TOBACCO ANGINA

AN ELECTROCARDIOGRAPHIC STUDY

J. MARION BRYANT, M.D.,* ANN ARBOR, MICH., AND J. EDWIN WOOD, JR., CHARLOTTESVILLE, VA.

SINCE Huchard used the term tobacco angina in 1899,[1] there has been much discussion of the relation which it suggests, but few definitive studies of this relation have been published. A review of the literature reveals only two case reports which present objective evidence of myocardial ischemia during anginal seizures induced by smoking.[2] It is the purpose of this paper to discuss some of the cardiovascular effects of tobacco and some observations in sixteen patients with angina pectoris in whom electrocardiograms were taken immediately after the patient had smoked two cigarettes.

Numerous observers have expressed the opinion that a close temporal relation between the use of tobacco and the onset of cardiac pain is exceedingly rare.[3-5] The majority of articles dealing with tobacco angina present little or no evidence that smoking is a cause of anginal seizures.[1,5-12]

Investigation of the effects of tobacco in man have been concerned mainly with the response of the peripheral vascular system. It is generally agreed that smoking usually induces arteriolar constriction, accompanied by lowering of the temperature of the skin and elevation of the blood pressure, pulse rate,[13-21] and blood sugar.[22] There are, however, various opinions with respect to the particular products of smoking responsible for these phenomena and the mechanisms through which they are effected. The question of an allergic response to tobacco smoke in certain cardiovascular diseases has been raised, but the evidence bearing upon it is inconclusive.[15,16,23-25]

There are many observations indicating that nicotine alone is capable of producing many of the reactions caused by smoking,[16,19,20,26-28] but some investigators believe that the same cardiovascular responses are induced by smoking material that does not contain this drug.[20] The initial effect of nicotine is to stimulate, but its subsequent and more prolonged action is to depress the parasympathetic and sympathetic ganglia, central nervous system cells, and skeletal

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From the Department of Internal Medicine, University of Virginia Medical School, Charlottesville, Va., and the Department of Internal Medicine, University of Michigan Medical School, Ann Arbor, Mich.

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*Formerly Fellow in Cardiovascular Diseases, Department of Internal Medicine, University of Virginia Medical School, Charlottesville, Va.

muscles. The results which follow its administration are, therefore, complex and unpredictable; they represent a varying combination of many different effects.[28] The magnitude of the response to nicotine varies from one time to another.[15,19] Studies of the effects of this drug and of tobacco smoke on the coronary blood flow have yielded conflicting results.[29-31] The complex action of nicotine and the many extrinsic as well as intrinsic factors influencing coronary flow suggests that this approach to the problem of its effects in man is of little value. Furthermore, as has been pointed out,[2] it cannot be assumed that diseased and normal coronary arteries will invariably react in the same way to a given stimulus. Physiologic and anatomic abnormalities are, so it would seem, likely to be found in company.

Statistical studies indicate that coronary disease develops before the seventh decade of life significantly more often in smokers than in nonsmokers[32,33] and that the life span of the former is shorter.[34] Pathologic studies comparing the coronary arteries of these two groups have not been reported. Experiments on animals have brought forth no evidence that tobacco smoke or nicotine produces structural changes in these arteries.[35] After coronary ligation in dogs, there is a pronounced increase in the sensitivity to tobacco smoke and nicotine, as evidenced by cardiac arrhythmias.[36] It has not been proved that smoking has an effect on the coronary vessels comparable to its unquestioned deleterious effect on the peripheral arteries in certain diseases.[37,38]

The most consistent effect of tobacco smoking upon the electrocardiogram of normal subjects is an acceleration of the heart rate with accompanying physiologic changes in the T wave,[19,20,39-42] which involve a reduction in the size; less often, inversion of this deflection. Although it is known that in some persons smoking may raise the pulse rate without altering the blood pressure or cardiac output,[43] these electrocardiographic changes have usually been attributed to increased cardiac work.[19,40,41] These changes have been referred to in a manner which suggests the inference that they are due to a direct effect of smoking upon the myocardium.[4,28,41] However, it has been clearly demonstrated in the case of normal subjects and in the case of the majority of patients with heart disease that the changes in the T wave induced by smoking and those induced by other agents which elevate the resting heart rate to a similar level are alike in kind and magnitude.[44,45] These electrocardiographic phenomena represent a physiologic response which has been studied both from the theoretical and from the empirical standpoint.[45,46] The administration of drugs that slow the heart is accompanied by an increase in the height of the T wave and the administration of those drugs that accelerate the rate is accompanied by a decrease in the height of the T waves. The latter effect occurs even when the drug given belongs to the parasympathomimetic group.[44,47]

There is a sharp difference of opinion concerning the mechanism through which smoking precipitates paroxysms of angina pectoris. One group of observers[3,5,6,41,48] attributes all such paroxysms to increased cardiac work resulting from an elevation of the blood pressure and the heart rate and ignores or discounts the possibility of coronary constriction. Others[1,2] believe that in some instances the occurrence of coronary spasm can hardly be doubted. Moreover,

from the time of Allbutt[6] to the present time[49] the idea has persisted that there is a fundamental difference in the pathologic background between tobacco angina and true angina pectoris.

The most recent paper on the relation of smoking to angina pectoris is that of Pickering and Sanderson.[5] In a detailed study of one patient, they found that smoking was attended by the occurrence of anginal pain only under certain circumstances; that is, only when the subject smoked immediately following the subsidence of a paroxysm precipitated by exercise and while a significant elevation of the pulse rate and blood pressure were still present. From these data, which did not include electrocardiographic tracings, the writers concluded that their "paper . . . has rendered redundant the hypothesis that constriction of the coronary arteries by tobacco is the cause of anginal attacks precipitated by smoking." This conclusion does not harmonize with numerous reports since the time of Heberden[50] to the effect that seizures were witnessed in which "the pulse was not quickened"[50-52] or in which no significant alteration in pulse or blood pressure occurred.[2,53,54]

In 1939, Wilson and Johnston[2] studied two patients with angina pectoris in whom paroxysms and transient electrocardiographic changes, similar in magnitude and in kind to those produced by myocardial infarction, were induced by having the patients smoke. In one of these (Case 5) no alteration in the pulse rate or blood pressure accompanied the electrocardiographic changes. These observers suggested that, in certain instances, changes in the caliber of the coronary arteries or arterioles rather than increased cardiac work must be assumed to explain the attendant myocardial ischemia. Levy and collaborators[55] and Master and co-workers[56] have shown that, in patients with coronary insufficiency, painless myocardial ischemia induced by anoxemia or exercise can be demonstrated electrocardiographically. It is, therefore, possible that if Pickering and Sanderson had made electrocardiographic observations while their patient was smoking, they might have found evidence of myocardial ischemia without pain.

There is considerable evidence indicating that the coronary circulation is regulated by direct vasomotor control as well as by purely mechanical factors.[57-59] It is the opinion of most investigators who have carried out experimental studies of coronary flow in animals that it is diminished by vagal and increased by sympathetic stimulation. The observations of Manning, Hall, and Banting,[60] that vagal stimulation in the intact dog uniformly produces areas of myocardial necrosis, which are most extensive after the prior administration of physostigmine and do not occur when atropine has been given, suggests that coronary spasm may be important in the production of myocardial ischemia. These experiments support the clinical observations of Gilbert,[61] who found that in some cases of angina pectoris the administration of atropine definitely increases the coronary reserve as estimated by the Levy anoxemia procedure. The possibility that smoking may cause coronary constriction by stimulation of the vagi is suggested by Hobbs (quoted by Gilbert),[61] who, in two patients with tobacco angina, demonstrated that atropine given prior to smoking prevented the occurrence of electrocardiographic changes of the type described by Wilson and Johnston.[2]

Moreover, Leary's suggestion,[62] that coronary spasm in the absence of obvious coronary disease may sometimes be responsible for sudden death, emphasizes the importance of more adequate knowledge concerning reflex constriction of the arteries of the heart and the effect of tobacco upon this reaction.

MATERIAL

This report is based on observations in sixteen patients with coronary disease in whom the effect of smoking upon the electrocardiogram was investigated. In no instance did the clinical history indicate a relation between the use of tobacco and anginal symptoms. All of the patients had smoked for a long time, but the majority should probably be considered moderate rather than heavy smokers; some did not "inhale." The series includes substantially all patients with symptoms of the kind indicated who were seen in the electrocardiographic laboratory of the University of Virginia Hospital between September, 1943, and October, 1944, and who presented themselves during a period when time to carry out the required special tests was available. This group is composed of two women and fourteen men ranging in age from 38 to 69 years. The diagnosis of coronary disease was made on the basis of one or more of the following criteria: a history typical of angina pectoris; abnormal electrocardiographc findings at rest; or abnormal electrocardiographic changes precipitated by exercise (Master "two-step"), and anoxemia (Levy), or smoking. In two instances a diagnosis of recent anterior myocardial infarction was made on the basis of diagnostic changes in the precordial electrocardiogram.

METHOD

The tests were performed under uniform conditions. After the patient had rested in the recumbent posture for a time sufficient to give a basal heart rate, a control electrocardiogram consisting of the standard and unipolar limb leads was taken. Immediately thereafter the patient smoked two cigarettes of the brand to which he was accustomed. A second electrocardiogram was taken about ten minutes later when he had finished smoking or sooner if he experienced discomfort in the chest. This test was always carried out at least two hours after the last meal. None of the subjects were under the influence of any medicine which affects the cardiovascular system.

RESULTS

The most frequent response to smoking was an increase in heart rate averaging 10 beats per minute. The maximum increase was 28 beats per minute. In three instances no appreciable change in heart rate occurred. Gross changes in the RS-T segment were recorded twice. These will be discussed in detail later. The amplitude of the T waves in the remaining fourteen patients were measured from the T-P isoelectric level and were corrected for errors in the standardization of the electrocardiograph. A decrease in amplitude of 1 mm. or more in one of the standard leads was present in six instances; the maximum decrease was 2.0

mm. in Lead III and was associated with inversion of a previously upright deflection. In five patients the decrease in amplitude was less than 1 mm. while in three there was an increase in the height of T of less than 1 millimeter. Although these changes were small, their magnitude was directly proportional to the increase in heart rate. This relation has been noted previously.[20,63]

Two 38-year-old men, who presented no objective evidence of cardiovascular disease but complained of precordial pain on exertion, exhibited T-wave changes after smoking similar in character but of lesser degree than those resulting from exercise in one case, and from exercise or anoxemia in the second case. These two cases have been reported in detail in a previous paper.[64]

A number of the fourteen patients who presented T-wave changes associated with an increase in heart rate complained of tingling and coldness of the fingers and toes, sweatiness, nausea, and "dullness in the chest" not typical of angina pectoris.

CASE 1.—A practicing physician first came to the hospital in April, 1929. A diagnosis of psoriasis was made. At that time the blood cholesterol was 178 mg. per cent and the blood Wassermann was negative.

His next visit was in March, 1936, when he was 60 years of age. He then complained of a burning epigastric sensation which occurred when the stomach was empty and which was relieved by alkalies and food; there were frequent episodes of water brash and "heart burn" and occasional bouts of vomiting without hematemesis. There had been no melena. These symptoms had persisted for two or three years. In the two weeks prior to this admission the patient had had an acute febrile illness during which he had been conscious of irregularity of the heart and a mild orthopnea. Physical examination revealed an initial blood pressure of 172/100 which fell to 140/80 on bed rest. The size, rate, rhythm, and sounds of the heart were normal; no murmurs were present. The tonsils were inflammed. Psoriatic changes were present over the elbows. Examinations of the blood, urine, and stool were negative. Gastric analysis showed 7 degrees free and 20 degrees total acid but no other abnormality. Roentgenographic examination of the chest and upper and lower gastrointestinal tract revealed no abnormalities. An electrocardiogram consisting of the three classical limb leads was within normal limits.

On May 24, 1944, this man was seen for the third time. He described his condition as follows: "I can't say just when the pain started but would say it was sometime since the first of the year. I never noticed it before that time and when it first started I tried to attribute it to hyperacidity from which I suffered a great deal. But it was high up under the sternum, in my jaws, and occasionally out in the deltoid muscles. I began to suspicion it was angina since it would come on and leave in a short while, not lasting long. The pain was never very bad so that I would probably take something for it; and it would usually be relieved by sitting down, bending forward, and pressing against the sternum with my hands. It seemed that exertion had very little to do with it, and I was frequently in the habit of going over to my orchard (which is a steep mountain orchard) and walking for an hour or two without precipitating an attack." This discomfort occurred as often as twenty or forty times a day and could not be correlated with any particular activity or habit. He used two packages of cigarettes per day.

The physical findings at this time were essentially the same as those recorded eight years previously. A moderate degree of peripheral arteriosclerosis was present. Over the course of a hour the blood pressure varied from 220/95 to 180/85. The blood Wassermann and Kahn tests were negative. Laboratory studies revealed no abnormalities. Orthodiagraphic cardiac measurements (Kurtz) showed the heart to be of normal size, and fluoroscopic examination demonstrated no abnormality of the heart contour or lung fields. The thoracic aorta was dilated to a moderate degree.

An electrocardiographic study consisting of the standard and unipolar limb leads and multiple unipolar chest leads from a series of points extending from the right border of the precordium

around the left chest to the scapular line showed no definite abnormalities (see Fig. 1). A few minutes afterward, while the electrocardiographic film was being developed and inspected, the patient began to smoke a cigarette. After only a few puffs he remarked that a squeezing substernal pain, an aching at the angle of both jaws, and a choking sensation had developed. A second electrocardiograph was immediately taken. However, the discomfort lasted only two or three minutes and disappeared before all leads were recorded. This tracing showed that, although

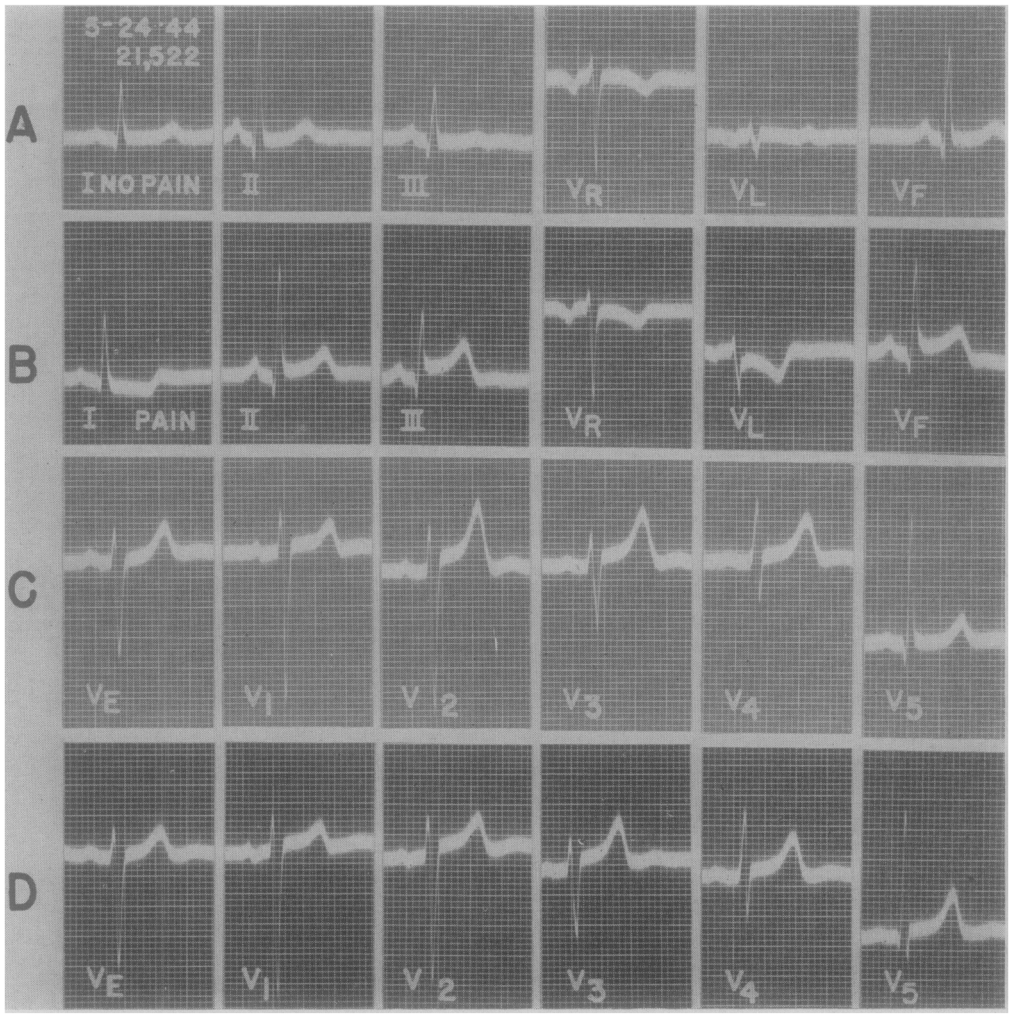

Fig. 1.—Case 1. Electrocardiograms taken before and during anginal seizure precipitated by smoking a cigarette. *A*, Limb leads before and, *B*, during smoking. *C*, Unipolar chest leads before and *D*, during smoking. Leads V_6, V_7, and V_B are not shown.

the heart rate had not changed from the control speed of 57 beats per minute, pronounced RS-T depression in Lead I and RS-T elevation in Leads II and III had appeared. The unipolar limb and chest leads, however, showed no RS-T displacement, although they were obtained as quickly as the recording of from eight to twelve beats per lead permitted. While still recumbent, the patient then smoked another cigarette. After he had inhaled only two puffs, the discomfort

returned. He was asked to continue smoking, in spite of the pain, while another complete set of limb and chest leads was obtained. The discomfort continued while he smoked and disappeared within a few minutes after finishing the second cigarette. The discomfort was "not severe." No blood pressure determinations were made during the paroxysm.

The electrocardiograms obtained during the second episode of discomfort are reproduced in Fig. 1. The standard leads show RS-T displacement identical with that obtained during the first paroxysm. The unipolar limb leads also show RS-T displacement, although it was not recorded in these leads during the previous seizure. After correction for standardization, the unipolar chest leads exhibit slight reduction in the amplitude of the T waves in Lead V_1, moderate reduction in Leads V_2 and V_3, slight increase in Leads V_4, V_5, V_6, and V_7, and no change in Lead V_8.

An intracutaneous test, using extracts of tobacco of ten popular brands of cigarettes, produced a wheal approximately 1 cm. in diameter and without pseudopodia. This reaction was interpreted by Dr. Oscar Swineford as being of questionable significance.

The patient was informed of the significance of the foregoing observations, but he was not convinced that his symptoms were precipitated by smoking. While driving home he smoked six cigarettes and experienced the same discomfort each time. Finally, having convinced himself that his seizures were induced by smoking, he ceased smoking altogether.

In a letter dated March 13, 1945, he wrote: "In spite of doing everything that you told me not to do except smoking, I have just gotten along fine, haven't had a pain. Work sixteen hours a day, eat irregular, pull the mountains or stairsteps with no discomfort whatever."

CASE 2.—A passenger train conductor, aged 62 years, was first seen as an outpatient on May 29, 1944. Six months previously he noted for the first time a squeezing substernal sensation associated with choking and pain at the angles of both jaws. It occurred in the evening when he was walking up a slight incline on his way home from work. This discomfort would promptly subside with rest or if he took nitroglycerin. In the succeeding months it appeared at more frequent intervals and was precipitated by progressively smaller amounts of exercise. Dyspnea did not accompany these episodes of pain. Large meals decreased the amount of exercise required to induce them. Approximately four weeks before he came under observation, the symptoms, previously associated only with exertion, began to appear regularly just after he lay down in bed at night and made it necessary for him to sit up or to take nitroglycerine for relief. The patient was not aware of any relation between smoking and the onset of discomfort.

His only other complaint was long-standing "gaseous indigestion" after meals. This symptom was relieved by belching initiated by sodium bicarbonate. He also stated that he had been informed a number of years previously that he had "high blood pressure." Nocturia of two or three times was present.

On examination, the heart was of normal size, a soft systolic murmur was present at the apex, and there was slight accentuation of the aortic second sound. The blood pressure was 150/70. The peripheral areteris were markedly sclerotic and tortuous. The eye grounds were not unusual. The liver edge was 2 cm. below the right costal margin on inspiration but was not tender. The lung fields were clear on fluoroscopy. No dependent edema was present. Examinations of the urine and blood were normal. The Wassermann and Kahn tests were negative. Orthodiascopy (Kurtz) showed that the area of the cardiac silhouette, in the frontal plane, was 15 per cent above the predicted normal for men of the patient's height and weight. This finding, however, was interpreted as within normal limits. There was a slight degree of dilatation of the thoracic aorta.

Routine electrocardiographic studies made with the subject recumbent and consisting of the classical leads, unipolar limb leads, and chest leads V_2, V_4, and V_5 were within normal limits. While still recumbent the patient was given a cigarette. Shortly after inhaling only a very few puffs he complained of severe squeezing substernal pain and of choking and aching at the angles of both jaws. The discomfort subsided in about ten minutes after he stopped smoking. Electrocardiographic tracings obtained while the discomfort was present show a slight increase in the heart rate, a decrease in the amplitude of the T waves, and depression of the RS-T segment, most pronounced in the chest leads.

After this information was obtained, the patient was again questioned as to the circumstances under which he usually experienced chest pain, and especially in regard to the effects of smoking. He stated that for several years he had been in the habit of smoking only two cigarettes a day, but these were consumed just before he retired at night. He insisted that he had never associated the chest discomfort with smoking.

On the following day, May 30, 1944, further electrocardiographic studies were carried out. Standard and unipolar limb leads, and unipolar chest leads from a series of points extending from the right sternal border around the left chest to the left scapular line, were within normal limits (Fig. 2). The subject then smoked his favorite brand of cigarettes while Lead V_5 was recorded continuously for two minutes and thereafter at two-minute intervals. This lead was chosen because it had shown the most pronounced changes on the previous day. A depression of the RS-T segment, measuring about 0.5 mm., was first noticeable one minute after the subject began to smoke (Fig. 3). However, chest discomfort did not appear until one minute later when the RS-T depression increased to 1.5 millimeters. The subject continued to smoke for twenty minutes, in spite of severe discomfort, and consumed several cigarettes. In addition to the symptoms previously described, he noted numbness of the right hand which occurred twenty minutes after he began to smoke. At this time he stopped smoking and 1/100 gr. of nitroglycerine was administered. The pain subsided gradually over the next thirteen minutes and ceased thirty-three minutes after it first came on. The RS-T depression in Lead V_5 increased to a maximum of 2.0 mm. approximately ten minutes after the onset of pain. The heart rate before smoking was 76 per minute. During the period of discomfort it varied between 84 and 94 per minute and, after the administration of nitroglycerine, it did not increase but gradually returned to the control level. No blood pressure readings were made.

A second complete set of tracings taken between twelve and twenty minutes after the beginning of the test shows changes identical with those exhibited by the curves of the previous day. It displays depression of the RS-T segment in Leads I, II, III, V_L, V_F, V_2, V_3, V_4, V_5, V_6, V_7, and V_B and elevation of this segment in Lead V_R. The voltage of the T waves decreased in Leads I and V_L and in all the chest leads but increased in Lead II. In Lead III the originally negative T waves became positive. Intracutaneous tests with tobacco extracts gave results similar to those obtained in Case 1.

The patient was seen for the last time in March, 1945. He had limited his activities and had discontinued the use of tobacco. He was taking aminophylline; nevertheless his attacks continued to occur with about the same frequency.

A patient previously reported by Wilson and Johnston[2]* was recalled and was re-examined on July 11, 1946. This man, an attorney, now 57 years of age, developed angina pectoris in 1938. The paroxysms were not related to emotion or to exertion. They were most likely to occur when he had gone to bed at night. He obtained relief by standing up and by belching, which he often induced by taking sodium bicarbonate or nitroglycerine. He gave a history of gaseous indigestion from his twenty-fifth year. Studies carried out in February, 1939, showed transient electrocardiographic changes, precipitated by smoking, similar in magnitude and character to those observed in acute posterior myocardial infarction. These changes were not accompanied by subjective symptoms or by changes in the pulse rate or blood pressure. More pronounced changes of a similar kind were, however, recorded during an apparently spontaneous attack of anginal pain.

Although the patient had been advised to give up the use of tobacco, he continued to smoke an average of one package of cigarettes per day throughout the succeeding seven years. When seen in July, 1946, he stated that he had continued to have anginal attacks similar to those described, but had never noticed any relation between smoking and the onset of the paroxysms.

Electrocardiograms taken on July 11, 1946, showed only minor changes when compared with the routine tracings obtained in 1939. The T wave in Lead I had become diphasic and a small Q wave had appeared in Lead II. At this time the smoking of three cigarettes produced neither symptoms nor changes in the electrocardiograms, blood pressure, or heart rate.

*See their Case 5.

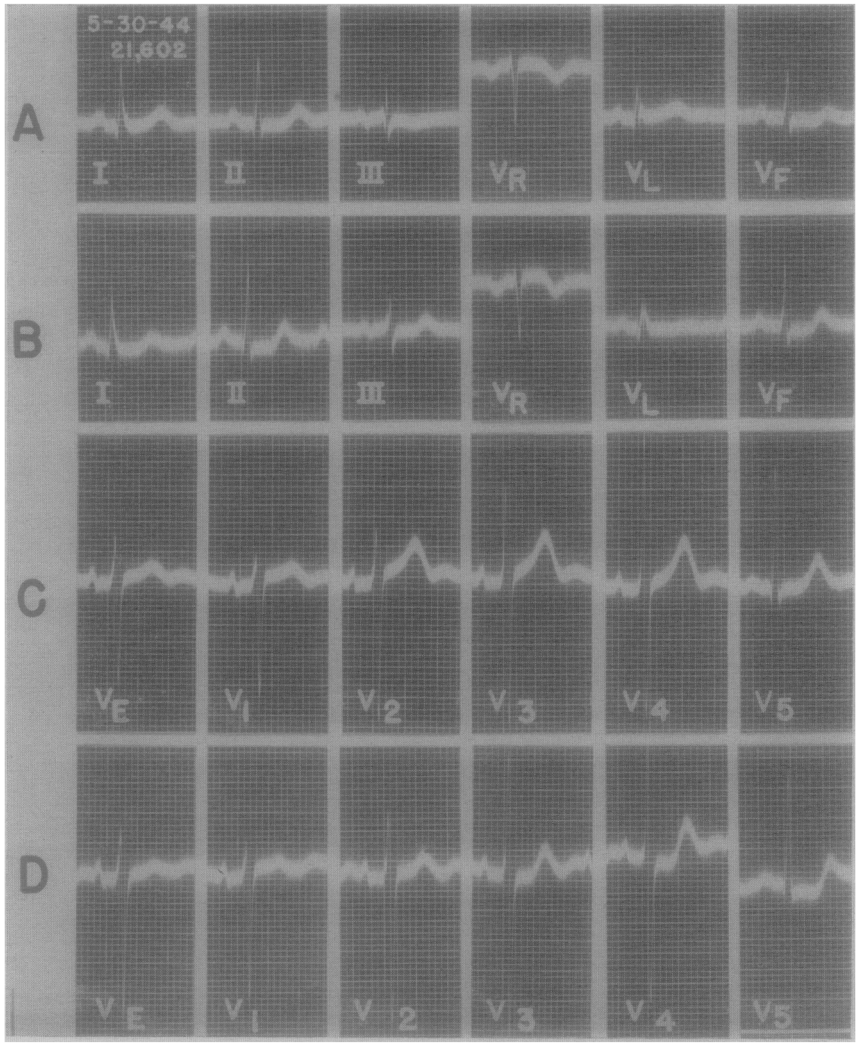

Fig. 2.—Case 2. Electrocardiograms taken before and during attack induced by smoking. *A*, Limb leads before and, *B*, during smoking. *C*, Unipolar chest leads before and, *D*, during smoking.

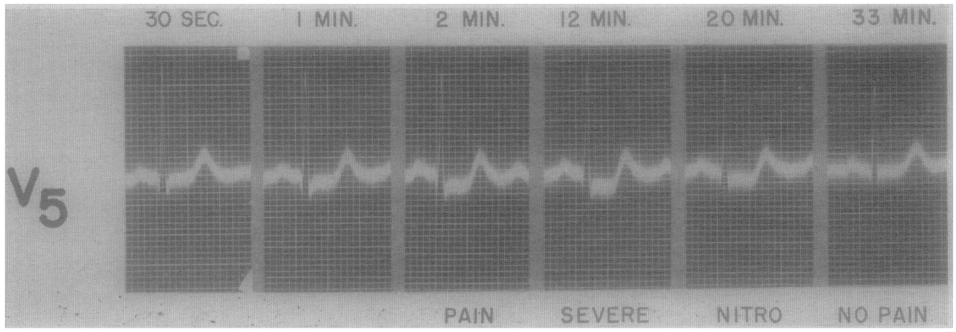

Fig. 3.—Case 2. Serial tracings of Lead V_5 taken before, during, and after anginal attack precipitated by cigarette smoking. No change from control (see Fig. 2, *C*) until one minute after subject began to smoke. Pain appeared two minutes after smoking started, right hand became "numb" at eighteen minutes, and subject ceased smoking and took 1/100 gr. nitroglycerin at twenty minutes; complete disappearance of pain 33 minutes after the subject began smoking.

DISCUSSION

Of the sixteen patients with angina pectoris on whom data are presented in this study, eleven showed an increase in heart rate and minor T-wave changes after smoking. The magnitude of the changes in the T wave was proportional to the increase in rate. Others[20,63] have observed this relation which probably represents a normal physiologic response. It has been suggested that these T-wave changes are due to the direct action of nicotine on the heart muscle fibers,[41] but we do not believe that there is much support for this view in the evidence available.

In two patients smoking induced the classical symptoms of angina pectoris accompanied by electrocardiographic changes diagnostic of pronounced myocardial ischemia.

Theoretical and experimental studies[65,66] indicate that injury which affects chiefly or predominantly the subendocardial muscle gives rise to RS-T segment depression in the unipolar leads taken with the exploring electrode adjacent to the epicardial surface of the part of the ventricular wall involved, whereas subepicardial injury produces RS-T elevation under similar circumstances. In the case of the unipolar right arm lead (V_R), the exploring electrode faces the basal ventricular orifices and often seems to reflect the potential of the ventricular cavities. The ventricular complex of this lead is frequently almost the inverse of those obtained when the exploring electrode faces the epicardial surface. If the RS-T displacements in the standard leads are plotted on the Einthoven triangle, the resulting vector gives the manifest axis of injury (—I).[67,68] When the injury is predominantly subepicardial, this axis points from the center of the involved ventricle toward the center of the injured area (Fig. 4). When the injury is predominately subendocardial it points in the opposite direction (Fig. 5).[68] Unfortunately, this type of analysis is complicated by a number of factors and possibilities that have not been fully developed. Some of these factors will be discussed at greater length in a subsequent paper.

When the electrocardiographic changes in Case 1 are analyzed by simple inspection of the unipolar limb leads or by the principles of the Einthoven triangle, the RS-T displacement suggests ischemia of the posteroseptal subepicardial muscle, which is irrigated by the right coronary artery (Fig. 4). The relatively minor changes in the T waves of the chest leads during the anginal attack were not accompanied by a change in heart rate. These changes probably reflect the influence of the ischemic area on the posteroseptal wall if it can be assumed that the same conditions were present when both the limb and chest leads were obtained. The failure of the heart rate to rise suggests that the work of the heart was not significantly increased during the paroxysm. Moreover, the absence of exertional heart pain supports the view, in this particular instance, that an increase in cardiac work was not the sole or even the chief factor inducing anginal seizures. It seems necessary to assume that the series of events described were a consequence of spasm of the right coronary artery or its branches.

In Case 2 there was concordant RS-T displacement without significant QRS changes during the anginal paroxysms precipitated by smoking. This suggests

a more widespread ischemia. Leads in which the exploring electrode faced the epicardial surfaces of the ventricles show RS-T depression, whereas in the unipolar right arm lead (V_R), which often reflects the potential variations of the ventricular cavities, there is RS-T elevation (Fig. 2). The axis of injury points

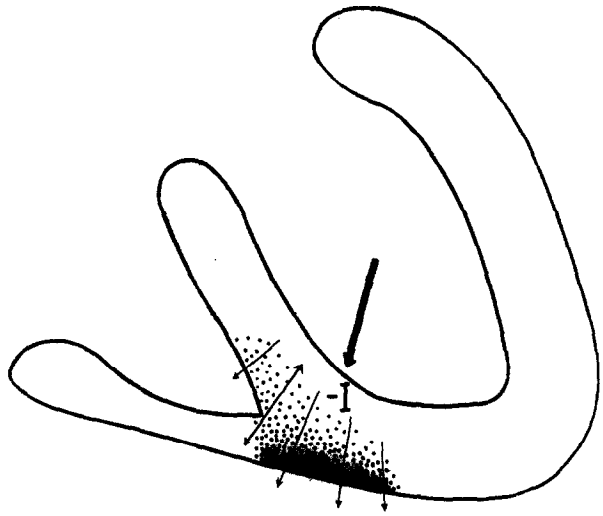

Fig. 4.—Case 1. Diagram representing hypothetical location of predominate myocardial ischemia induced by smoking and axis of injury (–I).

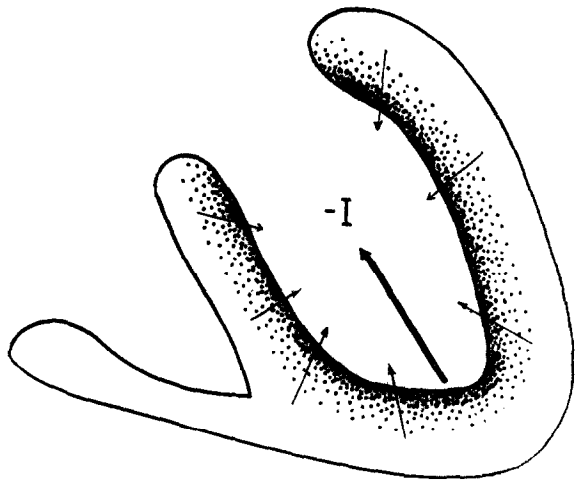

Fig. 5.—Case 2. Distribution of hypothetical ischemic region indicated by shaded area. Position of axis of injury (–I) during anginal seizure precipitated by smoking.

from the apex toward the center of the left ventricle (Fig. 5). These findings are consistent with uniform ischemia of the greater portion of the subendocardial muscle of the left ventricle. Such changes may be the result of generalized coronary spasm or spasm of the subendocardial arteriolar plexus.

Concordant RS-T segment depression in the standard leads is the most frequent electrocardiographic phenomenon accompanying anginal attacks induced by exercise[69] and anoxemia.[70] The majority of the relatively few electrocardiograms that have been taken during spontaneous anginal seizures show a discordant type of RS-T displacement.[2,54,69,71-73]

The follow-up on Wilson and Johnston's Case 5[2] is presented to show that in a case of proved tobacco angina the patient may lose his sensitivity to tobacco and still continue to experience pain unrelated to exercise.

It is interesting to note that all the patients who exhibited striking electrocardiographic changes on smoking had complained of "gaseous indigestion," suggestive of peptic ulcer, for a long time prior to the development of angina pectoris. This was also true of the two patients of Wilson and Johnston.[2] The possibility that there is a relation between diseases of the coronary arteries and the abdominal viscera has received considerable attention in the past few years.[74] Since both myocardial infarction and peptic ulcer have been produced in experimental animals by vagal stimulation,[60] it may be that these two conditions have one etiologic factor in common.

We wish to emphasize that in an unselected group of sixteen patients with angina pectoris, two habitual cigarette smokers with no previous suspicion of tobacco sensitivity developed typical anginal seizures accompanied by electrocardiographic changes indicating severe myocardial ischemia while smoking their usual brand of cigarettes. The evidence points to spasm of some part of the coronary arterial tree as the mechanism through which smoking induced paroxysms in these two patients. However, these findings by no means rule out the probability that in other patients smoking may precipitate attacks of angina pectoris by increasing the work of the heart.

In our experience, the clinical history and the clinical data routinely collected rarely suggests that smoking has an important bearing upon the symptoms in the course of the patient's illness in angina pectoris and other forms of coronary artery disease. But the circumstances which led to the discovery of a relation between the anginal attacks and the use of tobacco in two patients of this series and in two patients studied by Wilson and Johnston[2] suggest the possibility that this habit may play a more important role in these disorders than has been suspected heretofore. Routine smoking tests with electrocardiographic observations on patients with angina pectoris, even in the absence of a history of tobacco sensitivity, may help to decide this question.

CONCLUSIONS

1. In sixteen patients with angina pectoris, electrocardiograms were taken while the patient was smoking cigarettes of the brand to which he was accustomed. One instance of pure tobacco angina was discovered. In another instance the pain was precipitated by exertion and by tobacco. Neither patient had suspected that his symptoms were in any way related to smoking.

2. In these instances coronary spasm induced by smoking appeared to be the cause of the anginal seizures not related to exertion.

3. Minor changes in the T wave induced by smoking usually represent a physiologic response to an increase in the heart rate and not to myocardial ischemia. This phenomenon occurs in patients with angina pectoris as well as in normal subjects but is not associated with anginal pain.

4. The cardiovascular effects of tobacco smoking vary greatly from person to person and in the same person from time to time.

5. It is possible that the use of tobacco plays a more important role in determining the symptoms of coronary disease than has been realized in the past.

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