Special Article

Background of the Prevention of Cardiovascular Disease

II. Arteriosclerosis, Hypertension, and Selected Risk Factors*

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Diet and Arteriosclerosis

The relation of diet to arteriosclerosis has been the subject of studies in animals for over 75 years and of speculation by pathologists regarding disease in humans for a much longer period. Two eminent physician investigators, Soma Weiss and George R. Minot, published a review on "Nutrition in Relation to Arteriosclerosis" in 1933, citing in particular feeding experiments in animals beginning with Ignatowski in 1909 as well as limited data on humans. For the latter category, they concluded that there was "no proof that overnutrition leads to arteriosclerosis in man," that "the available studies certainly discredit the theory that a high protein or meat diet is responsible for arteriosclerosis in man," that "statements that fat is responsible for arteriosclerosis are not lacking in the literature, but these statements are not based upon controlled observations," and that "there is no positive or negative information that alterations in the inorganic elements of the diet or that disturbances in the metabolism of salts enhance the development of arteriosclerosis."

This negative approach to the scientific evidence linking diet and arteriosclerosis obviously was not shared by all. Rudolf Virchow, the founder of cellular pathology, had in the mid 19th century expounded his theory that the arterial wall imbibed substances from blood passing through it, leading to reactive degenerative changes that included a fatty metamorphosis of connective tissue cells. In 1925, Mjassnikow of Leningrad observed not only that patients with aortic and coronary arteriosclerosis often had high blood levels of cholesterol but that these levels might be reduced by diets in which vegetables were the chief foodstuffs. Professor Nikolai Anitschkow, also of Leningrad, performed numerous investigations on rabbits and was able to produce lesions similar to those of human arteriosclerosis by feeding cholesterol dissolved in vegetable oil. He wrote in 1933 that "atherosclerosis is not essentially of degenerative nature but rather of an infiltrative character," and, like Virchow, that "there is also under normal conditions a constant stream of liquid passing through the walls of the arteries in the direction from the lumen to the adventitia," and that "from the morphological point of view arterial cholesterol atherosclerosis in rabbits is in many respects analogous to human arteriosclerosis." Indeed, he later described "the two processes as analogous in all essential respects" and believed his findings to "provide valuable indications in respect to prophylactic and therapeutic measures."

Quite similar conclusions were reached by the pathologist Timothy Leary of Boston. In his Ludwig Heiktoren lecture of 1935, Leary summarized his many years of experiments on rabbits and his observations of human autopsy material. After discussing arteriosclerosis as a possible metabolic disease, similar to diabetes, he went on to say

This discussion of arteriosclerosis, dealing as it does with the harmful effects of cholesterol overdosage, cannot be closed without calling to attention the fact that cholesterol is an important food substance, as necessary as the carbohydrates, fats, proteins and mineral elements of the dietary. All the cholesterol needed by the cells of the human body is ingested. Milk and eggs are wholesome foods to which the human race is accustomed and which are necessary sources of cholesterol. As one advances in years, the needs for this substance appear to grow less. In general, apart from the susceptibles, it is the abuse, the overeating of these foods, as is true in the case of other food substances, that is likely to produce disease.

A fellow Bostonian and vigorous clinical investigator, Elliott P. Joslin had written a few years earlier a broad indictment not of cholesterol but of fats in relation to diabetes and arteriosclerosis:

I believe the chief cause of premature development of arteriosclerosis in diabetes, save for advancing age, is due to an excess of fat, an excess of fat in the

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body, obesity, an excess of fat in the diet, and an excess of fat in the blood.

In mentioning obesity, he was echoing the long-held view that it was deleterious—an impression documented by Dublin in 1931 in a classic publication based upon life insurance data that revealed an excess of deaths for circulatory disease, strokes, nephritis, and diabetes in overweight male policy-holders above that seen in individuals of "normal" weight.

A leading investigator in this whole area was Ancel Keys of the University of Minnesota. After 15 years of varied basic physiologic studies, Keys in 1948 began to publish with his colleagues the results of metabolic and epidemiologic observations relating diet to atherosclerotic disease. He early emphasized that prevention through dietary means might best be achieved through "less rather than more"; and although there was an important relation between atherosclerosis and the serum cholesterol level, he stressed in 1950 that the "blood cholesterol level is independent of the intake of cholesterol over a wide range." Indeed, he wrote that "it is doubtful whether the most so-called low cholesterol diets in current use reach critical levels or have significant utility." In 1952, he concluded, much like Joslin, that "a substantial measure of control of the development of atherosclerosis in man may be achieved by control of the intake of calories and of all kinds of fats with no special attention to the cholesterol intake." Subsequently, his long-term investigations pointed to an excess of both calories and saturated fats as the chief dietary culprits. Others, notably Kinsell and Ahrens and their associates, also found, like Mjassnikow in 1925, that whereas increased consumption of unsaturated fats from vegetable sources contributed to a fall in serum cholesterol levels, substitution of isocaloric amounts of saturated fat of animal origin had the reverse effect.

These basic studies provided the foundation of the dietary approach to the prevention of atherosclerosis in most of the second half of the 20th century. This early evidence was summarized by Katz, Stamler, and Pick in 1958, when they recommended that high-risk individuals should correct their obesity, if present, and should reduce the quantities of saturated fat in their diets. The weight of the evidence from the animal and human studies also induced the American Heart Association to issue in 1961 its first (and cautious) statement on "Dietary Fat and Its Relation to Heart Attacks and Strokes," a document essentially containing the advices propounded by the above investigators. In addition to its condemnation of obesity, the key sentence in the document was:

the reduction or control of fat consumption under medical supervision, with reasonable substitution on poly-unsaturated fats, is recommended as a possible means of preventing atherosclerosis and decreasing the risk of heart attacks and strokes.

During the next 25 years, as sophisticated approaches to the understanding of the nature of lipids and of lipid-tissue relations developed, similar recommendations were made by other groups and with increasing application to the public at large and not just to high-risk populations. The subject of diet and its effect on atherosclerotic disease became a highly discussed and popular area, involving not just physicians and allied health personnel but also profit-making books, food products, drugs, preventive programs, etc. The pursuit of good arterial health became a food business. However, the topic of the relation of diet to atherosclerosis and of what to do about it was to remain somewhat controversial, a fertile field for certain skeptics.

Hypertension

Hypertension has to be recognized to be treated and to prevent its complications. The clinicians of the 19th and early 20th centuries estimated the presence of an elevated peripheral arterial pressure by palpation of the pulse. The limitations of this method were well expressed by one physician who said, "I can estimate the blood pressure with the fingers quite accurately in about eight of 10 patients, but those in which it is of real importance are always the other two." Instruments for measuring blood pressure began to be developed in the second half of the 19th century by the work of Vierordt (1855), Marey (1876), von Basch (1887), and Pottain (1895). It was the Italian scientist Riva-Rocci who in 1896 introduced the inflatable rubber bag that was wrapped around the upper arm and connected to a manometer, thereby bringing the sphygmomanometer into practical use. However, as late as 1909, Sir Lauder Brunton observed that "the ordinary method of ascertaining blood pressure is to put three fingers upon the radial pulse." Brunton also wrote, "it is in cases of high tension that the sphygmomanometer is especially useful. Like the storm signal at a seaport, it gives timely warning of dangers to come."

Documentation of such "dangers" began to be obtained through the increased recording of the blood pressure. An important early study was that of J.W. Fisher, medical director of the Northwestern Mutual Life Insurance Company, who reported in 1914 that his company began to take blood pressures on applicants in 1906. He found that in the years from 1907 to 1910, 2,661 applicants aged 40 to 60 years were accepted for life insurance coverage with an average systolic pressure of 142 mm Hg and that a subgroup of 525 applicants with an average systolic pressure of 153 mm Hg showed by 1914 a 30% excess above the "general average mortality." He also commented that "we have received but little diagnostic value in our work from low pressure."
Important also was the recognition early in the 20th century of the existence of primary hypertension of idiopathic origin, labeled by Frank of Wiesbaden in 1911 "essentielle Hypertension." That this category and not definable renal disease with secondary high blood pressure was the principal cause of hypertension in the community gradually became apparent. Eventually, from such pioneer beginnings came a succession of clinical, insurance, military, and other population testaments to the hazards of both systolic and diastolic hypertension for the brain, heart, and kidneys. Specifically, the data showed an increased death rate from cardiovascular and renal causes with levels of systolic and diastolic pressure initially considered benign, with a progressively increasing mortality the higher the values found. Further, although the correlation of hypertension and deaths from strokes was obvious relatively early, it also became apparent starting with the uncontrolled observations of Allan in 1934 that "hypertension should be considered a major factor in the etiology of both angina pectoris and coronary occlusion."

A first step in the prevention of morbidity and mortality from hypertension could be a reduction in its amount and severity. As with rheumatic fever, such a favorable (and unexplained) change actually began well before specific measures of intervention were developed. Starting in 1940, death rates in the United States for hypertensive disease (and cerebrovascular diseases) began to decline substantially for white men and women in all adult age groups and to a lesser extent for nonwhite individuals. Similar declines were seen in other countries, chiefly those with high initial rates.

The eventual development of efforts to prevent the complications of hypertension—stroke, heart attack, and renal vascular disease—emphasized both recognition of the presence of high blood pressure in the individual and of its treatment. There was some early concern that the new gadget, the sphygmonanometer, was being used too often, and the findings served only to frighten the patient. This was true even though the pioneer insurance company data had shown the value of the casual office blood pressure reading as a guide to potential cardiovascular disease. However, Sir Thomas Lewis wrote in 1937,

Patients in whom high blood pressure is found should rarely be informed of the fact . . . The habit of following blood pressure by frequent readings during treatment and of allowing patients access to such readings is strongly to be deprecated. The patient becomes obsessed by blood pressure, and the manometer is regarded as the gauge of health.

The importance of the casual blood pressure for the physician and the patient of course was enhanced when effective pharmacotherapy became available. Thus, as it became known in the United States that perhaps one half of individuals with hypertension did not know of its existence, campaigns were developed to educate the health professions and the public regarding the hazards of unrecognized and untreated hypertension and the need for prolonged regular treatment for those afflicted, typified by the National High Blood Pressure Education Program conducted by the National Institutes of Health beginning in July 1972. In 1975, the month of May was designated as National High Blood Pressure Month. These programs, and efforts by the American Heart Association and its affiliates, made a significant impact on public and health profession awareness of the problem.

The second aspect of prevention involved the availability of drugs capable in many instances of converting hypertension to normotension. Before 1949, physicians had at their disposal unsatisfactory means of therapy including barbiturates, thiocyanates, veratum alkaloids, the rice diet, and thoracolumbar sympathectomy. In rapid succession from 1949 to 1957 came a series of effective agents including rauwolfia (1949), hydralazine (1950), new powerful autonomic blocking agents (1950), and chlorothiazide (1957). Frequently, two or more drugs might be administered simultaneously. Thus, a new era of pharmacotherapy was ushered in, one which continued to expand during the next 40 years. Evidence that such treatment did indeed have a favorable influence on morbidity and mortality was finally obtained by the critically important Veterans Administration study headed by Freis and published in 1967.

The third aspect was that of primary prevention, the last to be confronted and the least to be documented in terms of scientific data. As noted above, there was good evidence that, for obscure reasons, deaths from hypertensive diseases and strokes began to decline in the United States in incidence about or before 1940. This trend, and with it a reduction in deaths from coronary heart disease, has continued, in part at least attributable to the increasing pace of recognition and treatment of high blood pressure by the medical and allied health professions. There is no evidence that national changes in salt or alcohol intake, or reductions in body weight, have contributed to this process. It may be important, however, that deaths from chronic nephritis also declined beginning early in the 20th century, thus reducing one reservoir of potentially hypertensive persons.

United States data from the national Health Survey of 1960–1962 and the Nutrition Examination Surveys of 1971–1974 and of 1976–1980 showed significant reductions in mean systolic blood pressure during this period for both genders and for white and black races. For example, the age-adjusted mean systolic blood pressure for white men aged 18–74 years was 133 mm Hg in 1960–1962 and was 129 mm Hg in 1976–1980, and the blood pressure for black men was 138 mm Hg and 130 mm Hg, respectively. It is tempting to conclude that these findings explain the favorable mortality trends.
However, there were no consistent changes in diastolic pressure during the same time frame, and the overall age-adjusted proportion of adults with elevated blood pressure (systolic pressures equal to or greater than 140 mm Hg or diastolic pressures equal to or greater than 90 mm Hg) was essentially the same.

The international data on mortality trends in hypertension and its complications do not show universal improvement. However, as Rose has commented, international "trend data on blood pressure are so weak that we are driven to use stroke mortality as a proxy," and "the decline in stroke mortality is unfortunately by no means universal."

Primary prevention may be taking place in some countries, including the United States where both stroke and coronary disease mortality have fallen sharply. This is probably partly with a targeted intervention approach and partly without.

Exercise

The role of physical exercise in the management and prevention of cardiovascular disease has been controversial until recent decades. A review of some of the older literature shows views that are decidedly contrasting.

In 1879, J.M. Fothergill of London published The Heart and Its Diseases, With Their Treatment: Including the Gouty Heart. Although he, like most authors, did not address the role of exercise in prevention, he wrote, "Rest is of the greatest value in all forms of organic disease of the heart," and "If a man with a diseased heart follows a laborious employment, he must be counselled to abandon it for a less trying one." Also, in reference to early stages of disease, he wrote, "it is only necessary to economize the body-forces, by diminished exertion, the avoidance of all causes of exertion." William Osler in the first edition of his famous The Principles and Practice of Medicine published in 1892 laid the blame for some cases of aortic valve disease, and of cardiac dilatation and hypertrophy, on physical exertion. Regarding the former, he wrote,

A very important factor, particularly in the case of the aortic valves, is the strain of prolonged and heavy muscular exertion. In no other way can be explained the occurrence of so many cases of sclerosis of the aortic valves in young and middle-aged men whose occupations necessitate the over-use of the muscles.

And with regard to the latter he wrote,

There is a group of cases of dilatation and hypertrophy dependent upon prolonged overexertion, which rarely comes under observation until compensation has failed, and which then may be very difficult to distinguish from the similar conditions produced by valvular disease.

The 1927 edition of Cecil's A Text-Book of Medicine included the admonition for persons with chronic myocardial disease of rheumatic, syphilitic, arteriosclerotic, or hypertensive origin to "avoid all overtaxation of the heart." On the subject of coronary occlusion were the words:

If death does not result after a few days or a week, recovery is to be expected. Recovery may be so incomplete that the patient dies from congestive heart failure in a few weeks or months. In other cases it is sufficient to allow the patient to lead a greatly restricted life for a few years.

Typical of the attitude of less distinguished medical minds, and of lay men and women, were the following quotations from a book on the heart published in 1934 and intended to educate the public:

Physical strain is likely to induce serious damage in an adolescent heart. Overindulgence in tennis, swimming and wrestling, may so stress the heart that the valve leaflets fail to approximate and a functional murmur results. Repeated physical overstrain aggravates the heart condition and persistent striving in sports will lay a foundation for the athletic type of heart which thereafter is never again fully efficient when at rest. . . . The continual putting forth of physical effort is a most common cause of middle age breakdowns of the heart . . . Rest is the most valuable and dependable remedy on earth for heart hurts.

Quite different views were expressed by others who did not share these concerns for the deleterious cardiac effects of exercise. In 1854, William Stokes of Dublin in writing about fatty degeneration of the heart stated,

We must be cautious in too narrowly limiting the powers of nature . . . The symptoms of debility of the heart are often removable by a regulated course of gymnastics, or by pedestrian exercise, even in mountainous countries such as Switzerland, or the highlands of Scotland or Ireland.

In 1897, W.H. and F.J.H. Broadbent stated in their volume entitled Heart Disease and Aneurysm of the Aorta the following in relation to valvular disease:

The principle on which recommendations must be based will be to interfere as little as possible with the avocation, habits, and mode of life of the patient, as long as these are not injurious, and especially to allow a maximum of exercise in fresh air compatible with safety. Nothing can be worse than to debar all patients who are found to have valvular disease from games and vigorous exercise, and to forbid them to go upstairs or to walk uphill, and on no cases do I look back with greater satisfaction than on those, and they have not been few, in which I have liberated boys and girls from such orders.

In relation to angina pectoris, the Broadbents wrote, "Whatever exercise the patient can take without provoking an attack at the time, or prostration afterwards, he will be the better for."
Mackenzie, writing in 1910, expressed similar thoughts:

The heart, like every other organ, becomes more efficient with reasonable exercise of its functions... In the great majority of cases of serious heart failure, even after recovery has set in, the judicious employment of muscular exertion is beneficial.

The person who was the most responsible in the 20th century for promoting physical exercise as a means to health and especially cardiovascular health was unquestionably the cardiologist Paul Dudley White of Boston. Without conducting scientific studies on the subject, he became convinced from his observations of many patients, as well as from his own personal experience, that a routine of regular physical exercise was an important ingredient in the maintenance of good physical and mental health and in the prevention of cardiovascular disease. Further, he believed, like the Broadbents, that many patients with heart disease were made invalids unnecessarily. He was a champion of physical exercise that was moderate in its demands, readily available, inexpensive, and generally pleasurable—such as walking, bicycling, and golf. He urged that such activities should be undertaken on a regular and not a fitful basis. He began to spread this message to the health professions in the 1920s and soon thereafter to the public at large. Because he was articulate and energetic and endowed with a convincing and charming personality, he was extraordinarily influential.

In 1927, he wrote somewhat cautiously, "Exercise as an aid in maintaining good health is beneficial in heart disease providing there is cardiac reserve sufficient to permit it." Two years later, he was more definite:

Exercise to keep fit.... To have good muscles and a freely moving diaphragm, not obstructed by abdominal fat, is an important and vital element in maintaining good health and in aiding the heart and blood vessels in their work.

Thereafter, he was the leading voice in the cause, frequently speaking to and writing for lay groups about this favorite topic of his. The veritable flood of interest in exercise and physical fitness in the United States after World War II was in good measure attributable to the Paul White message, a message accepted with enthusiasm by literally millions of people. When President Dwight Eisenhower had a heart attack in 1955 and Paul White was his consultant cardiologist, Paul White used the extraordinary visibility surrounding the episode to push his philosophy. It was thus natural that after a period of convalescence, President Eisenhower returned not only to the White House but also to the golf course.

A pioneer in population studies of physical activity at work and its effect on cardiovascular disease was J.N. Morris of the Social Medicine Research Unit of the Medical Research Council of Great Britain. In 1953, Morris and his collaborator published an analysis of the cardiac health histories of London transport and postal workers, contrasting more active conductors and postmen with less active drivers and sedentary grades. Further information on body physique of members of these groups was added in 1956, and 2 years later, data were added from a limited national necropsy survey that were correlated with records of the last occupations of the deceased. The investigators developed from these efforts the hypothesis that physical activity of work is a protection against coronary (ischemic) heart disease. Men in physically active jobs have less coronary heart disease during middle-age, what disease they have is less severe, and they develop it later than men in physically inactive jobs.

Mortality data from another population, namely physically active and sedentary employees of the railroad industry, were reported in 1962 by Taylor et al., ending with the similar hypothesis "that men in sedentary occupations have more coronary heart disease than those in occupations requiring moderate to heavy physical activity."

These and other early investigations were reviewed in 1964 by Fox and Skinner with the conclusion that "the evidence that increased physical activity might be beneficial to cardiovascular health is sufficient to justify further extensive studies." Such studies, including the study of leisure time activity, were shortly undertaken by many other investigators, especially Paffenbarger et al. The thrust of their findings has been to provide scientific support to the belief of Paul White and the hypothesis articulated by Morris.

Cigarette Smoking

During the first decades of the 20th century, the smoking of cigarettes was viewed dimly, not because of any possible harm to health, but because of the implications that smoking was somehow morally wrong. That there was something more important for the heart and lungs than this puritanical view began to be known during the 1920s when there were suggestions by Fahr (1923), Tylecote (1927), and Lickint (1929) among others that tobacco smoke may be carcinogenic. In 1939, Müller of Cologne wrote a major paper in which he showed a significant history of heavy cigarette smoking among 86 lung cancer patients compared with 86 age-matched control subjects. Further evidence was provided in 1939 and 1941 by the similar experience reported by Ochsner and DeBakey. Thereafter, the lung cancer and smoking relation was extensively documented and confirmed.

The relation between heart disease and the smoking habit was confirmed more slowly. A brief paper by Pearl appeared in 1938 based upon observation of 6,813 men, observations which were only sketchily described. He concluded that "the smoking of
tobacco was statistically associated with an impairment of life duration, and the amount or degree of this impairment increased as the habitual amount of smoking increased." Specific reference to coronary heart disease and smoking (nearly all of cigarettes) was first made by English, Willius, and Berkson\textsuperscript{55} of the Mayo Clinic in 1940, who reviewed the clinic records of 1,000 men aged 40 years and over with a diagnosis of angina pectoris, or recent or old myocardial infarction, and they compared these with the records of 1,000 age-matched men without evident coronary heart disease. These investigators showed both more smokers among the younger (aged 40–49 years) of their coronary cases than among the control subjects and a positive relation of the incidence of clinical coronary disease to the amount of smoking. It is interesting to read the comments of the four discussors when this was first presented. Two of them were clearly skeptical, one distinguished professor (who was one of my teachers) saying that the history of smoking "does not justify a conclusion that the smoking per se is a causative or even a contributory agent of coronary disease." Of course, at that time, the concept of smoking as a risk factor for heart disease was new, and the amount of data was retrospective and limited.

The first impressive documentation of the hazards of smoking for the heart was the unexpected by-product of a major prospective epidemiologic study of the American Cancer Society organized by Hammond and Horn. This investigation was intended to document the relation between smoking habits and lung cancer death rates as well as with overall death rates. A four-page smoking questionnaire was developed in 1951, and over 22,000 volunteers were recruited and trained to administer it annually to men initially aged 50 to 69 years. Follow-up included examination of death certificates. In 1954, Hammond and Horn\textsuperscript{56} reported on 187,766 men in the study, 4,854 of whom had died. Disease of the coronary arteries was listed as the cause of death in 46\% of the deaths, and it was found that the death rates from coronary heart disease in the age group of 50 to 65 years were approximately twice as high in cigarette smokers as in nonsmokers. Further, the greater the number of cigarettes smoked, the higher was the coronary death rate. Shortly after this, several ongoing population studies of coronary disease produced similar findings. Over time (and it took many years), the consistency of these observations convinced essentially all scientists. Meanwhile, Auerbach with Hammond and Garfinkel\textsuperscript{57} investigated the coronary artery pathology and showed in a cohort of 1,372 men not dying with coronary heart disease as the chief cause of death that "the proportion of men with moderate to advanced degree of coronary atherosclerosis was considerably greater among the cigarette smokers than among the non-smokers."

The historical background of peripheral arterial disease and smoking is actually more ancient than the above, although less well known. In 1893, Henri Huchard\textsuperscript{58} wrote, "The [unfavorable] influence of nicotine on the development of arteriosclerosis appears to have been demonstrated, and this is not surprising since nicotine produces most often arterial hypertension by vasoconstriction, as the experiments of Claude Bernard have proved." Professor Wilhelm Heinrick Erb\textsuperscript{59} of Heidelberg in 1904, after reviewing 45 cases of intermittent claudication and finding that 25 were heavy smokers, concluded somewhat reluctantly that the tobacco habit must play an important causative role. A study of patients with thrombo-angiitis obliterans reported by Weber\textsuperscript{60} in 1916 included the finding that "in nearly every case there is a history of habitual cigarette smoking, and in some cases the patients, owing to being employed in cigarette factories, have been able to smoke large numbers of cigarettes daily without paying for them." Despite this evidence, he concluded that "it is extremely improbable that the cigarette smoking is more than a contributory factor in inducing the disease." By 1928, however, Brown and Allen\textsuperscript{61} writing about thrombo-angiitis obliterans on the basis of extensive experience at the Mayo Clinic concluded that in regard to smoking, "there is sufficient evidence to interdict its use during any stage of the disease." Similar recommendations by Allen, Barker, and Hines\textsuperscript{62} for individuals with peripheral arteriosclerotic disease followed soon thereafter.

It was clear at the outset that mounting an effective program against smoking would not be easy, especially when the habit was so widespread among physicians. Older physicians well remember scientific meetings during the 1940s and 1950s, and later, when the air in conference rooms was literally blue with smoke, the dense haze being penetrated by the bright beam from the projection lantern. In 1956, the American Heart Association issued its first cautious statement on the relation between heart disease and smoking, and this was followed in 1960 by a somewhat stronger version.\textsuperscript{63} On February 27, 1960, the Board of Directors of the National Tuberculosis Association (predecessor of the American Lung Association) approved a strong statement on the relation of cigarette smoking to lung cancer, chronic bronchitis, and emphysema.\textsuperscript{64}

Not surprisingly, with the size and importance of the Congressional delegations from tobacco-growing states, the Federal Government was slow to move in this area of prevention, although the Surgeon General Leroy E. Burney of the U.S. Public Health Service issued a statement on lung cancer and cigarette smoking in 1957 and also in 1959.\textsuperscript{65} However, when the Public Health Service did move, it did so with a crucially important document. Dr. Luther L. Terry, who had become the Surgeon General, served as chairman of a Surgeon General's Advisory Committee on Smoking and Health that in 1964 issued a 387-page report that was widely circulated and had a major impact...
in pointing to the hazards of smoking. In relation to cardiovascular disease and smoking, the statements were couched in careful terminology, such as that it is more “prudent to assume that the established association between cigarette smoking and coronary disease has a causative meaning than to suspend judgement until no uncertainty remains” and also “male cigarette smokers have a higher death rate from coronary artery disease than non-smoking males, but it is not clear that the association has causal significance.” Within 2 years of the report, a national Interagency Council on Smoking and Health had been formed by the several concerned voluntary health agencies, and the Federal Government established a National Clearinghouse for Smoking and Health with an initial (1966) appropriation of $2,000,000. The low-key ambivalent conclusions on cardiovascular disease in the 1964 report were succeeded over the years by increasingly forthright statements, leading in 1988 to Surgeon General C. Everett Koop’s warning that nicotine was as addictive as heroin and cocaine.67

The current status of smoking as a global health problem is not satisfactory. World-wide tobacco production has increased by 37% over the past 20 years, with China by far the largest producer, followed by the United States. Whereas tobacco consumption has nearly leveled off in the major industrial countries, it has almost doubled in developing countries in this 20-year period. Preventive efforts are now legion, including a world-wide effort to increase taxes on tobacco, frequent health warnings on cigarette packages (41 countries), increased restrictions on advertising (47 countries), and some legal limitation on smoking in public places (37 countries). There has been a significant shift to the manufacture of cigarettes delivering less tar and nicotine. Antismoking programs are conducted in numerous work places and many schools, and there are numerous smoking cessation programs, characterized unfortunately by high rates of drop out and recidivism. That these and other efforts have had some favorable effect has been shown in the United States where the proportion of adult men smokers has decreased from 52% in 1964 to 35% in 1983, with a decrease in women smokers from 34% to 30%. It is logical to conclude that the recent declines in the U.S. death rates from coronary heart disease, and lung cancer in men, are in major part a reflection of these and other preventive efforts.

Comment

Thus, the record of achievements in the prevention of cardiovascular disease is more than respectable. It is impressive. During the past 100 years, at least 11 causes of important heart disease have been studied and treated and to a variable extent prevented. These successes represent the fruits of international efforts by scientists from many disciplines. In eight of the areas—rheumatic fever, diphtheria, syphilis, alcohol, diet, hypertension, physical exercise, and smoking—the achievements reflect contributions made by many individuals during a considerable passage of time. In three areas—beriberi, rubella, and cobalt—a breakthrough leading to prevention came rapidly, the results of a few inquiring minds and keen observations. Today, significant problems remain with regard to rheumatic fever, syphilis, alcohol, diet, hypertension, physical exercise, and smoking, which are problems existing as much from needs in education, socioeconomic issues, and difficulties in changing human habits as from deficiencies in scientific knowledge. As is well known, it is easier to prevent with a vaccine or pill or simple dietary modification than to persuade individuals to alter life-long customs. Further, we probably have not recognized all the potentially correctable influences unfavorable for the cardiovascular system. However, the record of the past century and the escalating pace of scientific knowledge are favorable for an ultimately more complete success in prevention than is present today. We must be sure, however, as technology changes our environment, that we do not introduce new factors, like cobalt, which will in turn require their own identification and elimination.

Summary

The prevention of cardiovascular disease antedates our current preoccupation with risk factors for coronary heart disease and hypertension. Indeed, earlier preventive efforts have in part been so successful that many people have forgotten that they existed. The almost forgotten entity, beriberi heart disease, was first prevented in 1883 by Takaki of Japan. With diphtheria, it was the identification of the causative bacillus by Klebs in 1883, leading finally to the development of diphtheria toxoid by Ramon in 1923, which resulted in the disappearance of diphtheritic heart disease. Success in the attack on syphilitic heart and vascular disease began with Bordet and Mengou in 1901 with the discovery of the phenomenon of complement fixation, and with the formulation of Salvarsan by Ehrlich in 1907. The story of the prevention of rheumatic fever has a large cast of characters, but special recognition must be given to Coburn for his observations confirming the role of the hemolytic streptococcus published in 1931 and showing the prophylactic value of sulfanilamide published in 1939. The important association of maternal rubella with congenital heart malformations was revealed by Gregg in 1941. Alcoholic heart disease was identified particularly by Brigden and Evans in 1957 and 1959, respectively. In relation to coronary and hypertensive heart disease, the names of Anitschkow (1933), Leary (1935), and Keys (1948) in relation to diet, of Freis (1967) in the field of hypertension treatment, of White (1927) in relation to physical exercise, and of English, Willius, and Berkson (1940) and Hammond and Horn (1954) in the role of cigarette smoking, deserve special recognition.
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