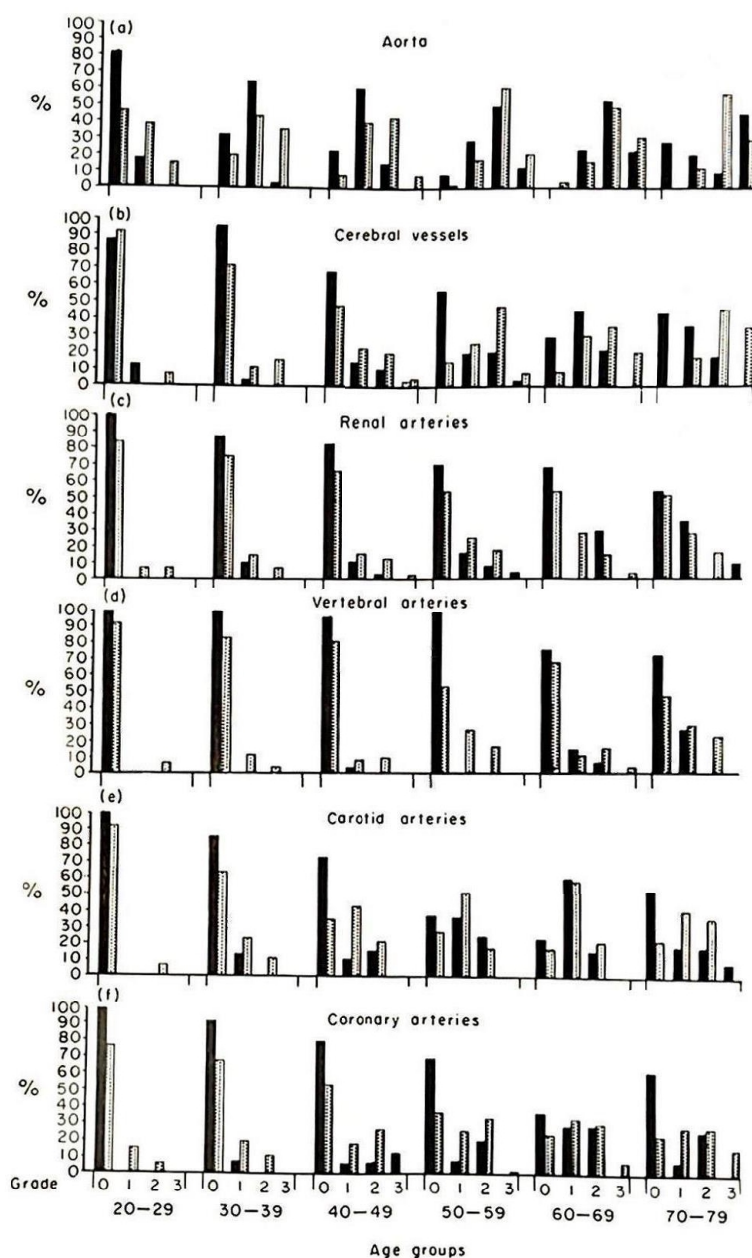
Age groups (years)	Normotensives					Hypertensives				
	Total	Grade				Total	Grade			
		0	1	2	3		0	1	2	3
20-29	23	23	0	0	0	13	10	2	1	0
30-39	28	26	2	0	0	25	17	5	3	0
40-49	26	21	2	2	1	37	20	7	10	0
50-59	24	17	2	5	0	53	20	14	18	1
60-69	13	5	4	4	0	32	8	11	10	3
70-79	11	7	1	3	0	17	4	5	5	3
80-89	3	0	1	2	0	3	1	1	1	0
90-99	1	0	0	1	0	1	0	1	0	0
Total	129	99	12	17	1	181	80	46	48	7

plications of hypertension, such as cerebrovascular haemorrhage, which occurs in younger age groups in Ghana (Anim, 1984; Anim & Kofi, 1984) and hypertensive cardiac failure, which is a common cause of death in African hypertensives.

#### *Aortic and coronary lesions*

Relatively advanced atherosclerotic lesions are seen in the aorta compared with other vessels,

even in the normotensives in this study. This is more obvious when coronary and aortic lesions are compared. A greater disparity between coronary and aortic lesions have also been demonstrated in Jamaica and Japan than in the United States (Gore *et al.*, 1960). The relative absence of grade 3 lesions in the coronary arteries in this study (Fig. 2) supports the current relative rarity of myocardial infarctions in Ghanaians (Anim, 1984), and in other Africans (Florentin *et al.*, 1963). Gore *et al.*



**Fig. 1.** Atherosclerosis of six major arteries in 181 hypertensives (▨) and 129 normotensives (■) of various age groups. (a) Aorta, (b) cerebral vessels, (c) renal arteries, (d) vertebral arteries, (e) carotid arteries, (f) coronary arteries.



Table 7. Comparison of atherosclerosis in six major arteries between 181 hypertensives and 129 normotensives

		Normotensive				Hypertensives			
		Grade				Grade			
		0	1	2	3	0	1	2	3
Aorta	No.	16	47	88	30	39	51	26	13
	%	8.8	26.0	48.6	16.6	30.2	39.5	20.2	10.1
Cerebral vessels	No.	59	42	60	20	88	24	14	3
	%	32.6	23.2	33.1	11.0	68.2	18.6	10.9	2.3
Carotid	No.	67	79	35	0	84	29	15	1
	%	37.0	43.6	19.3	0	65.1	22.5	11.6	0.8
Coronary	No.	80	46	48	7	99	12	17	1
	%	44.2	25.4	26.5	3.9	76.7	9.3	13.2	0.8
Renal	No.	113	39	27	2	103	14	10	2
	%	62.4	21.6	14.9	1.1	79.8	10.9	7.8	1.6
Vertebral	No.	124	31	24	2	118	9	2	0
	%	68.4	17.1	13.3	1.1	93.0	5.5	1.5	0

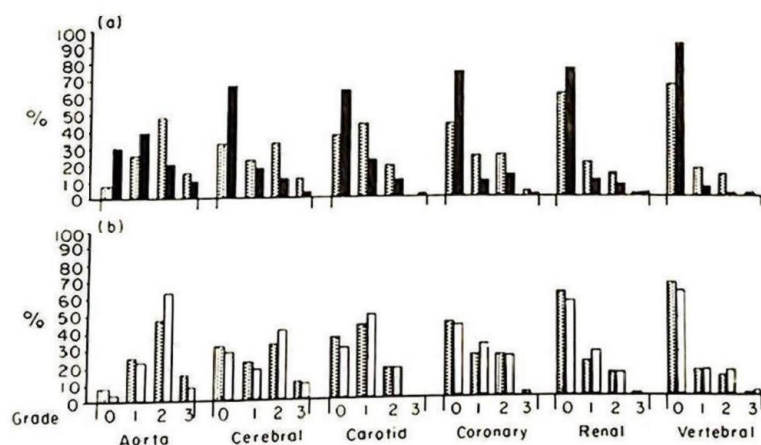


Fig. 2. Comparison of atherosclerosis of six major arteries in 181 hypertensives (▨) and (a) 129 normotensives (■), (b) 68 cerebral haemorrhage cases (□).

(1960) have considered that it is unlikely that racial factors are implicated in this difference. They also concluded that the augmenting effect of elevated blood pressure upon atherogenesis is greater in the aorta than in the coronary arteries. The reasons for this may well be mainly haemodynamic.

#### *Vertebral, carotid and intracranial arteries*

Solberg *et al.* (1968) in their multi-racial study

have found that all grades of atherosclerotic lesions develop more slowly with age in the vertebral and intracranial arteries than in other arteries. They found more severe lesions in the aorta and carotid artery. We have found much less atherosclerosis of the carotid arteries but significant lesions in the aorta. Like Solberg and associates, we found the vertebral arteries are among the least involved but, unlike them, we found the cerebral arteries more involved

**Table 8.** Comparison of atherosclerosis in six major arteries between 181 hypertensives and 68 cases with cerebral haemorrhage

		Normotensive				Hypertensives			
		Grade				Grade			
		0	1	2	3	0	1	2	3
Aorta	No.	16	47	88	30	3	16	43	6
	%	8.8	26.0	48.6	16.6	4.4	23.4	63.2	8.8
Cerebral vessels	No.	59	42	60	20	20	13	28	7
	%	32.6	23.2	33.1	11.0	29.4	19.1	41.2	10.3
Carotid	No.	67	79	35	0	21	34	13	0
	%	37.0	43.6	19.3	0	30.9	50.0	19.1	0
Coronary	No.	80	46	48	7	29	22	17	0
	%	44.2	25.4	26.5	3.9	42.4	32.3	25.0	0
Renal	No.	113	39	27	2	39	19	10	0
	%	62.4	21.6	14.9	1.1	57.4	27.9	14.7	0
Vertebral	No.	124	31	24	2	43	12	11	2
	%	68.4	17.1	13.3	1.1	63.2	17.6	16.2	3.0

**Table 9.** Comparison of atherosclerosis in six major arteries between 181 hypertensives and 28 diabetics

		Normotensive				Hypertensives			
		Grade				Grade			
		0	1	2	3	0	1	2	3
Aorta	No.	16	47	88	30	1	6	15	6
	%	8.8	26.0	48.6	16.6	3.6	21.4	53.6	21.4
Cerebral vessels	No.	59	42	60	20	6	7	12	3
	%	32.6	23.2	33.1	11.0	21.4	25.0	42.9	10.7
Carotid	No.	67	79	35	0	9	12	7	0
	%	37.0	43.6	19.3	0	32.1	42.9	25.0	0
Coronary	No.	80	46	48	7	9	7	11	1
	%	44.2	25.4	26.5	3.9	32.1	25.0	39.3	3.6
Renal	No.	113	39	27	2	15	7	6	0
	%	62.4	21.6	14.9	1.1	53.6	25.0	21.4	0
Vertebral	No.	124	31	24	2	20	5	2	1
	%	68.4	17.1	13.3	1.1	71.4	17.9	7.1	3.6

than the carotids, especially at their bifurcation. The absence of severe atherosclerosis of the extracranial part of the carotid arteries is in keeping with the low incidence of cerebral infarction, which tends to be associated with severe atherosclerosis of the large extracranial vessels (Pickering, 1968).

#### *Cerebral infarction*

Of the six cases with cerebral infarction, two showed grade 3 lesions and one a grade 2 lesion in the cerebral vessels. All, however, showed either grade 2 or grade 3 lesions of the aorta. The numbers are small; larger numbers are



required for a more complete evaluation of the degree of atherosclerosis in the Ghanaian hypertensive with cerebral infarction. Other workers (Katsuki, Omae & Hirota, 1964; Yates, 1964) have shown that the incidence of cerebral infarction parallels the incidence of coronary heart disease in a population. It may, therefore, not be mere coincidence that the low incidence of myocardial infarction in the Ghanaian (Anim, 1984; Anim & Kofi, 1984) tends to parallel the low incidence of cerebral infarction.

### *Cerebral haemorrhage*

Table 8 and Fig. 2b compare the severity of atherosclerosis in all vessels studied between the sixty-eight hypertensives with cerebral haemorrhage and all hypertensives. The haemorrhagic cases do not show any significant increase in severity of atherosclerosis. Of particular note is the absence of any significant increase in grade 3 lesions, although the aorta and cerebral vessels show a slight increase in grade 2 lesions. This finding also confirms the already stated view (Williams *et al.*, 1975; Anim & Kofi, 1984) that severe atherosclerosis is not a prerequisite for cerebral haemorrhage. Its effect in contributing to the general weakness of the vessel wall cannot, however, be discounted.

### *Diabetes mellitus*

Table 9 compares the severity of atherosclerosis in the six vessels studied, between twenty-eight diabetics and all hypertensives. Although this number of diabetics is small, there is a significant increase in severe lesions (grades 2 and 3) in the aorta of the diabetics. Similarly, there is a slight increase in grade 2 lesions in the coronary arteries in the diabetics. The other vessels (cerebral, carotid, renal and vertebral) do not show any significant increase in severity of atherosclerosis in diabetics over all hypertensives studied. The more severe lesions in cerebral vessels reported by other workers (Baker & Resch, 1964; Solberg & McGarry, 1968) are not supported by the findings in this study, although the numbers are small and firm conclusions, therefore, can not be drawn.

In view of the fact that twenty-one (75%) of the diabetics in this study were also hypertensive, it can be concluded that the increase in

severe lesions recorded above is due to the combined effect of hypertension and diabetes mellitus, both known risk factors of atherosclerosis (Robertson & Strong, 1968; Solberg & McGarry, 1968; Newman *et al.*, 1981). The effect of diabetes mellitus alone on atherogenesis and progression of atherosclerosis in the Ghanaian population requires study in a project comparing normotensive diabetics with hypertensive ones. No conclusions can be drawn on the effect of diabetes mellitus alone from this study.

### **Conclusion**

A qualitative autopsy evaluation of the pattern of atherosclerosis in six major arteries in 310 Ghanaian adults has shown the following: (a) atherosclerosis increases in severity with age in the Ghanaian adult; (b) hypertension accelerates the process of atherosclerosis; (c) diabetes mellitus, when combined with atherosclerosis, further accelerates the process of atherosclerosis in the Ghanaian adult; (d) severe, complicated atherosclerotic lesions are not common in the Ghanaian normotensive or hypertensive, using this qualitative method of assessment; (e) severe atherosclerosis is not a necessary association of cerebral haemorrhage (haemorrhagic stroke), which is perhaps the commonest cause of death of all the complications of hypertension in the Ghanaian adult; (f) the small number (six) of cerebral infarcts (thrombo-embolic stroke) is further underlined by the small number of severe, complicated atherosclerosis, therefore, is an uncommon cause of neurological morbidity or mortality in the Ghanaian.

The more aggressive nature of hypertension in Ghanaians (as in other blacks) culminates in devastating complications such as haemorrhagic stroke or cardiac failure. These factors have been suggested as important reasons for the much smaller number of complicated atherosclerotic lesions in the Ghanaian.

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