

# Comparative Severity of Atherosclerosis in Costa Rica, Guatemala, and New Orleans

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The present study is concerned with the comparative severity of aortic atherosclerosis in specimens obtained from 941 necropsies performed in low-income Costa Ricans, Guatemalans, and New Orleans whites. The findings indicate geographic differences in the severity of atherosclerosis after the age of 30 years. The dietary habits, serum cholesterol, and lipoprotein patterns of similar populations are compared with the present pathologic findings.

**P**REVIOUS studies have described the relative extent and severity of atherosclerosis observed in aortas taken from unselected autopsies of a group of low-income Guatemalans as compared to a similar group of United States inhabitants in New Orleans.<sup>1, 2</sup> These reports indicated that the early lesions of aortic atherosclerosis, which simple fatty streaks are presumed to represent, developed at very nearly the same rate in both groups up through the third decade; but the more advanced changes—fibrous plaques, ulceration, hemorrhage, thrombosis, and calcification—were much less severe in the Guatemalans than in the individuals from New Orleans. These population samples represented individuals dying in a large general charity hospital in each area, and consequently represented the lowest income groups of both regions. Racially, however, the 2 groups were quite distinct. The United States white population as a whole is characterized by an approximate 45 per cent incidence of blood group “O.”<sup>3</sup> On the other hand, the low-

income Guatemalans of pure or predominant Mayan Indian extraction as noted by their physical appearance and way of life, have a blood group “O” frequency ranging from 80 to 96 per cent depending on the village studied.<sup>4, 5</sup> Since the racial differences between the 2 regional groups were as prominent as the differences in dietary habits and serum lipoprotein and cholesterol values,<sup>6</sup> the relationship of the latter factors to the atherosclerotic lesions could not be evaluated. A solution to this problem was sought by studying in a similar manner the prevalence of atherosclerotic lesions in individuals from Costa Rica. The low-income Costa Rican population is predominantly white<sup>4</sup> as indicated by history, appearance, and blood-group distribution, but their living conditions are similar to those for comparable socioeconomic groups in Guatemala. Moreover, data on their dietary habits and on their serum cholesterol and lipoprotein concentrations are available<sup>6, 7</sup> for comparison with the extent and severity of atherosclerotic lesions.

It should be pointed out and emphasized here that these studies are based on visual assessment of the actual atherosclerotic lesions in the aorta, in contrast with many other studies in which the incidence of various clinical manifestations of arterial disease has been determined.<sup>8-13</sup>

## MATERIALS AND METHODS

Three hundred and ninety-eight aortas were obtained from unselected autopsies at the San Juan de Dios Hospital, San José, Costa Rica, a large charity institution. The number of cases in

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This work was assisted by grants-in-aid to INCAP from the Nutritional Heart Institute of the U. S. Public Health Service (H-2653); to the Harvard School of Public Health from the John A. Hartford Memorial Fund and the Nutrition Foundation; and to the Louisiana State University School of Medicine from the National Heart Institute of the U. S. Public Health Service (H-655 and H-1785).

TABLE 1.—*Number of Cases by Age Group*

Age in years	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	Over 80	Total
New Orleans whites	42	25	33	28	20	27	26	16	12	229
Guatemala	31	20	39	62	50	47	34	22	9	314
Costa Rica	131	24	27	34	42	56	45	31	8	398

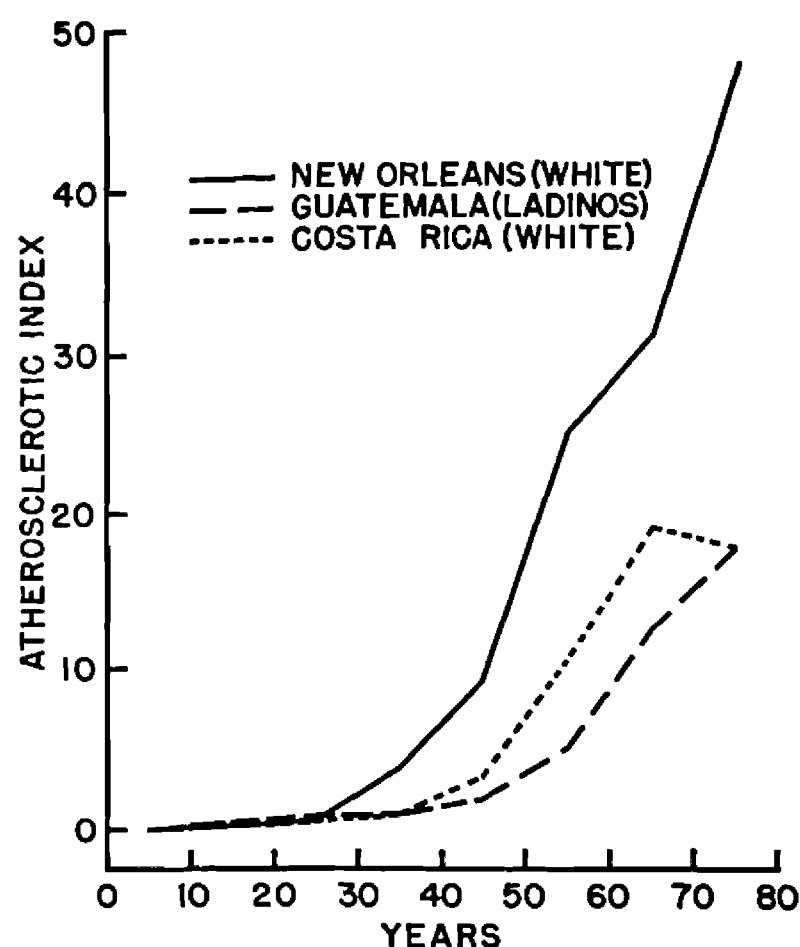


FIG. 1. Severity of aortic atherosclerosis.

each decade is listed in table 1, together with a similar tabulation of the New Orleans and Guatemala cases.

Prior to examination the aortas, which had been fixed in 10 per cent formalin, were stained with Sudan IV. Examination was completed with no knowledge of age, sex, race, cause of death, or associated disease processes. The extent and severity of atherosclerosis was evaluated according to the procedure previously described.<sup>14</sup> This method takes into consideration both the type of lesion and the relative surface extent of each. Intimal lesions are classified in 4 grades: grade I, fatty streaks; grade II, fibrous atheromatous plaques; grade III, necrotic, ulcerated, hemorrhagic or thrombotic plaques; grade IV, calcified plaques.

In terms of area, surface involvement is estimated and recorded in 1 of 5 groups as follows: group O, less than 5 per cent surface involvement; group A, 6 to 15 per cent surface involvement; group B, 16 to 33 per cent surface involvement; group C, 34 to 50 per cent surface

involvement; group D, more than 51 per cent surface involvement.

The findings are incorporated into an "atherosclerotic profile," a 5-digit figure that expresses both the proportion of the intima that is diseased and the decimal fraction of the diseased portion made up by each of the 4 types of lesions. By appropriate weighting, the elements of the profile are integrated and an index of atherosclerosis is derived that expresses severity on a scale ranging from 0 to 100.

### RESULTS

As reflected by the atherosclerotic index, the progression of the severity of atherosclerosis with age is depicted in figure 1. Significant differences in the weighted index of atherosclerosis in the 3 countries were not observed before the age of 30. Subsequently, intimal disease appeared to develop more rapidly in New Orleans than in either Guatemala or Costa Rica. After the age of 40, but not before, atherosclerosis increases more rapidly in Costa Rica than in Guatemala, although it is still significantly less than in New Orleans.

When the data were analyzed only for the *extent* of intimal surface involvement (fig. 2) geographic differences still did not appear before the age of 30 years. In all 3 localities, virtually all aortas showed some degree of intimal disease by the end of the first decade. After age 30, the extent of involvement increased progressively with age; most rapidly in New Orleans, least rapidly in Guatemala. At the age of 50, for example, the proportion of aortas with more than half the intima diseased was 54 per cent in New Orleans, 47 per cent in Costa Rica, and 28 per cent in Guatemala. At both 70 and 80 years of age, corresponding figures were 85 and 92 per

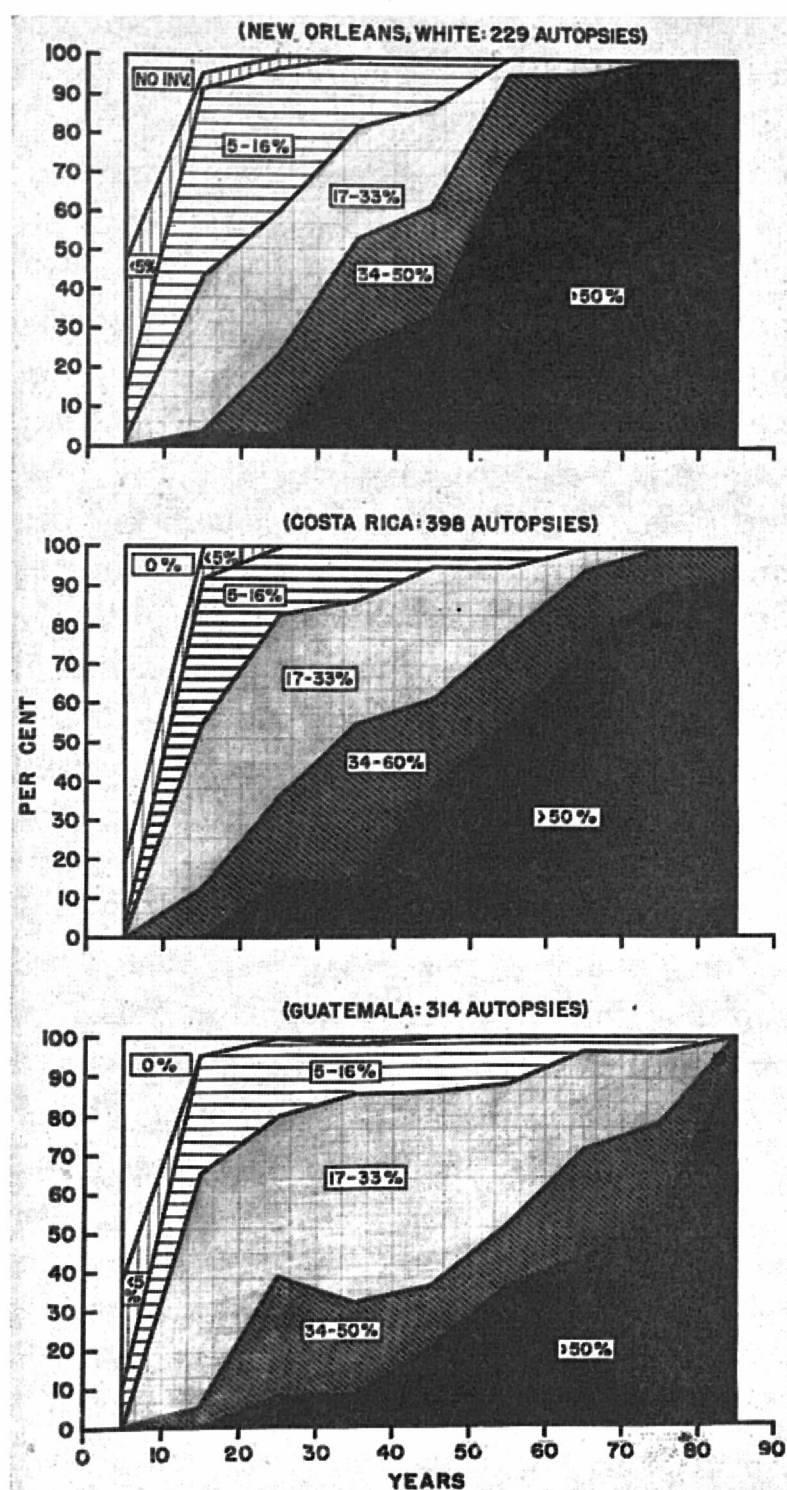


FIG. 2. Amount of aortic surface involvement with atherosclerosis.

cent in Costa Rica and 54 and 78 per cent in Guatemala.

Again, with increasing age, the relative proportions of the 4 grades of atherosclerotic lesions shifted toward an increase in the more advanced types (fig. 3). During the first 2 decades, lipid streaks (grade I) predominated; less than 5 per cent were fibrous plaques (grade II); and there were no complicated (grade III) or calcified lesions (grade IV). During the third decade, fibrous plaques (grade II) became more numerous, especially in the New Orleans material. Prior to 30 years of age there were only infrequent lesions that were complicated or calcified. Beginning with the fourth decade, there was

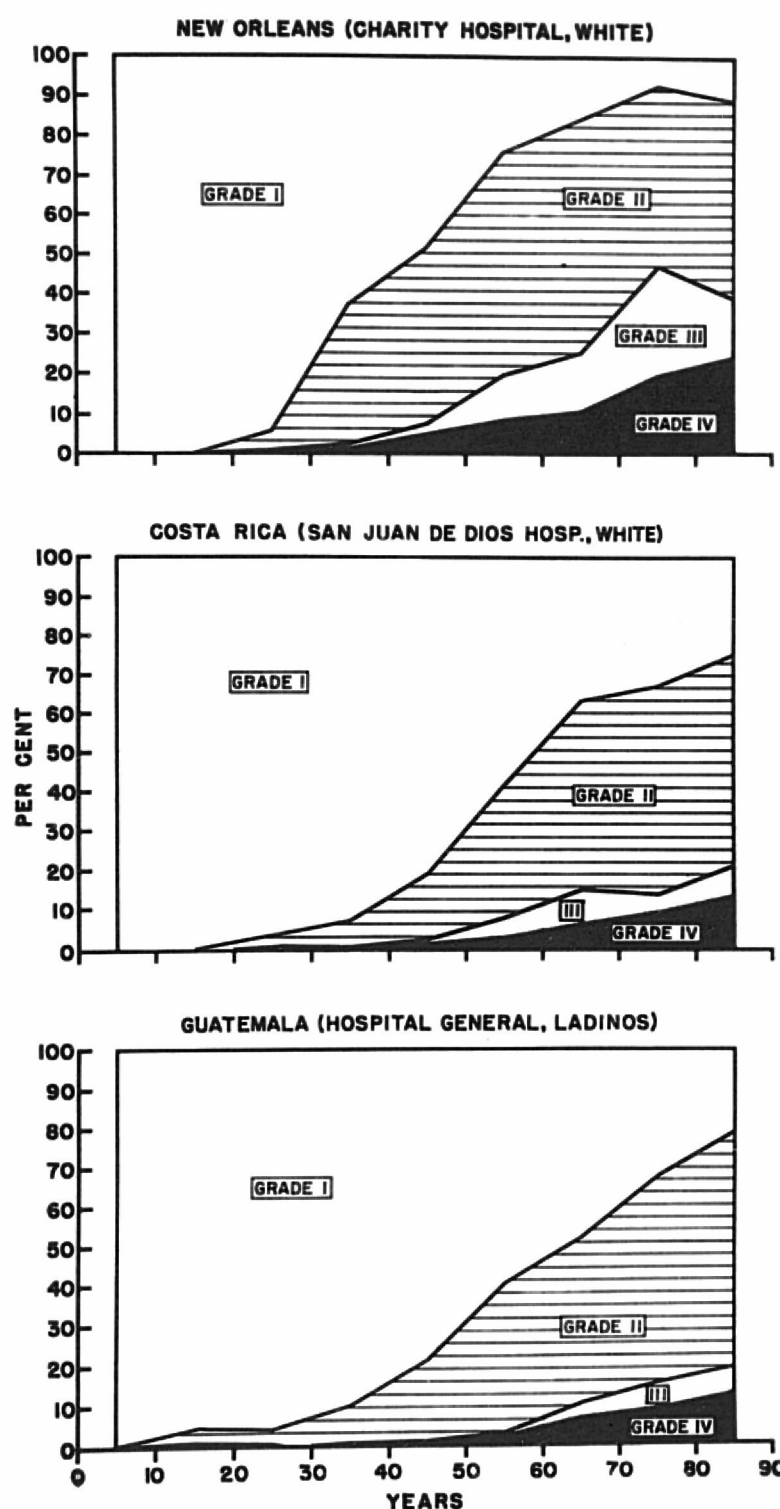


FIG. 3. Aortic type of atherosclerotic involvement.

a progressive increase in the proportion of grade III or IV lesions. The rate of increase was greatest in New Orleans, intermediate in Costa Rica, and least in Guatemala. For instance, in the sixth decade, 20 per cent of the lesions in New Orleans were grade III or IV in type, while the corresponding figures for Costa Rica and Guatemala were 8 and 3 per cent respectively. By the eighth decade, the same lesions comprised 48, 15, and 15 per cent of the aortic disease in the 3 respective localities.

#### DISCUSSION

As a result of this comparative study, it appears that up to 30 years of age the development of atherosclerotic lesions is similar

in quality and degree in the population samples examined from New Orleans, Costa Rica, and Guatemala. These conclusions are supported by the assessment of lesions in the same material by 2 different pairs of individuals using methods similar in principle.<sup>2</sup>

However, this particular study has shown that after 30 years of age there are differences in the severity of the process in the 3 groups. The highest rate of development is apparent in New Orleans as indicated by both a greater surface extent of the disease and a higher proportion of advanced lesions. Severe lesions appear less rapidly in Costa Rica and more slowly still in Guatemala. The previous study<sup>2</sup> also showed the fibrous plaques in New Orleans aortas to be much more extensive than in the aortas from either of the 2 Central American countries by the age of 40 years.

Since Costa Ricans and New Orleans whites are both principally of European extraction, racial factors are unlikely to be primarily responsible. Therefore, environmental factors must be sought to account for these differences.

Of possible environmental factors, diet appears at present to be one of the most important. Differences in serum cholesterol and lipoprotein concentration have been reported<sup>6, 7</sup> and related to the dietary habits prevalent in the United States, Guatemala, and Costa Rica. It is interesting to note that, virtually paralleling the difference in atherosclerosis reported above, the caloric and fat intakes are the highest in the United States, considerably less in rural Costa Rica, and still lower in rural Guatemala. In fact, more than 40 per cent of the total calories in the United States diet are derived from fat, compared to 12 per cent in Costa Rica, and 7.5 per cent in Guatemala.<sup>6, 7</sup> Dietary fat and protein of animal origin are high in the United States, low in rural Costa Rica, and still lower in rural Guatemala. In like fashion, serum cholesterol levels are relatively high in the United States, low in rural Costa Rica, and still lower in rural Guatemala.<sup>6</sup> The relatively low serum cholesterol levels and severity of atherosclerosis were not associated with lower

S<sub>f</sub> 12 and higher lipoprotein fractions<sup>6, 7</sup> than in the United States population. S<sub>f</sub> 12-20 and S<sub>f</sub> 20-100 levels were even lower in Costa Rican males than in comparable Guatemalan and United States samples, and Costa Rican females had higher values than females of the other 2 groups. Further examinations showed, however, that the S<sub>f</sub> 0-12 levels were low in Costa Rica by an amount sufficient to account for the lowered cholesterol levels. Certainly, in this population serum levels of the S<sub>f</sub> 12-20 and S<sub>f</sub> 20-100 lipoprotein fraction did not parallel the severity of atherosclerosis, while S<sub>f</sub> 0-12 levels and serum cholesterol both appeared to do so.

In connection with the mechanism by which the etiologic agent, whatever that may be, produces the atherosclerotic lesions, it is of interest to note that the differences found are in the advanced lesions and are not in the simple intimal lipid deposits encountered during the first 3 or 4 decades of life. If the relationship between serum lipids and atherosclerotic lesions demonstrated here is actually a causative relationship and not a coincidental one, the data suggest that the mechanism is not one of perfusion and filtration of the arterial wall with lipid-rich plasma, but has something to do with the inflammatory and reparative reaction in and around the atheromatous plaques.

It is possible that the chemical type of lipid deposited in the early fatty streak is different in the aortas from each area, so that one combination of lipid is more injurious and excites a more intense reaction than another. Since the method of evaluation used here does not take into account the concentration of lipid material in the tissue, it is also possible that the amount of lipid per unit of tissue differs. Qualitatively different lipids may furthermore influence the coagulative mechanism in either direction, leading to an increased tendency to hemorrhage within the plaque or thrombosis on its surface. These possible interpretations have been discussed extensively in previous reports.<sup>2</sup>

Attractive though the assumption of a causal relationship between diet, serum lipids,

and atherosclerosis may be, certain gaps in the chain of evidence and criticisms of the presently reported data must be pointed out. For one, the dietary habits of the population group represented by the New Orleans sample have not been as specifically determined as those for the Guatemalan or Costa Rican groups. This part of the United States cannot be accepted as "average" for the United States population, as it is culturally and geographically rather unique. Furthermore, although we believe that the people dying in large general charity hospitals offer the most reproducible autopsy population sample available, the possibility of biased selection remains. The size of the sample for each group is being continually increased, so that it should soon be possible to make not only age-specific but also sex-specific and cause of death-specific comparisons. Finally, it must be remembered that these data deal only with aortic lesions, and that a correlation of aortic with coronary and cerebral lesions remains to be firmly established.

#### SUMMARY

The incidence and severity of aortic atherosclerosis was studied in 941 aortas obtained from autopsies performed on low-income Costa Ricans, Guatemalans, and New Orleans whites. The study covered cases ranging from 1 to 80 years of age and the findings indicated geographic differences in the severity of aortic atherosclerosis after the age of 30 years. The severity of involvement with atherosclerotic lesion as indicated by 3 different indices was greatest in New Orleans, intermediate in Costa Rica, and lowest in Guatemala. The dietary habits, serum cholesterol, and lipoproteins previously reported in the 3 countries were compared with the pathologic findings. There is an apparent correspondence between the dietary fat intake, the serum cholesterol levels, S<sub>f</sub> 0-12 lipoprotein patterns, and the degree of aortic atherosclerotic lesions as measured by these methods.

#### SUMMARIO IN INTERLINGUA

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nite ab necropsias de individuos a basse stato economic de Costa Rica, Guatemala, e le population de racia blanc in Nove Orleans. Le studio includeva casos con etates de inter I e 80 annos. Le resultatos indicava le existentia de differentias geographic in le severitate de atherosclerosis aortic post le etate de 30 annos. Le severitate del lesiones atherosclerotic—evalutate super le base de 3 differente indices—esseva le plus marcate in Nove Orleans, intermediari in Costa Rica, e le minus marcate in Guatemala. Le habitudes dietari, le valores pro cholesterol seral, e le valores pro lipoproteinas reportate previemente in le 3 areas esseva comparate con le constataciones pathologic. Le methodos usate resultava in le conclusion que il existe un correspondentia apparente inter le ingestion dietari de grassia, le nivellos seral de cholesterol, le configuration del lipoproteinas de S<sub>f</sub> 0-12, e le grado del lesiones de atherosclerosis aortic.

#### ACKNOWLEDGMENT

The authors wish to acknowledge the valuable cooperation of Dr. Rodolfo Céspedes, Pathologist-in-Chief, San Juan de Dios Hospital, San José, Costa Rica, in the collection of aortic specimens and the corresponding clinical and anatomic data. Without his cooperation, this study would have been impossible. We would also like to acknowledge the assistance of Dr. Nevin S. Scrimshaw, Director of INCAP, and Dr. Russell L. Holman, Professor of Pathology and Head of Department, Louisiana State University School of Medicine.

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