

Stress and Coronary Heart Disease

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There has been a rapid increase in the rates of illness and death due to coronary heart disease in most Western countries. Several factors such as a diet rich in fat, hypertension, age, male sex, increased serum cholesterol, cigarette smoking and a sedentary life have been associated with coronary heart disease. The evidence relating psycho-social stress to coronary heart disease is briefly reviewed. It seems likely that long-term behavioural arousal, associated with aggressive competition between men, and a sense of urgency interact with other factors such as diet and cigarette smoking to produce the various manifestations of coronary heart disease, but the physiological mechanisms are uncertain.

1. Introduction

Coronary heart disease (CHD) is the most common cause of death in Australia and many other economically developed countries. The incidence of CHD has increased considerably over the last 50 years, and although some of this increase may be attributed to greater awareness of the disease and to better diagnosis, this cannot account for the whole of the increase (Hipsley *et al.* 1966, Wynn 1967). It is estimated that there are now some 400,000 Australians who suffer from CHD, if the prevalence in Busselton, Western Australia, can be extrapolated to other parts of the country (Welborn *et al.* 1969).

Many explanations for this modern epidemic have been offered. All must take into account the fact that it is an epidemic affecting mainly the economically advanced countries of the Western world. It is generally conceded now that CHD is due to the interaction of multiple factors none of which, by itself, is 'the cause' of CHD, but all of which may be associated with it in individual patients or in whole populations. Throughout the world considerable amounts of money have been spent in trying to elucidate the nature of CHD and its causation, with some success: but there remain large areas of ignorance and uncertainty. One of the difficulties in this research is that there are several different diseases which are often considered together under the name of CHD—these include angina pectoris, myocardial infarction or coronary occlusion, and sudden death due to certain abnormalities of the rhythm of the heart beat. These disorders may not have the same causes. Even the name CHD may be misleading, for in a sizeable proportion of cases of sudden death and myocardial infarction there is no obvious disease of the coronary arteries (Baroldi 1969).

The National Heart Foundation of Australia (1971), acting largely on the results of research work in the U.S.A. and a few Western European countries, has listed the 'known' risk factors in CHD as follows:

- increasing age,
- male sex,
- family history of CHD,
- diabetes,
- cigarette smoking,

sedentary habits,
blood pressure above normal,
elevated blood lipid concentration,
electrocardiographic abnormalities.

It is interesting that stress is omitted from this list. Further, the NHF of Australia (1971) has stated: 'Few doctors, however, believe that the evidence at present available clearly incriminates any form of emotional stress as an important factor in coronary heart disease'.

Yet, in private practice many doctors seem to place considerable emphasis on the consequences of 'high pressure living' and stress in terms of CHD. There is publically expressed doubt but covert recognition of the fact that some aspects of the way people feel, think and behave affects their likelihood of suffering from CHD. One reason for the difficulty in accepting that psycho-social stress is important in CHD is that there is no generally accepted way of measuring such stress. Some of the measures used to date have provided suggestive evidence, but none has provided proof of a causal relationship with CHD.

I would like to outline some of the problems and methods which have been used to study the effects of psycho-social stress in relation to CHD. I shall do this from the point of view of an applied human physiologist interested in the physiological components and concomitants of different behavioural states.

2. Community Surveys of Coronary Heart Disease

Over the last 15 years several large-scale community surveys have been undertaken by teams of research workers in different countries, including one survey in progress in Busselton, Western Australia. Recognizing that CHD is influenced by many factors, these surveys have attempted to measure the characteristics of healthy people which may be shown at a later date to be predictors of their development of CHD. The results of most of these surveys have been very similar, although only a few have included measurement of the psycho-social characteristics of their subjects. Without wishing to discuss each survey in detail, I would like to mention one from which the results have recently been published to illustrate the sort of difficulties encountered in this research.

A community survey was carried out in Evans County, Georgia, U.S.A. (Cassel 1971). The prevalence of CHD among 92% of the population of that county (more than 3000 people) was assessed in 1960-62, at the same time as various biochemical, physical and social parameters were recorded. The same 3000 people were re-examined in 1967-69 and the new incidence of CHD was related statistically to each subject's characteristics measured 7 years earlier. Evans County is mainly a rural district where the white population has one of the highest rates of CHD in U.S.A., whereas the rate among negroes is low. The main purpose of the study was to find out the cause of this racial difference.

Starting with 20 of the physical characteristics and laboratory tests which are commonly thought to be risk factors in CHD, a stepwise discriminant analysis was used to determine the best combination of these factors to predict CHD in white men (Kleinbaum *et al.* 1971). Many variables such as obesity and systolic blood pressure were eliminated because their influence was

accounted for by their close association with other significant predictors of CHD. The interaction between diastolic blood pressure and age, a person's smoking history, presence of ECG abnormalities, and the interaction of his age and serum cholesterol concentration predicted that there should be 70 new cases of CHD expected in the population of white males examined in 1960-62, when in fact there were 71 cases observed.

However, as a test of validity in another population, the same predictive model was used among the male negro population. It predicted that there should be 54 new cases of CHD in the 7 years when there were only 13 observed. That is, on the basis of their measured blood pressure, age, cigarette smoking, serum cholesterol and ECG abnormalities the negroes should have had four times as much CHD as they did. This provided strong evidence that in no simple sense could the best predictors of CHD in the white population be considered to be the 'cause' of their CHD. These factors are neither necessary nor sufficient by themselves to explain each new case of CHD. They may be important only in so far as they are associated with or interact with other factors which were not included in the predictive model in Evans County.

One important finding in the latter survey was that differences of diet, and particularly the proportion or amounts of saturated fat in the diet, could not explain the racial difference in CHD. It has been suggested that differences in the usual levels of physical activity and long-term psycho-social stress may explain why the only white men in Evans County to have an incidence of CHD as low as that seen among negroes were 'sharecroppers'—men who were low on the social scale for white men and who presumably had a considerable amount of physical exertion in their work (Cassel 1971). However, manual work and low socio-economic status, by themselves, do not always provide protection against CHD.

The reason for our failure to answer many questions about the causes of CHD may be that we are asking the wrong questions—at least with respect to the role of psycho-social factors.

3. Indices of Stress and Coronary Heart Disease

Investigations into the relationship between stress and CHD have been of three main types:

- (1) the search for psycho-social characteristics which distinguish people with CHD from others;
- (2) investigations among people who are thought to live under high or low levels of stress to see if their incidence of CHD is affected;
- (3) investigations into the relationship between stress and the other factors which are known to be associated with CHD, e.g. blood pressure, serum cholesterol, smoking history.

Examples from each of these categories are outlined below.

3.1. *Coronary-prone Behaviour*

As early as the 19th century William Osler, a famous physician of the day, stated that he could make a diagnosis of angina solely by the appearance and bearing of a patient as he walked into the consultation room. The man with angina was 'not the delicate, neurotic person . . . but the robust, the vigorous in

mind and body, the keen and ambitious man, the indicator of whose engine is always at full speed ahead' (Osler 1892).

In recent years this idea has been elaborated in considerable detail by Friedman and Rosenman (1971). They have defined a pattern of behaviour called Type-A Behaviour Pattern which is associated with the risk of developing CHD, regardless of the level of other risk factors such as serum cholesterol, smoking and ECG abnormalities (at least in men up to middle-age). This behavioural pattern or style of life is characterized by extremes of striving for achievement, competitiveness, aggressiveness (which may be repressed from overt expression), haste, impatience, extreme alertness, a feeling of being under the pressure of time and under the challenge of responsibility. Such a person grapples confidently with life's problems, especially with his work. Friedman and Rosenman believe that this Type-A behaviour pattern is not simply a personality trait, but arises when certain environmental conditions of challenge, and social rewards for overcoming them, are present—as in the U.S.A. and Australia. The opposite extreme from Type-A behaviour is called Type-B. Extremes of behavioural type are not restricted to any one group in American society, although the prevalence of Type-A behaviour is high among business men striving towards the top of their ladder (Friedman *et al.* 1971).

In a prospective study, middle-aged men with Type-A behaviour had more than twice as much CHD, especially myocardial infarction, than men with Type-B who were almost totally immune to CHD if their serum cholesterol was not elevated (Rosenman *et al.* 1970). Type-A behaviour was associated to some extent with high serum cholesterol, but both variables made an independent contribution to the prediction of CHD. Unfortunately, a self-administered questionnaire defining these Types of behaviour failed to predict CHD in another prospective study (Jenkins 1971). Thus it seems that while the characteristics of Type-A behaviour are readily observed in some people, they have little awareness of any differences in their own behaviour compared to that of others.

3.1. *Personality Inventories and Prediction of CHD*

The Minnesota Multiphasic Personality Inventory (MMPI) is widely used as a means of describing many different personality characteristics at the same time. Ostfeld *et al.* (1964) used the MMPI in a prospective study of CHD among middle-aged men in U.S.A. They found that healthy men who developed angina during the follow-up period had higher scores on some scales of the MMPI initially, suggesting more neurotic illness than in men who remained free from CHD. However, men who developed myocardial infarction were indistinguishable from controls. The importance of carrying out prospective rather than retrospective surveys was emphasized by the finding that there was a considerable change toward more neurotic illness after CHD symptoms appeared.

Brozek *et al.* (1966) also used the MMPI in a prospective study and found that men who later developed CHD, especially those who had a fatal episode of CHD, were more neurotic than controls. However, it seems that manifest anxiety is not a long-term characteristic of people who will develop CHD. Whatever their psychological characteristics are, they are not consistently related to individual scales on personality inventories such as the MMPI.

Nevertheless, there is evidence that an episode of depression, associated with difficulties at work or in family life which seem insurmountable, may precede myocardial infarction of sudden death in many instances (Wolf 1971).

3.3. *Life Dissatisfaction and CHD*

Blohmke *et al.* (1969) found that men with CHD differed from controls in feeling that their work was tedious, and usually being ill at ease there. However, this was a retrospective survey and the results may reflect the more critical and complaining nature of men who have already suffered from CHD.

Sales *et al.* (1971) reported that those occupational groups which had higher job dissatisfaction had higher rates of mortality from CHD than other groups, regardless of social class.

Other parameters of tension in people's lives have been derived from measures of their social mobility and status incongruity. As an example of the importance of social mobility Syme *et al.* (1964) found that among men with a white-collar occupation who were born in urban U.S.A., those with at least four changes in their job or two geographical moves over a period of time had significantly more CHD than other men. This relationship remained significant after allowance was made for any differences in their blood pressure, smoking history or dietary fat intake. As an example of status incongruity, a man is more likely to develop CHD if he has received less rather than more education than his wife (Bruhn *et al.* 1966). Such a man has characteristics which place him on more than one status level at the same time, a situation which often seems to be a source of long-term tension.

Several investigations of CHD among people in different socio-economic classes, without regard to their social mobility, have produced conflicting results (Jenkins 1971). In whole communities CHD appears to be more common at higher socio-economic levels than at lower levels but even this difference can change with time. In the Evans County Survey described earlier, a significant difference in the prevalence of CHD between the highest and lowest social classes in 1960-62 had disappeared by 1967-69, perhaps as a result of changes in the pattern of rural life which have been observed over that period (Cassel *et al.* 1971).

By contrast, employees of particular urban industries often have more CHD at lower socio-economic levels (Pell *et al.* 1963). Thus, social status is not related to psychological stress or CHD in any simple or constant way in different groups of people.

4. CHD in People under Psychological Stress

The period of mourning after the death of a spouse is commonly a period of prolonged distress for the surviving partner. During the first 6 months after bereavement widowers have been found to have seven times the mortality rate of age-matched controls. The majority of these excess deaths involve CHD (Murray-Parkes *et al.* 1969).

By contrast, there is a very low incidence of CHD (particularly myocardial infarction) associated with the serene life of Benedictine or Trappist monks, regardless of their diet which in some cases resembles that of the general community (Russek 1967).

5. Effect of Stress on other Risk Factors in CHD

The concentration of cholesterol in serum seems to be affected by diet, especially by dietary fat. However, there is evidence that psychological stress also tends to increase serum cholesterol, even when the diet is held constant (Friedman *et al.* 1958, Wolf *et al.* 1962).

In a longitudinal study of naval underwater demolition trainees, Rahe *et al.* (1971) found positive correlations between each subject's serum cholesterol and his reported mood and feelings of depression, anger, fear and lethargy, over a period of 2 months. Thus, it seems that any form of emotional distress is associated with increased serum cholesterol over prolonged periods.

Many of the problems in studying the relationship between stress and CHD have been encountered also in the study of hypertension. The prevalence of hypertension does not always follow that of CHD—for example, in Japan hypertension is common but CHD is not. Nevertheless, both epidemiological and experimental studies have shown that elevated arterial blood pressure is related to environmental conditions which are perceived as threatening, or requiring some adaptation (Henry *et al.* 1969, Gutman *et al.* 1971). This is reflected in a different incidence of hypertension in urban as compared with rural populations (Gampel *et al.* 1962) and in groups with different socio-economic status in the same community (Langford *et al.* 1968).

Continual recordings of blood pressure during the day and night in people going about their usual daily lives have shown how variable blood pressure is, particularly in response to situations involving social interactions with other people (Bevan *et al.* 1969, Sokolow *et al.* 1970). The mechanisms producing these variations are uncertain, but probably involve increased secretion of the catecholamines, adrenaline and nonadrenaline (Nestel 1969), the secretion of which is known to be increased by emotional arousal of any kind (Levi 1965).

6. Possible Nature of the Stress Related to CHD

Two of the most important predictors of CHD, increased blood pressure and serum cholesterol, are related to emotional arousal in a non-specific way. A person need not be highly neurotic nor obviously anxious to undergo these changes in bodily state. Thus, our concept of stress must be broadened to include diffuse states of increased arousal lasting, perhaps, for years. It is this prolonged state of alertness in facing life as a struggle, aggressively and with a sense of urgency, which commonly forms part of the life-style in Western countries, especially in North America and Australia. In the past men have had this life-style more commonly than women, although this may change with the so-called liberation of women—a liberation which may carry with it increasing rates of CHD.

Whether, or by what means, this life-style is causally related to CHD has not been conclusively demonstrated. The same can be said of increased serum cholesterol, although a role in the production of coronary atherosclerosis seems probable. There are other biochemical and psychological changes in response to stress such as increased secretion of hormones from the adrenal cortex. These may be involved in CHD by their influence on the ionic composition of myocardial cells, lessening their ability to withstand reduced oxygen supply from coronary arteries narrowed by atherosclerosis (Raab 1970). In his

paper, Mr. Goodyear discusses the sensitivity of the adrenal cortex to changes in psychological state, emphasizing the fact that whether or not a person feels life to be stressful depends not so much on the circumstances of his actual environment and social situation, but on the way he perceives these things—and this is what makes so difficult the study of human stress as it is implicated in CHD.

Accepting that there is a statistical association between psycho-social stress and CHD, we must not be too definite about the causal nature of this relationship in the absence of further evidence at this stage. Other factors such as a diet rich in fat, lack of exercise with consequent inefficiency of the whole cardiovascular system, and smoking may act as independent risks or, even more likely, interact with stress to produce CHD (Russek 1967, Raab 1970).

There is a need for more research in human physiology with the whole person being taken into account. We need to know much more about the mental and bodily reactions of people going about their daily lives, eating their usual meals and engaging in their usual daily routine with its frustrations and challenges, punishments and rewards. Only with this information obtained over prolonged periods from people in various socio-economic positions and under different environmental conditions will the relationships between stress and illness, including CHD, be established. This research will be technically difficult but surely not impossible.

Dans la plupart des pays occidentaux, on a constaté un accroissement rapide des taux de morbidité et de mortalité dû à des affections coronariennes. Plusieurs facteurs en ont été rendus responsables: un régime alimentaire trop riche en lipides. L'hypertension, l'âge, le sexe (masculin), l'hypercholestérolémie, le tabac, une vie trop sédentaire.

Cet article passe brièvement en revue des recherches montrant que le stress psycho-social peut également jouer un rôle favorisant l'apparition des coronaropathies. Il semble qu'un niveau d'activation comportementale prolongée, associé à la compétition agressive entre les hommes et au sentiment d'urgence et de presse, interagisse avec d'autres facteurs tels que le régime alimentaire et la fumée de cigarettes pour produire les différentes manifestations des coronaropathies, mais les mécanismes physiologiques restent encore à élucider.

In den meisten westlichen Ländern hat ein rapider Anstieg in der Häufigkeit von Krankheit und Tod aufgrund von Herzkranzgefäßerkrankungen stattgefunden. Mehrere Faktoren wie fettreiche Ernährung, Hypertonie, Alter, männliches Geschlecht, erhöhter Cholesterinspiegel, Zigarettenrauchen und sitzende Beschäftigung sind mit Herzkranzgefäßerkrankungen in Zusammenhang gebracht worden. Die Darlegungen, die psychologisch/soziale Anspannung mit Herzkranzgefäßerkrankungen zusammenbringen, werden kurz besprochen. Es scheint wahrscheinlich, daß langfristige Verhaltensanregung in Zusammenhang mit aggressiver Konkurrenz zwischen Männern und ein Gefühl der Dringlichkeit eine Wechselbeziehung mit anderen Faktoren wie Ernährung und Zigarettenrauchen hat, um die verschiedenen Manifestationen der Herzkranzgefäßerkrankung hervorzubringen, doch sind die physiologischen Mechanismen ungewiß.

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