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Ætiology of Coronary Artery Disease: An Historical Approach

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The incidence of coronary artery disease and the number of deaths that it causes have been increasing throughout the Western World. Some of this increase has been paralleled by an increase in total population and in the proportion surviving into middle and late life. There have been many recent changes in the pattern of living and among the factors particularly incriminated are increasing use of sugar (Yudkin, 1957), rising tobacco consumption (Doll and Bradford Hill, 1956; Hammond and Horn, 1958), excessive consumption of animal fats (Katz, Stamler, and Pick, 1958), and lack of adequate exercise (Morris *et al.*, 1953). Supporting epidemiological studies have for the most part utilized contemporary comparisons of these factors in different communities. In the present communication the significance of the factors listed is considered on an historical basis. Predominant attention is given to relevant developments in England and Wales during the past three centuries.

Angina Pectoris—Early Descriptions and their Significance

The only Graeco-Roman description of chest pain associated with a sense of impending dissolution is that of Caelius Aurelianus (Drabkin, 1950), and there were no accounts of angina by mediaeval or renaissance physicians. The case of the Earl of Clarendon was the only one described in seventeenth century England (Major, 1945). There was no clearly recognizable account of angina in a series of patients prior to Heberden's in 1768. Heberden was one of the most learned physicians of his day and by 1768 a Fellow of the Royal College of Physicians of London of 22 years' standing as well as a Goulstonian and Croonian lecturer. He nevertheless described angina pectoris in his *Commentaries* (1802) as a condition which "hitherto hardly had a place . . . in medical books" and was able to quote but two possible earlier accounts, neither of which mentioned chest pain. Fothergill in 1781 referred to angina as "the disease which Dr. Heberden has so fully described". The absence of any systematic prior description is particularly remarkable in view of the dramatic nature of angina as recognized even in the early accounts: Heberden (1802) observed the fear of death during attacks and documented deaths that did, in fact, occur in association with the pain. The absence of descriptions of angina before 1768 could be due to one of two causes: either angina pectoris first made its appearance at about that time, or it was prevalent previously, but contemporary physicians lacked the clinical acumen necessary to recognize it.

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Clinical Acumen—The Eighteenth Century and Earlier

In an attempt to gauge the likelihood of a prevalent condition being unrecognized, comparison of the historical status of angina with that of two other conditions was made. The first selected was gout because, like coronary artery disease today, it has been associated with overeating and under-exercising (Cadogan, 1771), and its victims have since been found to be particularly prone to develop coronary artery sclerosis and angina (Osler, 1907). The second selected was migraine because, like angina, it presents as a distinctive symptom complex but is without visible outward manifestations of disease.

Gout was described in antiquity by a number of authorities including Hippocrates, Galen, and Caelius Aurelianus. Celsus recommended avoidance of corpulence, and treatment was discussed in the renaissance era by Paracelsus. Graunt in 1662 remarked that while "not above one in one thousand die of gout, many die gouty", and Sydenham ob-

served the frequent association with kidney stones and, on occasion, anuria (Copeman, 1964), noting that gout was most common in elderly people living lives of luxury. Distinguished sufferers included Lord Burghley, Milton, Oliver Cromwell, Walpole, and Samuel Johnson. The eighteenth century has been described by Copeman (1964) as "the golden age of gout".

It is possible that in past eras migraine was confused with headaches due to other causes. Nevertheless, an association between headaches and visual and abdominal disturbances was recognized in antiquity by Galen and many others. Alexander of Tralles described hemicrania, the concept of unilateral headaches being implicit in the term and the name migrana was already in use in Roman times (Balyeat, 1933). In the seventeenth century John Locke discussed its treatment (Dewhurst, 1963). Heberden included an account of migraine in his *Commentaries* (1802). It is as comprehensive as his account of angina. He noted that liability to attacks may be lifelong and recorded the association with fortification spectra and "great disorders of the stomach". Of greatest importance, however, for the present discussion, is the way in which he alludes to migraine as a well-known and familiar disease. In this respect, the contrast with his approach to angina is striking.

In the eighteenth century and earlier, knowledge of basic sciences may have been primitive, ideas about causation of disease being speculative and therapy irrational. Symptom complexes and disease entities were often confused. However, clinical description, as exemplified by gout and migraine, was of a high order. That a symptom like angina pectoris could have gone unobserved seems particularly unlikely in view of its dramatic features, fully recognized at the time the disease was first described. The remarkable absence of systematic descriptions before 1768, therefore, raises the distinct possibility that angina pectoris first made its appearance to any appreciable extent in the second half of the eighteenth century and had hardly existed previously.

Angina Pectoris—The Next 150 Years

During the century and a half that followed Heberden's description, angina pectoris was apparently not just somewhat uncommon, but exceedingly rare. At the time of his original description in 1768, Heberden had only seen 20 cases despite having been in practice for 29 years. By 1782 he had seen less than 80 more, or about 6 a year. Not all of these were necessarily patients with coronary artery disease. They were victims of angina pectoris irrespective of cause. Withering (1785) was acquainted with angina pectoris and referred to it by name. However, only 2 of the 218 patients whose histories were detailed in the *Account of the Foxglove* had chest pain, though all had œdema—probably of cardiac origin in the majority. No mention was made of angina pectoris by Cullen (1792) in his all-embracing classification of disease.

Late in the nineteenth century Balfour (1876) saw only 2 cases in Edinburgh Royal Infirmary and did not mention it in an introductory analysis of 200 cases of heart disease. Osler (1910) had not seen a single patient before becoming a Fellow of the Royal College of Physicians of London—12 years after beginning clinical work.

Between 1901 and 1910 deaths in England and Wales attributed to angina pectoris averaged 842 a year (Registrar-General, 1919), or a little over one two-hundredth of the 150,611 deaths due to arteriosclerotic heart disease in 1962 (Registrar-General's Statistical Review of England and Wales, 1962, 1964). The number of patients with coronary artery disease at the beginning of the century may have been even less, as an unknown number of the patients with angina pectoris may have had other causes such as syphilitic aortitis. Angina pectoris was well known to doctors of the day and fully described in standard textbooks of the time, and the severe pain could hardly escape notice. The minority of coronary deaths occurring painlessly or suddenly are the only ones likely to have been overlooked.

Coronary Thrombosis—Early Descriptions and Their Significance

Angina pectoris was exceedingly rare: apparently unknown were attacks of a type associated today with coronary thrombosis, a single attack lasting several hours and neither preceded nor followed by angina. Major (1945) credits Herrick (1912) with the first clinical description of a series of subjects with coronary thrombosis, his 6 patients having single attacks of pain with at any rate short-term survival. This description, dating from as recently as 1912, appeared 32 years after Weigert's account of the pathology. Herrick was himself a student of the history of cardiology and yet, writing many years later (1939), he was only able to report a few individual earlier cases. In 1910, only two years before Herrick's report, Osler devoted his Lumleian lectures to angina pectoris and yet made no reference to coronary thrombosis. In 1915 Clifford Allbutt did not mention it as a clinical entity which he personally had met, though devoting an entire book to *Diseases of the Arteries including Angina Pectoris*. In the United States, White (1957) only saw his first

case in 1921 during his second year of private practice. It seems hardly likely that lack of clinical acumen or ignorance of the pathology could account for this singular omission when physicians of the calibre of William Osler, Clifford Allbutt, and Paul White are concerned. One is drawn strongly to the possibility that early in the present century coronary thrombosis was virtually non-existent. It is noteworthy in this respect that Morris (1951) has reported that between the periods 1908–13 and 1944–49 there was an apparent change in the character of coronary artery pathology as observed in London Hospital necropsies. The earlier series showed relatively more sclerosis of the coronary arteries with extensive calcification, but intraluminal thromboses were rare. In the later series, calcification was less evident, but thrombosis much commoner.

In conclusion, early accounts raise strongly the possibility that angina pectoris first made its appearance in the late eighteenth century and remained exceedingly rare for the next 150 years with coronary thrombosis being virtually non-existent. It remains to examine in this context the factors for which the present high incidence of coronary artery disease is being partly or wholly blamed.

Population

In the eighteenth century the population of England and Wales was much smaller than now and even at the beginning of the twentieth century it had not reached much more than two-thirds of the present level. Deaths from infectious disease in early life were relatively common, and life expectancy was less than now. Nevertheless, the population was numbered in millions and survival to late middle or old age was by no means uncommon. At the time of the Glorious Revolution, Gregory King (1696) made a comprehensive survey of all aspects of English life. He estimated the population of England and Wales in 1688 to be 5,500,000 and those over 60 years of age to number 600,000. Withering, writing in 1785, stated the ages of 150 of his patients; 69 were 50 years of age or older. It is not possible to ascribe the apparent complete absence of angina pectoris 200 and more years ago to failure of people to survive into the ages at risk: the middle-aged and elderly were numbered in their hundreds of thousands.

In the nineteenth century the numbers of the middle-aged and the elderly increased rapidly, and from 1821 on census figures for total numbers at different ages are available (Table I). At a time when angina pectoris was exceedingly rare and coronary thromboses apparently unknown, the middle-aged and the elderly, though fewer than now, were nevertheless numbered in their millions. Deaths from arteriosclerotic and degenerative heart disease in 1962 were almost 200 times as numerous as deaths from angina pectoris in 1901–10. The number of people aged 50 or more increased but threefold during this time: from 4,790,000 in 1901 (Mitchell and Deane, 1962) to 14,158,000 in 1961 (Central Statistical Office, 1962). Only a very small part of the increasing incidence of coronary artery disease can be explained by reduction in the death rate from other causes and consequent increase in the number of middle-aged and elderly at risk.

TABLE I

NUMBER OF PERSONS 50 YEARS OLD AND OVER IN ENGLAND AND WALES (IN THOUSANDS)*

Year	Males	Females	Total
1821	720·7	765·7	1,486·4
1851	1,204·4	1,342·8	2,547·2
1901	2,205·3	2,584·7	4,790·0
1951	6,897·4	5,317·9	12,216·3

* Mitchell and Deane (1962).

Sugar

Sugar consumption in mediæval times was negligible. Production for the European market only became significant in the sixteenth century with introduction of the sugar cane into the newly discovered West Indies. Its popularity grew in the eighteenth century with increasing use of tea and coffee. Calculation of national sugar consumption is comparatively easy. Production from home grown beet sugar only became significant in the last century. In earlier times, therefore, import statistics relate directly to actual consumption, though they are necessarily underestimates as smuggling was widespread.

Table II shows per capita sugar consumption over the past two and a half centuries. The rise in the eighteenth century was more than threefold, and the subsequent increase almost eightfold. The

TABLE II

PER CAPITA CONSUMPTION OF: (a) SUGAR, (b) TOBACCO (LB./YEAR)

Area	Year	Sugar	Year	Tobacco
England and Wales	1700*	4·1	1700†	2·0
Great Britain	1793‡	14·70	1786†	0·7
	1809–13‡	20·96	1800†	1·1
Great Britain and N. Ireland	1938‡	100·51	1924†	3·0
	1962§	111·7	1938‡	4·0
			1962§	5·2

* Calculated from data reported by Trevelyan (1946).
† Rive (1926).
‡ Mitchell and Deane (1962).
§ Central Office of Information (1964).

data are therefore compatible with there being an association between rising sugar consumption and a rising incidence of coronary artery disease.

Tobacco

For the period under review calculation of national tobacco consumption is not unduly difficult. As import duties were an important source of revenue, home tobacco production was prohibited between 1661 and 1910 and illicit plantations uprooted. In consequence, import statistics relate directly to actual consumption, though, as with sugar, they are underestimates, as smuggling may have accounted at times for up to 25 per cent of all tobacco brought into the country.

Tobacco consumption since 1700 is shown in Table II. There was a decline during the eighteenth century, but subsequently consumption increased steadily, and the ways tobacco is used have changed. In the eighteenth century most was smoked in pipes, both sexes indulging. The remainder was chewed or taken as snuff. The early nineteenth century saw the introduction of cigars, a decline in the use of snuff, and restriction of smoking to men. In this century, cigarette smoking has become the rule amongst both men and women. In the United Kingdom, over-all tobacco usage has increased two and a half times since 1900 (Rive, 1926; Central Office of Information, 1964), but consumption of cigarette tobacco has increased almost twentyfold from 0·2 lb. per head per annum in 1900 to 3·9 lb. in 1960 (McCurdy, 1958). The incidence of fatal coronary artery disease is higher among cigarette smokers than among non-smokers (Table III), and the incidence increases with the number of cigarettes used (Doll and Bradford Hill, 1956; Hammond and Horn, 1958). There is no association between pipe smoking and coronary mortality, while cigar smokers occupy an intermediate position (Table III). Data are not available concerning the coronary mortality of people habitually chewing tobacco or using snuff, but the changes in *smoking* habits over the centuries have been from the kind associated with *no* increased liability to death from coronary disease, to the intermediate form, and then to the type that *is* most closely linked with a high coronary death rate. However, in Britain, the extent of the increase associated with cigarette smoking is such that it could at most account for a rise of 23 per cent in coronary disease mortality rates (Table III) during this century.

Fat Consumption

Current epidemiological studies suggest that communities with a high incidence of coronary artery disease are ones with a high consumption of animal fats, and communities with a low incidence are ones with a low consumption (Katz *et al.*, 1958). It is therefore pertinent to inquire into fat consumption before 1768 when coronary artery disease, as manifested by angina pectoris, was apparently unknown, and during the century and a half after 1768, when it was apparently very rare. The best starting point for such an inquiry is the comprehensive late seventeenth century survey of all aspects of English life by Gregory King (1696). King estimated the average meat consumption to be 3¼ oz. (90 g.) per day, or 82 lb. (37 kg.) per year. The poor were then very poor indeed, but those able to afford food in plenty were not an insignificant minority. King (1696) calculated that about half the population, some 2,700,000, ate flesh regularly, their consumption averaging 147½ lb. (67 kg.) per year, or 8 lb. (3·6 kg.) more than the combined national average of meat, bacon, ham, and poultry consumption in 1962 (Central Office of Information, 1964). The total value of dairy products consumed yearly was £2,500,000 or almost 10 shillings per person—at a time when milk cost a penny a quart this must have represented an average annual consumption of about 300 lb. (136 kg.) of milk or its equivalent in cheese or butter. The corresponding figure for 1962 was 356·6 lb. (161·6 kg.) (Central Office of Information, 1964)—less than 20 per cent more. It is probable that with society less egalitarian than now, the more fortunate half of the community's consumption of dairy products was well above average, just as it was with meat.

TABLE III

RATIO OF OBSERVED TO EXPECTED DEATHS AMONG MALE SMOKERS

Authors	Country	No. of subjects	Follow-up (average in months)	Observed/expected deaths (non-smokers = 1·00)		
				Pipe only	Cigars only	Cigarettes only
Hammond and Horn (1958)	U.S.A.	187,783	44	1·03	1·28*	1·70*
Doll and Bradford Hill (1956)	U.K.	34,494	53	1·00	—	1·23

* Difference from non-smokers statistically significant.

TABLE IV

FAT CONSUMPTION IN 1900 AND 1950

	Social grouping	Ratio of adults to children	Year	Fat consumption (g./day)	Per cent of calories derived from fat
Adults	Servant-keeping class	—	1900	162·2*	37·4*
	Households with no children (all classes)	—	1950	118‡	39·2†
Adults and children grouped together	Servant-keeping class	2·54:1·00	1900	122·8*	37·4*
	Head of house earning £13 weekly or more	2·72:1·00	1950	109‡	39·8†

* Calculated from data reported by Rowntree (1901).
† Calculated from data reported by National Food Survey Committee (1962).
‡ Reported by National Food Survey Committee (1962).

King's findings suggest that for over half the population the consumption of animal foods in 1688 was about the same as now—if not greater. It is probable, therefore, that their consumption of animal fats was about the same as now or greater, even if allowance is made for possible changes in the composition of animal foods over the centuries.

Drummond and Wilbraham's (1939) findings are similar. They estimated that the St. Bartholomew's Hospital diet in 1686, hardly likely to have been the most liberal, contained 110 g. of fat daily. This was completely of animal origin and identical with their estimate of the fat content of the average British middle-class diet shortly before the Second World War.

If Deane and Cole's (1962) estimate that London accounted for 10 per cent of the meat eaten in England and Wales is accepted, calculations based on Smithfield sales suggest an average national consumption for the years 1751 to 1760 of 75 lb. (34 kg.) per person—excluding bacon, ham, and poultry. It is probable that, as in 1688, the more fortunate half of society ate substantially more than the average and exceeded the 1962 mean national meat consumption of 97·7 lb. (44·3 kg.) per person (Central Office of Information, 1964).

With the Enclosures, the exodus from the countryside and the growth of the industrial working class, undernutrition became widespread. However, even after the Industrial Revolution, the farming community and the upper and middle classes were not an insignificantly small group. They were numbered in their millions and possibly even constituted a majority. According to the census of 1801 there were over one and a half million people connected with agriculture. Only persons with a net income of over £60 per annum were liable to income tax in 1803, yet 1,059,314 were charged (Deane and Cole, 1962). The Reform Bill of 1832 extended the franchise to the upper and middle classes only, and women were excluded. It nevertheless resulted in 720,784 becoming eligible to vote, and by 1867 the number had reached 1,130,372 (*Encyclopædia Brittanica*, 1960). Rowntree (1901) estimated that in 1900 28·8 per cent of the population of York belonged to the servant-keeping classes. The evidence all points to there having been in nineteenth century England and Wales several million people who could afford to eat well.

At the end of the nineteenth century Rowntree (1901) made a careful study of the food consumption of sample populations living in York, with costing of each item, analysis of budgets, and recording of the nature of individual meals over one to two weeks. He concluded that the poorer half of the working classes was seriously undernourished, but the remainder adequately fed. The servant-keeping classes, 28·8 per cent of the population, ate in excess of their needs. Comparison shows that the percentage of calories derived from the fats in their diets was almost identical with that of the highest social class in 1950; the absolute amount of fat consumed daily was much higher in 1900 than in 1950 (Table IV). If York was in any way typical of the whole country, there were, in 1900, perhaps 10 million people in England and Wales whose consumption of animals fats was excessive by present standards.

The apparent extreme rarity of coronary disease under the circumstances considered must be taken into account by any theory linking the disease with unduly high consumption of animals fats.

Weights

The drawings of Hogarth and Rowlandson, and illustrations in books of the time, suggest that obesity was formerly common. For about the past 70 years, detailed reports about average weights of large groups of people have been available from the United States. Comparisons of recent observations on weights of insurance applicants (Metropolitan Life Insurance Co., 1959) with those recorded in 1897 in the case of men (Shepherd, 1912), and between 1897 and 1912 in the case of

women (Weisse, 1912), shows that any gain in weight has been confined to the shorter men and is of the order of 2 or 3 pounds—at most 5. Among the taller men and among the women there has been a decline in weight. The findings of Morris (1951) in Britain were similar. He found that the weights of London Hospital patients coming to necropsy in the years 1906 to 1914 and those in the 1950's differed very little.

An association between excessive weight and an above average incidence of coronary artery disease has been demonstrated in contemporary short-term follow-up studies (Dawber, Moore, and Mann, 1957). A rising mortality from coronary disease over many decades and affecting both sexes cannot, however, be attributed to increasing obesity when the available evidence suggests that there has not been in fact any such increase.

Exercise

Among the working classes the need for regular physical exercise is becoming reduced by industrial mechanizing, increase in car ownership, and in the availability of domestic appliances. An association between lack of exercise and a rising incidence of coronary artery disease is, therefore, possible, though unproven. This reasoning is, however, invalid when applied to the middle and upper classes among whom the coronary artery disease death rate has been increasing steadily (Logan, 1952). These groups were not previously engaged in manual labour and were, therefore, unaffected by mechanization. Appliances for use in the home may have been unknown, but throughout the eighteenth and nineteenth centuries, domestic help was plentiful. Gregory King (1696) estimated that in 1688, 10·5 per cent of the population of England and Wales were servants. In 1801 they accounted for 11·8 per cent of the labour force, and in 1901 for 14·1 per cent—as opposed to 2·2 per cent in 1951 (Deane and Cole, 1962). Cars may not have existed, but privately owned carriages were plentiful. In 1775 they numbered 18,600 and by 1869 437,602 (Dowell, 1884). Travel by carriage may have been slower and less comfortable than travel by car; it did not involve greater physical effort.

It is unlikely that the middle and upper classes took more leisure exercise than their present descendants. Many of the sports of eighteenth century England, such as boxing, cock-fighting, and badger baiting were spectator sports. Tennis and cricket did not enjoy their present popularity and golf was unknown (Turberville, 1933). Gardening only became popular in the nineteenth century. Riding and hunting were probably the only way in which the upper classes took exercise. There were only 138 packs of harriers and 101 packs of foxhounds in England in 1835 (Trevelyan, 1946), so that hunting could have been the sport of but a small minority even among the privileged. Furthermore, it was usually given up in middle life.

There is no evidence to suggest that the eras during which the middle and upper class incidence of coronary artery disease was apparently much less than now, were eras in which these classes led a physically more vigorous life than now.

Summary and Conclusions

There are almost no clearly recognizable descriptions of angina pectoris before that of Heberden in 1768. A possible explanation is that angina pectoris first made its appearance at about that time, rather than having been prevalent but unrecognized previously. During the next one and a half centuries angina pectoris appeared to have remained extremely rare. Before 1912 coronary thrombosis remained virtually unrecognized as a clinical entity and the possibility must be considered that it had been almost non-existent rather than prevalent but unrecognized.

In the century before 1768 and in the following century and a half, there were in England and Wales a large number of people surviving into middle and late life: the extreme rarity of clinical manifestations of coronary artery disease cannot be explained solely by the near absence of persons "at risk".

Per capita sugar consumption was only about one-eighth of the present level at the time when angina was first described, and its use has increased steadily since. The historical evidence is, therefore, compatible with increased sugar consumption being linked ætiologically with a rising incidence of coronary artery disease.

Tobacco consumption in the eighteenth and nineteenth centuries was less than now and for the most part took the form of pipe and cigar smoking. These have since been found to be associated with little or no increase in liability to death from coronary artery disease, thereby contrasting with the modern practice of cigarette smoking which is so associated. A connexion between changes in smoking habits and rising death rates from coronary disease is, therefore, possible, though insufficient to account for more than a very small part of the increase.

During the century that preceded Heberden's first description and during the century and a half that followed, those whose means allowed—always numbered in their millions and at times about half

of the entire population—had a diet that was as plentiful in animal foods, including animal fats, as are the diets of today. During the decades for which data are available, weights have not changed consistently: there is nothing to suggest that populations as a whole are getting more obese. The middle and upper classes did not obviously engage in physical activity to any greater extent than today. Cognisance must be taken of these historical factors in any theories linking the present high and rising incidence of coronary artery disease with high consumption of animal fats, obesity, or declining physical activity.

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