Environmental Factors in Coronary Heart Disease
An Epidemiologic Study at Agra (India)

By Krishna S. Mathur, M.D., F.R.C.P.

CORONARY heart disease, emerging from obscurity in the early years of the century, has become the most serious and immediate health problem in many countries. In New England the incidence has risen from 37 per cent of 2,314 cardiac patients in 1928 to 48.5 per cent among 3,000 heart patients in 1951. A review of a series of 1,284 consecutive hearts examined by the injection-plus-dissection technic of Schlesinger, at the Beth Israel Hospital, Boston, during the decade 1941 to 1950 revealed myocardial infarction on gross and histologic examination of the myocardium in 268 or 20.6 per cent and occlusion of coronary arteries in 342 or 26.6 per cent of the hearts.

Comparable statistics on the subject are not available in India but the disease has apparently assumed menacing proportions and can be presumed to be on the increase. Sanjivi, Vakil, Samani, and Padmavati have reported incidences of 11.8 to 13.5 per cent in their hospital series of cardiac cases. In a similar study of heart cases in private practice Vakil found the frequency to be 26 per cent. Recently Malhotra reported an incidence of 28.3 per cent in combined hospital and private series.

A most striking and potentially important fact about this disease is its geographic variability, i.e., the great differences in its incidence and mortality in different populations. It has been reported, for example, that middle-aged men in the United States, Great Britain, and Finland are more prone to die of coronary heart disease than are men of the same age in Norway or Denmark, and are several times more prone than are men in Italy or Portugal; the disparity is even greater when comparison is made with middle-aged men in Japan, with the Bantu in South Africa, the Mayan Indians in Guatemala, the Navajos in New Mexico, the Jews in Yemen, the natives in Okinawa, the Negroes in Nigeria, and so on. Gordon observed that the death rate from arteriosclerotic heart disease is lower among Japanese in the United States than among white American men of the same age group, and it is still lower among Japanese in Hawaii and in Japan.

These observations indicate the need for new epidemiologic data that emphasize differences of race, culture, ways of life, stress and strain, and dietary habits. It is the purpose of this paper to determine the role of environmental and nutritional factors in the genesis of coronary heart disease from an analysis of case records of patients treated in hospitals and private practice as well as field surveys of the general population belonging to different socioeconomic groups. Such an approach may supply a few clues to investigators, who may then study these problems in the laboratory.

Material

These studies have been conducted at Agra, one of the 3 big medical centers of Uttar Pradesh—the biggest state of India. The patients are drawn to this center not only from the rural and urban population of Agra, but from most of the surrounding western districts of the State.

The material for these investigations has been obtained from 2 sources: (1) case records of coronary heart disease patients, and (2) surveys of the general population.

1. The clinical material for this study was drawn from both hospital and private cases of coronary heart disease seen by the author from January 1946 to August 1957. There were 553 cases of coronary heart disease among 3,273 cardiac patients during this period. These included 401 or 35.2 per cent of 1,127 private and 152 or 7 per cent of 2,145 hospital cardiac cases, giving

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an over-all incidence of 16.9 per cent in the combined private and hospital series. Of these 553 patients, 391 or 71 per cent were cases of myocardial infarction, 133 or 24 per cent were angina pectoris, and 27 or 5 per cent were cases of coronary failure.

The peak age incidence in the present series was 45 to 55 years (table 1). About two thirds of all cases between 40 and 50 years, 12.3 per cent were below 40 years, and the youngest was 18 years old.

There were 492 men (89 per cent) and 61 women (11 per cent), the sex ratio being 8:1. The sex difference was less marked after the age of 45 years.

The constitution of the patients was classified as ectomorphie in 39 per cent, mesomorphie in 51.3 per cent, and endomorphie in 9.7 per cent. Hypertension was present in 50.2 per cent, diabetes in 13 per cent; and the serologic test for syphilis was positive in 3.8 per cent.

A family history of coronary heart disease was available in 7.4 per cent, of hypertension in 3.8 per cent, and of diabetes in 2 per cent of the cases. These figures do not reflect the true familial incidence of these diseases, since most of them had been treated by practitioners of indigenous medicine who did not diagnose these diseases, and some others were ignorant of the cause of death among their close relatives.

2. The data concerning the general population have been obtained from records of a planned field survey12 of the incidence of coronary heart disease including clinical and electrocardiographic studies, detailed analysis of the dietary pattern, and estimation of the blood lipids among 1,056 persons of the general population over the age of 25 years belonging to different socioeconomic groups.

In deciding on the socioeconomic classification, consideration was given to vocation, education, status in society, and income. Doctors, lawyers, university professors, high government officials, and businessmen with a monthly income over Rs. 500 per month were classed as that "high-socioeconomic group"; clerks, school teachers, petty officers, shopkeepers with income levels between Rs. 100 and Rs. 500 per month were classed as the "middle-socioeconomic group"; and industrial, manual, and agricultural workers with less than Rs. 100 as their monthly wages were grouped together as belonging to the "low-socioeconomic group."

During the course of the present investigations 216 of the high-, 350 of the middle-, and 480 persons of the low-socioeconomic group were studied. In the last category were included 230 industrial, 121 manual, and 129 agricultural workers. Eleven cases of coronary heart disease were encountered, giving an over-all incidence of 1.04 per cent.

Observations

Urban Versus Rural

Of the 553 cases of coronary heart disease seen by the author 488, or 88.2 per cent, were from Agra and neighboring cities and towns, while the remaining 67 patients, or 11.8 per cent, came from villages.

One explanation may be that patients from rural areas are less likely to travel to Agra for an episode of chest pain, unless complications arise, whereas the city dwellers being conscious about heart attacks consult physicians on minor suspicion. The figures would not then give convincing proof of the relative frequency of coronary heart disease in urban and rural populations. The answer will come from field surveys. Although our experience of field studies in villages is limited, our impression is that the incidence is low in rural populations.

Socioeconomic Status

The incidence of coronary heart disease was 35.2 per cent of all cardiac cases in private practice and 7 per cent of cardiac patients admitted to the hospital. The majority of the former belong to the high-socioeconomic group and the majority of the latter come from the low-socioeconomic group. On further analysis

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 20</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>21-25</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>26-30</td>
<td>10</td>
<td>1.8</td>
</tr>
<tr>
<td>31-35</td>
<td>22</td>
<td>4.0</td>
</tr>
<tr>
<td>36-40</td>
<td>32</td>
<td>5.8</td>
</tr>
<tr>
<td>41-45</td>
<td>67</td>
<td>12.1</td>
</tr>
<tr>
<td>46-50</td>
<td>101</td>
<td>18.3</td>
</tr>
<tr>
<td>51-55</td>
<td>113</td>
<td>20.4</td>
</tr>
<tr>
<td>56-60</td>
<td>76</td>
<td>13.7</td>
</tr>
<tr>
<td>61-65</td>
<td>64</td>
<td>11.5</td>
</tr>
<tr>
<td>66-70</td>
<td>39</td>
<td>7.1</td>
</tr>
<tr>
<td>71-75</td>
<td>18</td>
<td>3.2</td>
</tr>
<tr>
<td>76-80</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Over 80</td>
<td>2</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Table 2

Incidence of Coronary Heart Disease in Different Socioeconomic Groups of the General Population

<table>
<thead>
<tr>
<th>Socioeconomic group</th>
<th>Number studied</th>
<th>Coronary heart disease</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>216</td>
<td>9</td>
<td>4.0</td>
</tr>
<tr>
<td>Middle</td>
<td>350</td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>Low</td>
<td>480</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Industrial</td>
<td>—230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>—121</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

it was observed that of the 553 cases of coronary heart disease 63.3 per cent belonged to the high-, 25 per cent belonged to the middle-, and 11.7 per cent to the low-socioeconomic group.

In the field studies among 1,056 unselected individuals, the incidence of coronary heart disease was 4.1 per cent in the high group, and 0.57 per cent in the middle group. No case was encountered among 480 industrial, manual, and agricultural workers (table 2).

These observations emphasize the marked preponderance of coronary heart disease in the privileged class of society in contrast to the socioeconomically backward class, which enjoys a relative immunity from this disease.

Diet

Of the 553 cases 62.2 per cent were vegetarians and 37.8 per cent were nonvegetarians. But this question is unimportant in India because, with few exceptions, the so-called nonvegetarians in India take meat only 2 or 3 times a week.

We have therefore studied the nutritional status of 102 consecutive cases of coronary heart disease with regard to daily intake of fat, proteins, carbohydrate, cholesterol, total calories, and percentage of calories from fat and compared them with similar studies carried out in field surveys among normal persons belonging to various socioeconomic groups. The focal point of interest in the diet has been the relationship of dietary fat to coronary heart disease.

The maximum incidence of coronary heart disease in the field survey was found in persons of the high-socioeconomic group who consume the highest amount of total dietary fat and derive the highest percentage of calories from dietary fat. Members of the high-socioeconomic group consumed 86.5 per cent of saturated fat versus 77.7 per cent by those in the middle and 52.1 per cent in the low groups.

The fat intake, percentage of fat calories, and saturated fat in the dietary pattern of coronary cases are similar to the high-socioeconomic group of society, which bears the maximum burden of coronary heart disease.

Serum Lipids

Studies of serum lipid in the field survey gave the highest values of serum cholesterol in the high-socioeconomic group and lowest in the low-socioeconomic group; this was also true for the values of serum lipid phosphorus. The cholesterol/phospholipid ratio in the 3 groups did not differ significantly from one to another. A gradual rise in serum cholesterol was also observed with age from 20 to 50 years, after which a slight fall occurred.14

Eighty normal controls were drawn from this study and matched according to age, sex, and socioeconomic status with 80 cases of coronary heart disease, and their serum lipids were compared.15

The mean values of total serum cholesterol, serum lipid phosphorus, and cholesterol/phospholipid ratio were significantly higher in the coronary group than in the control group. In cases of coronary heart disease, the rise in total serum cholesterol was greater than the rise in serum lipid phosphorus. There was a considerable overlap of values between the coronary group and the normal group but very high values were infrequent in normal individuals.

It is considered that determination of serum cholesterol is a reliable and simple procedure for identifying persons with gross disturbance of lipid metabolism, which is blamed as one of the factors in coronary heart disease.

Physical Activity

Business executives formed the largest percentage of 553 patients with coronary heart disease, with doctors, landlords, and high gov-
ernment officials following in order. Shopkeepers, clerks, and petty officers accounted for a smaller group of such patients. The minimum number of cases were found among laborers and farmers. The results of the field survey confirmed the observations made in the hospital wards and private practice.

In an evaluation of the amount of physical activity involved in each case, it was roughly assumed that the higher strata of society, which bear the maximum burden of coronary heart disease, did little manual work in marked contrast to the poorer sections of society, whose work and mode of life demand greater amount of physical work.

**Stress and Strain**

It is difficult to assess the part played by stress and strain on the incidence of coronary heart disease in an epidemiologic study of this nature. The emotional tempo of life has gone up considerably during the last 2 decades, and this is more evident in the big cities. The poor Indian villager is quite removed from this tension and relaxes more completely when away from his work; that may partly explain his relative protection from coronary heart disease.

**Smoking and Alcohol**

Our studies fail to establish any relation of smoking or alcohol to coronary heart disease. Of 553 cases, only 149 or 26.9 per cent smoked and 62 or 11.2 per cent took alcohol, most of them moderately.

**Discussion**

Published reports on coronary heart disease from India are few.6, 8, 9, 10 Their observations on the relationship of age, sex, and body build to its frequency are similar. Its high incidence in upper class and urban population has been reported. The conclusion drawn by Malhotra9 that vegetarians were no less predisposed to coronary heart disease than nonvegetarians has not much significance. Environmental factors with special reference to socioeconomic status and their relationship to the dietary pattern and blood lipids in cases of coronary heart disease as against the normal population are being presented from India for the first time.

A recent development in India has been the field studies of general population such as the one reported here. The only other parallel study is being conducted by Padmavati et al.17 at Delhi. She reported an incidence of 4 per cent in the high-socioeconomic group in contrast to 0.5 per cent in the rural population of Nazafgarh, and 0.17 per cent in the industrial workers. The corresponding incidence in the high-socioeconomic group in the present series was 4.1 per cent in the survey of the general population.

It seems clear from the studies on patients and the general population that coronary heart disease has a predilection for the privileged class of society in great contradiinction to individuals of low-socioeconomic group, who enjoy relative immunity from this disease. How these socioeconomic factors operate has been a baffling question in the highly complicated problem of coronary heart disease.

The answer to the relationship of diet to coronary heart disease has been sought in epidemiologic surveys, clinical studies, and metabolic ward experiments. The highest incidence of coronary heart disease has been observed in members of the high-socioeconomic group, who consume the highest amount of

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**Table 3**

<table>
<thead>
<tr>
<th>Dietary Factors in Different Socioeconomic Groups of General Population and Cases of Coronary Heart Disease</th>
<th>Daily fat intake (Gm.)</th>
<th>Percentage calories from fats</th>
<th>Percentage saturated fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary heart disease</td>
<td>69.1±29.1</td>
<td>29.1± 4.2</td>
<td>82.8± 9.6</td>
</tr>
<tr>
<td>High-socioeconomic group</td>
<td>77.1±25.8</td>
<td>32.8± 9.4</td>
<td>86.5±17.9</td>
</tr>
<tr>
<td>Middle-socioeconomic group</td>
<td>60.8±22.8</td>
<td>20.9± 8.6</td>
<td>77.7±15.3</td>
</tr>
<tr>
<td>Low-socioeconomic group</td>
<td>51.8±19.3</td>
<td>15.1±13.8</td>
<td>52.1±16.0</td>
</tr>
<tr>
<td>Industrial</td>
<td>40.4±14.2</td>
<td>16.9± 4.9</td>
<td>49.0±14.3</td>
</tr>
<tr>
<td>Manual</td>
<td>56.6± 6.9</td>
<td>22.4± 5.7</td>
<td>59.6±24.3</td>
</tr>
</tbody>
</table>

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Mean Lipid Values in Cases of Coronary Heart Disease and Normal Controls

<table>
<thead>
<tr>
<th>Serum lipids</th>
<th>Coronary heart disease</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total serum</td>
<td>218±52.4 (114-350)</td>
<td>182.6±38.2 (96-275)</td>
</tr>
<tr>
<td>cholesterol (mg. %)</td>
<td>9.46±1.92 (5.3-14)</td>
<td>8.44±2.49 (5-11)</td>
</tr>
<tr>
<td>phosphorus (mg. %)</td>
<td>24.1±3.21 (19.8-29.4)</td>
<td>21.7±2.18 (17-27.2)</td>
</tr>
</tbody>
</table>

dietary fat, the highest percentage of fat calories and saturated fat. But on subgrouping of each socioeconomic group on the basis of dietary fat intake, it was observed that the serum lipid level did not show a corresponding rise with the rise in dietary fat consumption.13

Although the total quantity of fat, percentage of calories contributed by fat, and percentage of saturated fat may have an important relationship with coronary heart disease, other factors like total caloric intake, relative rate of caloric expenditure, physical activity, emotional status, and hormonal influences cannot be easily isolated from the problem of excessive fat intake. Consequently the epidemiologic studies do not give a convincing answer to the relationship of dietary fat and coronary heart disease.

In India the dietary habits of people have not changed significantly during the last decade or two, but with the advance of modernization, industrialization, and urbanization, physical labor has been curtailed considerably, and people are exposed to greater stress and strain. These may be important factors in the increasing incidence of coronary heart disease.

Summary

Various factors relating to coronary heart disease were investigated in 2 groups of patients: 553 patients with clinical coronary heart disease and 1,056 persons selected in a field survey of the general population. The incidence of coronary disease was high in the urban population, in the upper socioeconomic classes, and in persons with highest amounts of total dietary fat and highest percentage of calories from dietary fat. Total serum cholesterol, serum phospholipid, and cholesterol/phospholipid ratio were higher in the coronary group.

Finally, it seemed that physical activity was less and emotional stress and strain greater in the patients with coronary disease.

No relation between coronary disease and smoking or alcohol was established.

Summario in Interlingua

Varie factori relate al morbo cardiae coronari eseva investigate in 2 gruppo de patiente. Le prime consisteva de 553 patiente con clinicemente manifeste morbo cardiae coronari, le secunde consisteva de 1,056 subjecto selige in un investigation profiliari del popolacion general.

Le incidence de morbo coronari eseva alte in le population urban, in le classes socio-economicamente superior, e in gruppo de subjecto con le plus alte totales de grassia dietari e le plus alte procentages de calorias ab grassia dietari. Le valores pro cholesterol total del sero, pro phospholipido soral, e pro le proportion de cholesterol a phospholipido eseva plus alte in le grupo coronari.

Finalmente, il pareva que le activate physic eseva inferior e que le stress emotional eseva superior in le patiente con morbo coronari.

Nulle relation eseva constata al inter morbo coronari e le uso de taboco e de alcohol.

References


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**An Awareness of the History of Medicine**

A physician is inevitably wrapped in the fabric of the history of medicine, for in his daily undertakings he comes face to face with the experience of his predecessors who effectively pursued the art and the science of both practice and research. The observational and constructive methods that he uses in creating a case through careful history taking may bring to his mind, if he is well oriented, the contributions of Plato, Aristotle, Hippocrates, Galen, Maimonides, Vesalius, Harvey, Leeuwenhoek, Boyle, Pasteur, Virchow, Sydenham and many others.

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It is a way of building a bridge between the practice of medicine and the humanity of science. There are distinguished physicians today who, though preoccupied with immediately practical or scientific problems, reap a sense of deep personal satisfaction in following the long course of medical history back through the Renaissance and the Middle Ages to Greco-Roman periods of thought and action. . . . The exercise of the intellect in this manner will focus his attention on the deductive and inductive methods, the dogmas, the tenuous speculations, the working hypotheses and the experiments themselves that led to the growth or the retardation of medical history.

Paul, the apostle, in his first epistle to the Thessalonians uttered the well known thought, "Prove all things; hold fast that which is good." This counsel is particularly applicable to those who tend to worship the present and to scorn the past. The present may indeed represent the high, immediate mountain view of medicine, but for all that the valleys of the past and the smaller mountain ranges that confine them are willy-nilly part of the present. A mere awareness of Greek, Hebraic, Arabic and Christian traditions as they relate to the present will give a physician a sense of pride in his calling and a feeling of being nearly complete in his total capabilities as he concerns himself with ethics, scientific education or patient-physician relations.—Editorial. New England Journal of Medicine 257: 290, 1957. (Reprinted with permission of the Publishers.)

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