

COMPARISON OF ATHEROSCLEROSIS IN GUATEMALA CITY AND NEW ORLEANS *

CARLOS TEJADA, M.D., and IRA GORE, M.D.

From the Institute of Nutrition of Central America and Panama (INCAP), Guatemala City, Guatemala; the Department of Nutrition, Harvard School of Public Health, and the Department of Pathology, Harvard Medical School, Boston, Mass.; and the Laboratory Service, Veterans Administration Hospital, West Roxbury, Mass.

Clinical experience with the low income group which constitutes the major part of the population of Guatemala has suggested a lower prevalence of atherosclerotic disease than is observed in the United States of America or among Guatemalans of higher income status. Guatemalans with low income tend to be physically active and underweight; they consume a diet which is low in fat and animal protein and high in vegetable protein. They fail to show the gain in weight with age which is common in North America. Racially, they represent Mayan Indian stock variably intermixed with European strains. Their average blood cholesterol is substantially lower than in the population of the United States¹; values for lipoproteins of the S_r 12 to 20 class and higher, as measured in the ultracentrifuge,² fail to show comparable differences.¹

Because of the current intense interest in serum cholesterol and lipoproteins as possible indices of atherogenic potential, a pathologic study of the actual prevalence of atherosclerosis in the two population groups would help to determine the relative value of the two measurements. Such a study would also help in the evaluation of the influence of other factors, such as the amount and kind of dietetic fat, upon the levels of blood cholesterol and the incidence of atherosclerosis. Present epidemiologic studies of the disease,³ although they have made noteworthy contributions, admittedly suffer from the lack of a uniform and comparable method of quantitating atherosclerosis. For example, although a low incidence of atherosclerosis has been reported in Japan,⁴ Costa Rica,⁵ Okinawa,⁶ and in the Bantu of South Africa,⁷ there is no satisfactory way of comparing these groups with one another. The appraisal procedure outlined previously⁸ is believed to have overcome this difficulty and was applied to this study.

* Supported in part by grants-in-aid from the John A. Hartford Memorial Fund; the Albert and Mary Lasker Foundation, New York, N.Y.; and the Fund for Teaching and Research, Department of Nutrition, Harvard School of Public Health, Boston, Mass.

Received for publication, January 2, 1957.

MATERIALS AND METHODS

The pathologic material available for review consisted of the Sudan-stained aortas from 616 unselected necropsies performed at the Charity Hospital, New Orleans, and 324 performed at the General Hospital in Guatemala. These were examined without knowledge of age, sex, race, or cause of death and classified according to the extent of atherosclerosis and the types of lesions.⁸ In this procedure the relative proportion of the total intimal surface involved is estimated and recorded in one of five groups as follows: group O with less than 5 per cent involvement; group A, 6 to 15 per cent; group B, 16 to 33 per cent; group C, 34 to 50 per cent; and group D, 51 to 100 per cent. The proportion of the diseased area represented by each of the four grades of lesion is then determined. These include in grade 1, lipid streaks; grade 2, fibrous atheromatous plaques; grade 3, necrotic, hemorrhagic, and/or ulcerated plaques; and grade 4, calcified lesions. An atherosclerotic index is obtained from these figures by appropriate weighting for both the extent of the disease and the types of lesion which constitute it.⁸ The Guatemalan material did not always include the aortic valve, a point to which further reference will be made.

TABLE I
Aortas Available for Review

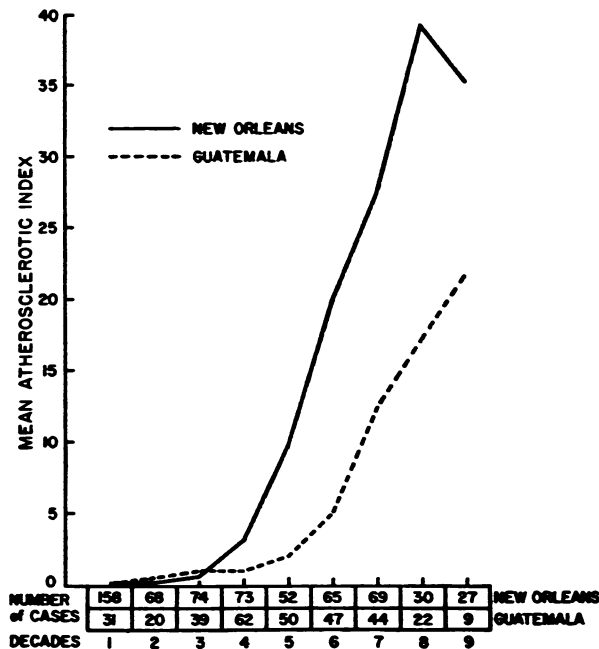
Decade	New Orleans				Guatemala	
	White		Negro		Males	Females
	Males	Females	Males	Females		
1	28	14	67	49	21	10
2	16	9	27	16	16	4
3	20	13	22	19	29	10
4	17	11	21	24	43	19
5	13	11	14	14	34	16
6	20	7	20	18	43	4
7	20	6	22	21	32	12
8	11	5	9	5	17	5
9 or more	7	5	11	4	7	2

Although natural illness was the cause of death in most cases, both groups included a proportion of medicolegal cases with sudden fatalities from traumatic causes in apparently healthy individuals. In Guatemala, all of the necropsy material was obtained from individuals in lower income groups whose dietetic habits are drastically different from those in the United States and from those of upper income mem-

bers of the same country. The sex and age by decade are listed in Table I. Although Strong, McGill, Griffin, and Holman⁹ have shown more severe juvenile atherosclerosis in the American Negro, the number of persons examined in the present study did not justify detailed comparison between Negro and white racial groups.

RESULTS

The atherosclerotic index, which has been developed as an expression of the extent and severity of the disease, shows a progressive rise with age in both groups. Under the age of 30 years there are no significant differences between them; the disease appears at an early age in both and is present universally after the second decade (Text-fig. 1). In the first decade, 37 per cent of the aortas of persons from New Orleans

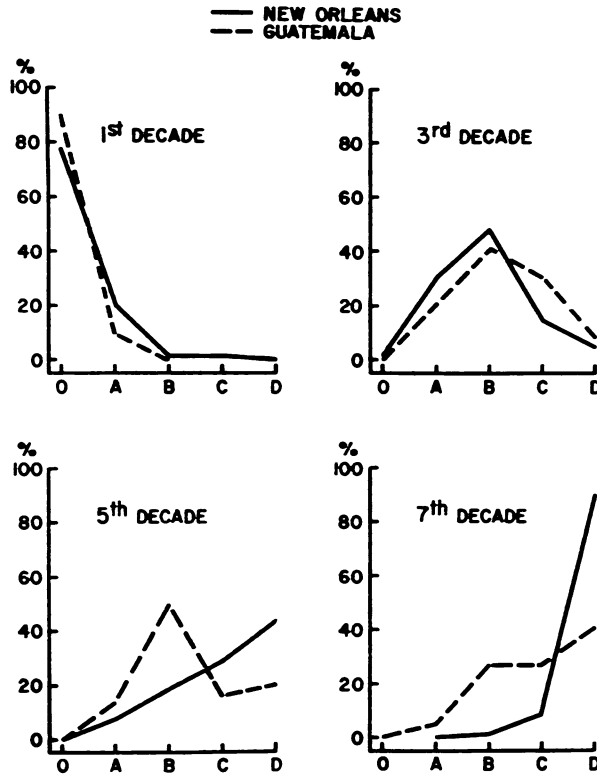


Text-figure 1. Progression of atherosclerosis with age.

and 61 per cent of those from Guatemalans were devoid of atherosclerosis. This discrepancy we believe to be the result of the unavailability of the aortic valve and the supra-avalvular aortic segment in much of the Guatemalan material. Griffin, Strong, and Holman¹⁰ have pointed out the frequency with which these sites show the initial involvement in juvenile atherosclerosis. In the second decade only 3 and 5 per cent, respectively, were devoid of atherosclerosis. After age 30,

the severity of atherosclerosis increases more rapidly in New Orleans than it does in Guatemala. When the differences between the means were evaluated for each decade above 30 years of age by the t-test, all proved significant at the 1 per cent level, except the last group, 80 years and older, which was significant at the 5 per cent level.

Analysis of the individual factors considered in arriving at the atherosclerotic index serves to specify the nature of the differences



Text-figure 2. Effect of age on surface area involvement.

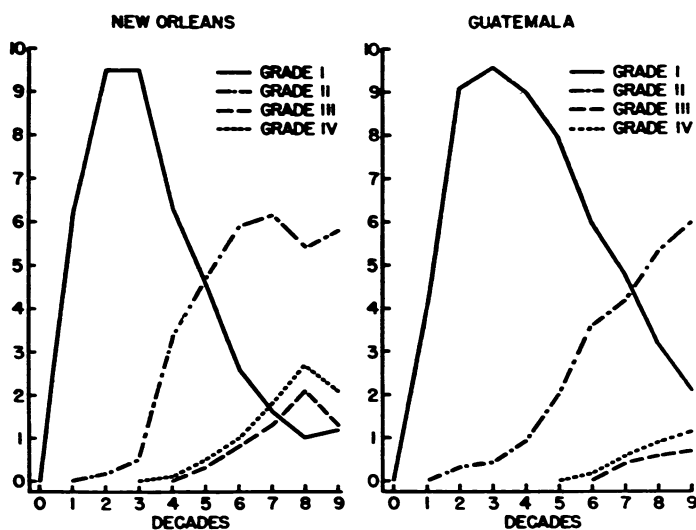
between the two localities. After age 30 a progressively increasing proportion of individuals present maximal surface involvement (Text-fig. 2). Whereas more than 90 per cent of the New Orleans group above 60 years of age had reached this stage, only about 40 per cent of the same group of Guatemalans were equally affected. Even those older than 80 years had a lesser likelihood of maximal area involvement than the New Orleans group 2 decades younger.

The average relative frequency of each of the four types of aortic lesions by decades in New Orleans and Guatemala is listed in Table II. These percentages do not always total ten to represent ten-tenths, or all, of the disease, as they must in individual cases. One cause for the

discrepancy results from using averages, which, in the first decade especially, include a fair proportion of individuals devoid of atherosclerosis. A second discrepancy occurs in the older age groups in whom an appreciable proportion of the lesions may be both ulcerated and calcified. Although overlapping figures for these two types of lesion

TABLE II
Relative Proportion of Atherosclerotic Lesions (Average Profile)

Decade	New Orleans				Guatemala			
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 1	Grade 2	Grade 3	Grade 4
1	6.2	0	0	0	3.9	0	0	0
2	9.5	0.2	0	0	9.1	0.3	0	0
3	9.5	0.5	0	0	9.6	0.4	0	0
4	6.3	3.3	0	0.1	9.0	0.9	0	0
5	4.6	4.7	0.3	0.5	7.9	2.0	0	0
6	2.6	5.9	0.8	1.0	6.0	3.6	0	0.2
7	1.6	6.2	1.3	1.8	4.8	4.2	0.4	0.6
8	1.0	5.4	2.1	2.7	3.2	5.3	0.6	0.9
9 or more	1.2	5.8	1.3	2.1	2.1	6.0	0.7	1.2



Text-figure 3. Relative frequency of grades of atherosclerotic lesions.

were avoided in calculating the atherosclerotic indices, purposeful duplication, as in Table II, permits comparison of the extent to which calcification occurs.

For both New Orleans and Guatemala (Text-fig. 3), the data show a progressive shift with age from predominance of grade I or lipid

lesions to plaques frequently complicated by necrosis or calcification, or both. However, the change occurs earlier in New Orleans. For example, after age 50, fibrous plaques were predominant in the New Orleans material whereas this was not true in the Guatemalan group until the eighth decade. Ulcerated and calcified plaques appeared in the aortas of the New Orleans group after the third and fourth decades but did not complicate the disease in Guatemala until the fifth and sixth decades. Moreover, the proportion of grade III and IV, ulcerated or calcified lesions increased more rapidly in New Orleans than in Guatemala. In the older age groups in New Orleans, as exemplified by the 70 to 79 age group, almost half the lesions were ulcerated or calcified, or both. By contrast, the process was of similar severity in only 15 per cent of the aortas in Guatemalans of the same age group.

DISCUSSION

The data presented demonstrate a highly significant difference in the severity of atherosclerosis in New Orleans and Guatemala. This becomes obvious and progressively more striking after the third decade. Although the incidence and severity of the disease in both countries are related to age, the fact that there is such a striking discrepancy reaffirms that other factors in addition to age must be considered in atherogenesis.¹¹ One suggested by a recent study¹ is that Guatemalans with low incomes have appreciably lower levels of blood cholesterol than Guatemalans with higher incomes or sampled populations of the United States.

Unfortunately, too few necropsies were available for the present study to permit adequate pathologic comparison with Guatemalans of the upper income groups. However, each of eight consecutive medicolegal necropsies performed on such subjects presented an atherosclerotic index in the upper range of that exhibited by the corresponding age group of their low-income compatriots.* This limited observation agrees with the impression of clinically significant atherosclerosis among Guatemalans whose activities, diet, and levels of serum cholesterol match those observed in the United States of America.

It is pertinent to note that paralleling the difference in atherosclerosis, over age 40 in the two localities, there were 51 cases of myocardial infarction in New Orleans from a total of 316 cases and only one in the Guatemalan group of 234 cases. On the other hand, of

* These cases, with dietetic habits and activities much like residents of the United States, were excluded from the Guatemalan material being studied.

the eight medicolegal necropsies in Guatemala on individuals of the upper income group, two had myocardial infarcts. Ten instances of aortic mural thrombosis and three arteriosclerotic aneurysms, both complications of severe disease, occurred in the New Orleans material whereas only one of the Guatemalans had mural thrombosis and there were no non-syphilitic aneurysms. The greater prevalence of ulcerated or calcified atherosclerotic lesions, or both, in the United States would appear to explain, at least in part, the difference in incidence of clinically apparent atherosclerosis. An intensive search should obviously be made to identify the environmental factors responsible for the dramatic differences between New Orleans and Guatemala in both atherosclerosis and ischemic heart disease.

SUMMARY

The extent and severity of atherosclerosis in the United States of America and Guatemala were compared by examining the aortas from 616 unselected necropsies in New Orleans and 324 in Guatemala limited to members of the low income group. In both countries the disease started at an early age and was uniformly present after the second decade. Its severity rose progressively with age, but after age 30, the increase was significantly lower in Guatemala. The calcified and ulcerated lesions, common in the older United States group, were also distinctly less prevalent in the material from Guatemala. It is significant that over the age of 40 there were 51 cases of myocardial infarction among 316 cases in the New Orleans material and only one among the 234 Guatemalans. There were also ten cases of aortic mural thrombosis and three of arteriosclerotic aneurysm in the United States material as contrasted to one of mural thrombosis in the Guatemalans.

We are greatly indebted to Drs. Russell Holman, Henry McGill, and Jack Strong of the Department of Pathology, Louisiana State University, for their generosity in making the New Orleans material available for review and extending the facilities of their department to us. The help in collecting aortas by Jorge E. López, Carlos Méndez M., José María Arriola, and Minor Hernández, of the School of Medicine of the University of San Carlos, Guatemala, is also gratefully acknowledged.

REFERENCES

1. Mann, G. V.; Muñoz, J. A., and Scrimshaw, N. S. The serum lipoprotein and cholesterol concentrations of Central and North Americans with different dietary habits. *Am. J. Med.*, 1955, 19, 25-32.
2. Gofman, J. W.; Jones, H. B.; Lyon, T. P.; Lindgren, F.; Strisower, B.; Colman, D., and Herring, V. Blood lipids and human atherosclerosis. *Circulation*, 1952, 5, 119-134.

3. Keys, A. Human atherosclerosis and the diet. *Circulation*, 1952, 5, 115-118.
4. Hueper, W. C. Arteriosclerosis. *Arch. Path.*, 1944, 38, 162-181, 245-285, 350-364; *Ibid.*, 1945, 39, 51-65, 117-131, 187-216.
5. Wilens, S. L. Bearing of general nutritional state on atherosclerosis. *Arch. Int. Med.*, 1947, 79, 129-147.
6. Steiner, P. E. Necropsies on Okinawans: anatomic and pathologic observations. *Arch. Path.*, 1946, 42, 359-380.
7. Higginson, J., and Pepler, W. J. Fat intake, serum cholesterol concentration, and atherosclerosis in the South African Bantu. Part II. Atherosclerosis and coronary artery disease. *J. Clin. Investigation*, 1954, 33, 1366-1371.
8. Gore, I., and Tejada, C. The quantitative appraisal of atherosclerosis. *Am. J. Path.*, 1957, 33, 875-885.
9. Strong, J. P.; McGill, H. C., Jr.; Griffin, O. R., and Holman, R. L. Natural history of aortic atherosclerosis, ages 1 to 40. *Federation Proc.*, 1956, 15, 533-534.
10. Griffin, O. R.; Strong, J. P., and Holman, R. L. Analysis of juvenile atherosclerosis; the first formation of pearly plaques. *Federation Proc.*, 1955, 14, 405.
11. Katz, L. N., and Stamler, J. *Experimental Atherosclerosis*. Charles C Thomas, Springfield, Ill., 1953, 375 pp.