CALCIUM AND MAGNESIUM CONCENTRATION IN THE AORTA OF WHITES AND BANTU


In a previous paper1 highly significant differences between the degree of gross atherosclerosis in certain arteries of Whites and those of Bantu were reported. However, nothing was said about the chemical composition of the vessels. The calcium content of the aortic wall increases with age and increasing degree of atherosclerosis.2,4

Anderson et al.5 analysed aortas obtained postmortem from 50 adult Whites and 70 adult Bantu and noticed an increase in the calcium content of the aortic wall with increasing age and degree of atherosclerosis in both racial groups. However, the increase was much more rapid in Whites than in Bantu after the age of 40 years.

The Bantu have a relatively low calcium intake and their serum-calcium level is about 10% lower than that of Whites.6 However, the lower calcium content of the Bantu aortic wall is not necessarily a reflection of the low serum-calcium level.

Comparative studies on the calcium content of arteries of Whites and those of Bantu have been carried out in South Africa, but magnesium has not heretofore been the subject of a similar study. In its capacity as cofactor in various enzyme systems, this element may play a part in atherogenesis, for it is actively concerned in the metabolism of the arterial wall, including protein, carbohydrate and fatty-acid metabolism and cholesterol synthesis.7,9

Like calcium, magnesium increases in the aortic wall with ageing and with increasing degree of atherosclerosis.10,11 Administration of magnesium apparently stimulates the excretion of calcium,12,13 and some success in the treatment of atherosclerosis and coronary thrombosis with magnesium salts has been recorded.14,15 Possible explanations for the beneficial effects reported are competition between magnesium and cholesterol for attachment to the beta lipoproteins or some kind of catalytic action of magnesium with the lipases in the metabolism of fat. In this respect the higher serum magnesium level of Bantu as compared with that of Whites16 may be important.

The present study was prompted by the differences between Whites and Bantu in atherosclerosis and calcium metabolism and the possibility that differences in magnesium metabolism might also be demonstrable.

MATERIAL AND METHODS

The aortas from White and Bantu subjects were obtained during consecutive autopsies conducted at the Pretoria General Hospital. Altogether 79 aortas from White patients and 139 from Bantu were analysed. Of the White subjects, 50 were over 30 years of age and of the Bantu 76 were over 30 years of age, and the series was entirely unselected except for the exclusion of syphilitic and tuberculous cases.

The aorta was severed about 1 cm. above the aortic valve and 1 cm. distal to its bifurcation. After removal of the vessel it was incised and the adventitia stripped.

Grading of the vessels and calculation of the atherosclerotic index were carried out according to the method of Gore and Tejada.17

After grading, the aortas were cut up into small portions about 0.5 cm. square and dried for 24-36 hours in a vacuum desiccator over concentrated sulphuric acid until the weight of the samples remained constant. This procedure removed about 95% of the moisture. The vacuum-dried material was ground in a Wiley mill fitted with a 20-mesh sieve and stored at −2°C in sealed glass containers if not analysed immediately.

After ashing of the dry material at 600°C, the calcium and magnesium content of the ash were determined. Calcium was determined as the oxalate salt by means of a micro-cerio-method based on the macro-method described by Vogel.18 Magnesium was determined through atomic absorption spectroscopy.19,20

RESULTS

Various statistical methods were used in the analysis of the data, including Terpstra's T-statistic for testing trends,22 the Mann-Whitney U-test,23 Kendall's rank correlation coefficient test,20 and the test for P-values as described by Hald.24

Age

With a single exception, Terpstra's T-statistic for testing against trend25 revealed a highly significant upward trend with age (level of significance = 0.01) in the case of calcium, magnesium, Ca/Mg ratio, and the atherosclerotic index, in both sexes of each racial group. White females formed an exception in that magnesium concentration in their case showed no significant trend with age. This discrepancy may be due to the limited number of White females studied.

Sex

The Mann-Whitney U-test28 showed no significant differences between males and females in any age group of either race with respect to calcium or magnesium concentration.

Race

The mean increase in calcium and magnesium was more or less of similar degree in the two racial groups up to about the age of 40 years. After this age the mean calcium concentration increased much more rapidly in Whites than in Bantu (Fig. 1). In spite of considerable variation in the calcium values within each age group, the racial differences were statistically significant23 from the age of 40 years upward. No significant difference in magnesium concentration was found between the two racial groups (Fig. 2).
Atherosclerotic Indices

Although Kendall's rank correlation coefficient\(^{22}\) showed a significant correlation at the 5% level between the calcium content, magnesium content and Ca/Mg ratio on the one hand and atherosclerotic index on the other hand in some age groups, there was no consistent pattern except in the case of the Ca/Mg ratio in White males over the age of 30 years. When the P-values\(^{24}\) were combined in one hand and atherosclerotic index on the other hand in the case of the Ca/Mg ratio in this latter case, a significant result at the 5% level was obtained, indicating a positive correlation between Ca/Mg ratio and atherosclerotic index in White males over the age of 30 years.

No clear-cut positive correlation was found between magnesium concentration and atherosclerotic index on statistical analysis, but mean magnesium concentration increased progressively with increasing degrees of atherosclerosis (Fig. 2).

Of special interest is the fact that in certain adults with no macroscopic signs of atherosclerosis (atherosclerotic index = 0), the calcium content considerably exceeded the values found in children.

**COMMENT**

The number of samples was small and the samples from the two population groups were not completely comparable, yet the chemical differences obtained between the aortas of the two racial groups almost certainly represent significant statistical differences.

**Calcium**

The increase in the calcium content of the aorta with age, and the lack of any statistically significant difference between the sexes in calcium content noticed in the present study, confirm the observations of other workers.\(^2\)\(^-\)\(^5\)

Before the age of 40 years little if any difference in the calcium content of the aorta in the two racial groups was noticed. The soft tissues, therefore, like the skeleton,\(^6\) do not reflect a calcium deficiency in the Bantu, and it seems probable that the lower serum-calcium levels so often found in the Bantu are the result of the lower serum-albumin level in Bantu than Whites, since a very significant fraction of the serum calcium is present in combination with albumin. The pattern of calcium increase in Whites after the age of 40 confirms the observations of Anderson et al.\(^8\) and seems to indicate that the deposition of calcium in the arterial wall is a secondary event in atherogenesis.

The explanation for the sudden sharp increase in calcium content in the aortas of White patients after the age of 40 years is at present not clear. According to Engel et al.\(^{22}\) the amount of calcium present in a tissue is related to the density of the negatively charged colloid it contains. Chondroitin sulphates, which have a strong negative surface charge and are present in considerable amounts in connective tissue colloids, might therefore considerably influence the ability of the tissue to bind calcium. According to Lansing et al.\(^4\) the elastin of the juvenile aorta contains very little calcium. However, with increasing age there is a progressive increase in calcium content, perhaps due to an increase in aspartic acid and glutamic acid.\(^{26}\)

The work of Miller et al.\(^{27}\) seems to indicate that most of the calcium in the aortic wall is present in the elastic fraction, while that of Gillman et al.\(^{28}\) favours the acid mucopolysaccharides.

The early stages of atherosclerosis affected the calcium content very little, but severer degrees of the disease tended to be associated with higher concentrations of calcium. The lower calcium concentration in Bantu aortas after the age of 40 can therefore probably be ascribed to the milder degree of atherosclerosis in Bantu aortas\(^3\) than in the aortas of Whites. Our results do not suggest that the...
The performance of work in man is accompanied by readjustment of circulatory and respiratory systems of the body to meet the demands of the active tissues for more oxygen. The greater metabolic demands of the body at submaximal work can be met mainly by increased oxygen uptake. With increasing loads there is a steady increase in oxygen uptake as well as a slow rise in the blood lactate concentration, indicating that anaerobic metabolism is contributing increasingly to the total energy output. A point is reached, with further increase in work, where no more oxygen can be taken up. There is a sharp rise in blood lactate at this level, indicating that metabolism is mainly anaerobic. Higher levels of work cannot be sustained for long periods, for exhaustion sets in within a short time. On this basis Astrand and Taylor et al. have defined maximum oxygen uptake as that level of oxygen consumption at which further increase in effort is not associated with any significant additional oxygen uptake.

The relationship of pulse rate and oxygen uptake to work load has been well established since the beginning of this century. Numerous workers established the linear relationship of oxygen consumption and pulse rate when exercise.

REFERENCES