CALCIUM AND MAGNESIUM CONCENTRATION IN THE AORTA OF WHITES AND BANTU

A. C. MEYER,* M.Sc., D.Sc.; B. J. MEYER,† M.B., Ch.B., D.Sc.; F. VERSTER,‡ M.B., Ch.B., M.Sc., AND W. J. PEPLER,† M.D., D.Sc., *Pretoria*

In a previous paper[1] 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 Whites[16] 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 tuberculotic cases.

* National Nutrition Research Institute (CSIR)
† Departments of Physiology and Pathology, University of Pretoria
‡ National Physical Research Laboratory (CSIR)

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.[19-21]

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,[23] and the test for P-values as described by Hald.[24]

Age

With a single exception, Terpstra's T-statistic for testing against trend[22] revealed a highly significant upward trend with age (level of signifance = 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-test[23] 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 significant[23] 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[23] 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 the 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.

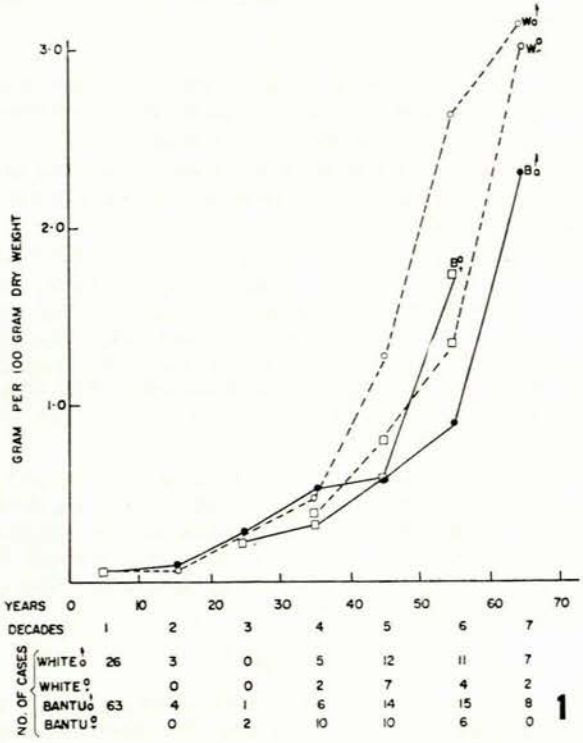

Fig. 1. Mean calcium content of aortas of White and Bantu males and females.

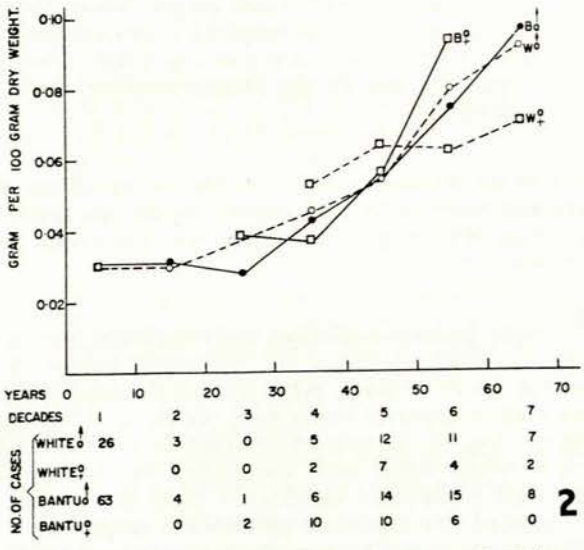

Fig. 2. Mean magnesium content of aortas of White and Bantu males and females.

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.*[5] 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.*[25] 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[1] than in the aortas of Whites. Our results do not suggest that the

low calcium concentration in Bantu vessels is the result of calcium-expelling activity on the part of magnesium.

Magnesium

The present study confirms the increase in aortic magnesium with increasing age reported by other workers, but does not confirm statistically the increase in magnesium with increasing degrees of atherosclerosis.[10, 11] The difference between Whites and Bantu in respect of serum-magnesium level reported by Bersohn and Oelofse[16] was not reflected in the aortic wall in our series. Like the racial difference in serum-calcium level the racial difference in serum-magnesium level is probably a reflection of the differences in the plasma-protein pattern of the two racial groups.

There are two separate, though probably related, aspects of atherosclerosis, namely the alterations in the wall of the blood vessel itself and the alterations in the contents of the blood vessel. If magnesium is concerned in atherogenesis, this has not been revealed by the present quantitative comparative study of the aortic wall. However, the possibility has not been excluded, for magnesium may perhaps affect the blood vessel wall indirectly through its effect on the contents of the blood vessel. In this respect the effect of magnesium on lipid metabolism[7, 9] and on serum-cholesterol concentration[29, 30] is suggestive. According to Krehl and Barboriak[29] a high-fat, low-magnesium diet raises the serum-cholesterol level in animals, while Vitale *et al.*[30] have reported an inverse relationship between magnesium concentration and the beta-lipoprotein concentration in the serum of animals.

SUMMARY

The aortas of 79 Whites and 139 Bantu were analysed to determine their calcium and magnesium concentration.

Calcium increased with age in males and females of both racial groups. Until the age of 40 years no significant racial differences in calcium concentration was found, but after this age calcium increased more rapidly in Whites than in Bantu and the differences were statistically significant.

Calcium values varied greatly within each age group, even for vessels with more or less the same atherosclerotic index, and there was no unquestionably significant correlation between calcium concentration and atherosclerotic index.

Magnesium increased with age in both racial groups. No correlation between magnesium concentration and race, sex, or atherosclerotic index was noticed.

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