

Cardiomyopathic syndrome due to coronary artery disease¹

II: Increased prevalence in patients with diabetes mellitus: a matched pair analysis

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To test the hypothesis that the prevalence of a cardiomyopathic syndrome in association with coronary artery disease is higher among diabetic patients, clinical, ventriculographic, and arteriographic features of coronary artery disease were evaluated in 84 patients with coronary artery disease. Forty-two diabetics were compared with 42 non-diabetics who were randomly selected and matched for age, sex, blood pressure, and serum lipids. The diabetic group represented all diabetic patients with angiographic coronary artery disease identified over a 6-year period who could be matched for these variables. The coronary circulation was divided into 6 arterial segments, and arteriograms were assigned a jeopardy score that expresses the number of segments jeopardised by significant proximal stenoses. Distal coronary artery disease was scored separately. The cardiomyopathic syndrome due to coronary artery disease was defined by evidence of chronic heart failure in association with significant reduction of the left ventricular ejection fraction (≤ 0.48) caused by multiple and widespread left ventricular wall motion abnormalities.

There was an increased prevalence of the syndrome in the diabetic group compared with the control group (20 patients vs 10 patients, $P < 0.05$) and this was reflected in a lower mean ejection fraction in the diabetic group as a whole (0.47 vs 0.56 , $P < 0.05$). There was also a higher prevalence of multiple myocardial infarcts (21 diabetics vs 9 controls with ≥ 2 myocardial infarctions, $P < 0.05$) and anterior myocardial infarcts (23 diabetics vs 13 controls, $P < 0.05$) in the diabetic group. There were no differences between the two groups in the prevalence of stable or unstable angina, persistent arrhythmias, or intraventricular conduction defects.

The mean jeopardy score in patients with the cardiomyopathic syndrome was the same (10.7 ± 0.4 vs 10.6 ± 0.3) whether diabetic or control. No patient, diabetic or control, with cardiomyopathy had a jeopardy score of < 8 . Furthermore, the relation of cardiomyopathy to multiple myocardial infarctions was as strong in the diabetic patients (15 of 20 diabetics with cardiomyopathy had had ≥ 2 myocardial infarctions, 6 of 22 diabetics without cardiomyopathy had had ≥ 2 myocardial infarctions; $P < 0.001$) as it was in the overall study population.

There was no significant difference in mean jeopardy score between diabetic and control groups as a whole (8.9 ± 0.5 vs 8.2 ± 0.5), but an increased fraction of the diabetic subpopulation with jeopardy scores of ≥ 8 had cardiomyopathy (20 of 30) compared with the control subpopulation with jeopardy scores of ≥ 8 (10 of 28). The prevalence of completely occluded coronary arteries did not differ between diabetic and control groups. There was a higher prevalence of distal coronary artery disease in diabetic patients (24 diabetic vessels vs 10 control vessels), which was significant, or not, depending on whether correction was made for non-visualised distal vessels.

We conclude that there is an increased prevalence of the cardiomyopathic syndrome in diabetic patients with coronary artery disease, compared with non-diabetic patients with coronary artery disease, who come to angiography, and that this difference exists independently of hypertension and hyperlipidaemia. However, the cause of the cardiomyopathic syndrome, i.e. its relation to the extent of proximal coronary artery disease and to the occurrence of multiple myocardial infarcts, is the same in both diabetic and non-diabetic patients.

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Diabetes mellitus is generally accepted to be an important risk factor for the development of premature coronary artery disease (Stearns, *et al.*, 1947; Liebow *et al.*, 1964; Ostrander *et al.*, 1965). It has been speculated that not only the incidence, but also the severity, of coronary artery disease is increased in diabetics (Badger and Liebow, 1965; Partamian and Bradley, 1965). It is not known whether diabetic patients with coronary artery disease differ from non-diabetics with coronary artery disease in clinical manifestations, angiographic anatomy, or extent of left ventricular function impairment. It has been our clinical impression, and that of others (Ryan *et al.*, 1972), that coronary artery disease in diabetics is more likely to be complicated by the development of a cardiomyopathic syndrome than is coronary artery disease in non-diabetic patients. This issue is complicated however, by the recent postulate (Rubler *et al.*, 1972; Kannel *et al.*, 1974; Regan *et al.*, 1974) that there may be a form of cardiomyopathy in patients with diabetes which is unrelated to coronary artery disease. The present study was undertaken to evaluate clinical, ventriculographic, and arteriographic features in 84 patients with coronary artery disease—42 diabetics compared with 42 randomly selected matched controls. In particular, this study is designed to test the hypothesis that the prevalence of a cardiomyopathic syndrome in association with coronary artery disease is higher among the diabetic patients. Furthermore, the present study examines whether the cause of the cardiomyopathic syndrome in diabetic patients with coronary artery disease is the same as the cause of cardiomyopathic syndrome in non-diabetic patients with coronary disease. For this reason the relations between the presence of cardiomyopathic syndrome, the extent of angiographic coronary disease, and the prevalence of myocardial infarction are analysed in the two groups of patients.

Methods

The study population consists of 42 matched pairs of diabetic and control patients with coronary artery disease. All patients admitted to the Massachusetts General Hospital between January 1968 and December 1973 who underwent coronary angiography were eligible for the study. Patients without significant coronary artery disease and patients with other types of heart disease were excluded.

Patients were considered to have diabetes mellitus if one of the following criteria were present: a fasting whole blood glucose ≥ 6.1 mmol/litre (110 mg/100 ml); in those patients with a positive family

history for diabetes, a 2-hour postprandial blood glucose ≥ 8.3 mmol/litre (150 mg/100 ml); or, in those patients with a negative family history for diabetes, a 2-hour postprandial blood glucose ≥ 11.1 mmol/litre (200 mg/100 ml). Patients were excluded if the raised blood sugars were measured during a stressful state or while they were taking a diabetogenic drug. The absence of diabetes was defined as a 2-hour postprandial blood glucose < 6.7 mmol/litre (120 mg/100 ml), and, when available, a fasting blood glucose < 5.6 mmol/litre (100 mg/100 ml). No patient with a positive family history for diabetes was accepted as a member of the control series. Whole blood glucose was determined by the ferric cyanide reduction method. These criteria are necessarily arbitrary and were designed to select a population which was definitely diabetic to compare with a population definitely non-diabetic, thus avoiding the ambiguity of borderline carbohydrate intolerance. Not only was the presence of 'chemical' diabetes (Williams and Porte, 1974) required, but also evidence of either 'genetic' diabetes or severe carbohydrate intolerance.

The subject population was selected from the computer files of patient diagnoses at the Massachusetts General Hospital. Patients with the diagnosis of 'diabetes mellitus' and 'coronary angiography' were identified and screened. Potential candidates for the control group were selected randomly from the computer files according to the diagnosis of 'coronary angiography'. Of 609 potential control patients 214 were excluded because there was no record of a postprandial blood glucose or of the family history as it pertained to diabetes, and 285 were excluded because they had either a positive family history for diabetes or raised blood glucose levels, but otherwise did not meet the criteria for inclusion as diabetics. Of the total number of patients screened, diabetes was confirmed in 56 patients and the absence of diabetes was confirmed in 110.

For each patient an average blood pressure was calculated on the basis of the initial and prevailing pressures during one or more hospital admissions, as well as any known past history of hypertension. In cases where there was more than one pair of lipid determinations, the values were averaged. Non-fasting measurements and lipid values drawn at the time of acute myocardial infarction were excluded. Each diabetic subject was individually and randomly matched with a member of the pool of control patients on the basis of age, sex, systolic, and diastolic blood pressure, serum cholesterol, and serum triglycerides. The maximal age difference was 10 years. The maximal difference in serum cholesterol was 2.4 mmol/litre, and in serum triglycerides

1.1 mmol/litre. Suitable controls could not be found for 14 diabetic patients, leaving 42 matched pairs which comprise the study population.

Each patient's medical record was examined for pertinent historical and clinical data. Angina pectoris was divided into two major categories: stable and unstable angina. Criteria used for the diagnosis of unstable angina were prolonged chest pain leading to hospital admission (without myocardial enzyme rises in serum or the development of Q waves on the electrocardiogram), the new onset of rest or nocturnal chest pain, and, when occurring over a period of less than 2 months, an increase in the frequency and severity of effort angina.

Persistent arrhythmias, atrioventricular conduction defects, bundle-branch blocks, fascicular blocks, and nonspecific interventricular conduction defects were enumerated.

Myocardial infarcts were defined as transmural or non-transmural. The former were diagnosed only in the presence of electrocardiographic Q waves of at least 0.04 s in duration, or, if Q waves were equivocal, akinesis or dyskinesis of the appropriate segment of the left ventriculogram and a typical history. Non-transmural infarcts were diagnosed when typical serum enzyme changes were unaccompanied by the evolution of Q waves. Electrocardiographic left atrial enlargement was defined as terminal P wave negativity in lead V1 exceeding 0.03 mm/s.

The assessment of selective coronary arteriograms, left ventriculograms, and plain chest films in this patient population has been described in a companion paper (Dash *et al.*, 1977). All angiograms and x-rays were viewed by one of us (R.E.D.) without knowledge of the clinical status of the patient. Eighty-one patients had cineventriculograms (right anterior oblique in 78, biplane in 3) from which left ventricular volumes were calculated by the modified area-length method, using outlines drawn from estimated end diastolic and end systolic cine frames. Left ventricular ejection fraction was calculated for each by dividing left ventricular stroke volume by left ventricular end diastolic volume.

'Cardiomyopathic syndrome due to coronary artery disease' is a name we have applied to patients with multiple and widespread left ventricular wall motion abnormalities leading to significant reduction in the resting left ventricular ejection fraction and evidence of chronic heart failure. The purpose of this name is to distinguish cardiomyopathy resulting from coronary artery disease from other causes of chronic heart failure in coronary artery disease (isolated ventricular aneurysm, chronic and relatively isolated mitral regurgitation, rupture of the interventricular septum, and cases where epi-

sodic pulmonary oedema is secondary to reversible ischaemia). All patients diagnosed as having cardiomyopathy had a left ventricular ejection fraction ≤ 0.48 and clinical features consistent with chronic heart failure. Patients were considered as having evidence of chronic heart failure if they had had definite radiological evidence of left heart failure, had had raised mean jugular venous pressure, or had 2 of the 6 clinical features listed in Table 1 in Paper I (Dash *et al.*, 1977). Only 3 patients not classified as having cardiomyopathy had an ejection fraction below 0.48 (the lowest of these was 0.44), and none of these 3 had any of the criteria for heart failure.

The extent of proximal coronary artery disease was scored by the angiographic 'jeopardy score' system which has been described in detail previously by Dash *et al.* (1977). This system assigns value to significant coronary lesions (greater than 70% estimated luminal area reduction) according to their location relative to major branch points of the involved artery. The coronary circulation is considered as 6 arterial segments (right coronary artery, 1 segment; left anterior descending coronary artery, 3 segments; left circumflex coronary artery, 2 segments) and 2 points are assigned for each segment jeopardised, directly or indirectly, by significant proximal stenosis. For example, had there been a normal coronary arteriogram in the present series, it would have been assigned a jeopardy score of zero; patients with disease affecting all of the segments had a jeopardy score of 12. The 2 points assigned to the right coronary artery (posterior descending artery) were considered in the circumflex system if there was left coronary arterial dominance.

Distal coronary artery disease was assessed by adding the number of arterial segments significantly narrowed in their distal extent. By 'distal' is meant smaller than a size able to accept connection of a venous bypass graft (less than 1 to 1.5 mm). Vessels counted as being distal included arterial branches other than the 6 segments designated in the jeopardy score system as well as the distal third (approximately) of these 6 arteries. Some distal vessels were either poorly opacified or not visualised because of proximal stenosis or occlusion. For this reason the following adjustment was made in order to accomplish comparative analysis of diabetics and controls: in each matched pair of patients in which a distal vessel was poorly visualised the corresponding artery in the paired arteriogram was eliminated from the analysis. This was done for 8 vessels in the diabetic group and 3 vessels in the control group.

Matched-pair statistical analyses were done by the paired Student's t test. Analyses not involving

Table 1 Comparison of matched characteristics in diabetic and control groups

Matched characteristic	Diabetic	Control
Age (y)	54 ± 1*	54 ± 1
Systolic blood pressure (mmHg)	133 ± 3	133 ± 2
Diastolic blood pressure (mmHg)	81 ± 2	82 ± 2
Serum cholesterol (mmol/litre)	6.5 ± 0.2 (249 ± 9 mg/100 ml)	6.4 ± 0.2 (246 ± 9 mg/100 ml)
Serum triglycerides (mmol/litre)	2.1 ± 0.3 (188 ± 23 mg/100 ml)	2.1 ± 0.1 (185 ± 12 mg/100 ml)

*In all tables and throughout the text ± refers to standard error of the mean.

comparison of the diabetic and control patients on a matched-pair basis were performed either by the Student's *t* test or by χ^2 analysis with Yates' correction.

Results

The matching process for age, blood pressure, and serum lipids was successful; the similarity in group means for these variables, comparing diabetics with controls, is shown in Table 1. Analysis of risk factors that were not specifically matched showed no significant differences between the two groups for past history of smoking, family history for premature coronary artery disease, the presence of left ventricular hypertrophy on electrocardiogram (Sokolow and Lyon, 1949), or the prevalence of alcoholism. Diabetics tended to have a higher prevalence of obesity (15 diabetics, 7 controls), but the difference was not statistically significant. Obesity was defined according to the percentage of ideal body weight (Metropolitan Life Insurance Company, *Statistical Bulletin* 1959). Of the 42 diabetics, 29 had symptoms referable to their diabetes and 13 were asymptomatic patients with chemical diabetes. Thirty-two diabetics had raised fasting blood glucose values and 16 required insulin. Only one patient had diabetes of juvenile onset.

There were no differences between diabetic and control groups in the prevalence of stable or unstable angina, persistent arrhythmias, or intraventricular conduction defects (Table 2). Approximately 75 per cent of the patients in each group developed unstable angina at some point in their clinical course. Though the prevalence of ventricu-

lar aneurysm was higher in the control group, the numbers are too small for statistical analysis.

There were a total of 59 myocardial infarcts (transmural and non-transmural) in the diabetic patients and 45 myocardial infarcts in the control group; this difference is not significant. The prevalence of transmural myocardial infarcts also did not differ in the two groups (44 in diabetics, 33 in controls). However, there was a significantly increased prevalence of multiple myocardial infarcts in diabetics (21 diabetics and 9 controls with ≥ 2 myocardial infarcts, $P < 0.05$). This is also true if multiple transmural myocardial infarcts are considered separately (14 diabetics and 4 controls with ≥ 2 transmural myocardial infarcts). Diabetic patients also had a significantly higher prevalence of anterior myocardial infarcts (23 in diabetics, 13 in controls, $P < 0.05$).

Table 3 shows the number of patients with cardiomyopathy in each group. Of the 42 diabetic patients 20 had cardiomyopathy whereas only 10 controls had this syndrome ($P < 0.05$). The higher prevalence of cardiomyopathy among diabetic patients is reflected in the mean left ventricular ejection fraction of the diabetic group (0.47), which is significantly lower than that of the control group (0.56) ($P < 0.05$). The fraction of patients with cardiomyopathy who had cardiomegaly on plain chest films was similar in diabetics and controls (14/20 diabetic patients and 6/10 control patients).

It has previously been shown that in this population of patients as a whole there is a higher jeopardy score in the patients with cardiomyopathy compared with those without it (Dash *et al.*, 1977).

Table 2 Frequency of coronary artery disease syndromes

Syndrome	No. of patients	
	Diabetic	Control
Stable angina of effort	35	39
Stable angina at rest	14	19
Unstable angina	30	32
Recurrent unstable angina	16	15
Persistent arrhythmias	5	2
Intraventricular conduction defects	16	11
Ventricular aneurysms	0	4

Table 3 Prevalence of cardiomyopathy due to coronary artery disease in diabetics and controls

	Diabetic		Control	
	No. of patients	Mean EF*	No. of patients	Mean EF*
Patients with cardiomyopathy	20†	0.29	10†	0.35
Patients without cardiomyopathy	22	0.64	32	0.62
Total	42	0.47†	42	0.56†

*EF, ejection fraction; † $P < 0.05$, comparison of diabetic with control groups.

Table 4 Jeopardy score in relation to cardiomyopathy in association with coronary artery disease (CM)

	Patients with CM	Patients without CM	P
Diabetic	10.7 ± 0.4	5.2 ± 0.2	< 0.001
Control	10.6 ± 0.3	5.4 ± 0.6	< 0.01

Table 4 shows that this was equally true of diabetic and control patients.

In both the diabetic and the control group there was a tendency for cardiomyopathy to be associated with multiple myocardial infarcts (1.9 ± 0.2 and 1.7 ± 0.4 myocardial infarcts per patient in diabetics and controls with cardiomyopathy, respectively, and 0.9 ± 0.2 and 0.9 ± 0.1 myocardial infarcts per patient in diabetics and controls without cardiomyopathy, respectively). The higher prevalence of patients who had had multiple myocardial infarcts among those with cardiomyopathy reached significance in the diabetic group (15 of 20 with cardiomyopathy had ≥ 2 myocardial infarctions, 6 of 22 without cardiomyopathy had ≥ 2 myocardial infarctions, $P < 0.01$), but the number of control patients with cardiomyopathy was too small to allow analysis by the χ^2 test (4 of 10 controls with cardiomyopathy had ≥ 2 myocardial infarctions, 5 of 32 controls without cardiomyopathy had ≥ 2 myocardial infarctions).

The figure shows the study population divided into diabetic and control groups so that the distribution of jeopardy scores and the distribution of the cardiomyopathic syndrome relative to jeopardy score may be compared in the two groups. Cardio-

myopathy occurred only in patients with jeopardy scores of 8 or greater. The mean arteriographic jeopardy score did not significantly differ between diabetic and control groups as a whole (8.9 ± 0.5 versus 8.2 ± 0.5). Also, considering only the subpopulation at risk for the occurrence of cardiomyopathy (jeopardy score 8 or more), there are about the same number of diabetics and controls. Within this subpopulation, however, a larger fraction of the diabetics compared with controls had cardiomyopathy (20 of 30, compared with 10 of 28) ($P < 0.02$) and multiple myocardial infarcts (17 of 30 versus 7 of 28) ($P < 0.02$).

There was no difference in the number of completely occluded vessels between diabetics and controls (1.1 ± 0.2 versus 0.9 ± 0.1 vessels per patient). In addition, the prevalence of collaterals did not differ between the two groups (0.7 ± 0.1 versus 0.6 ± 0.1 collateral sources in diabetics and controls).

Using the method of cancelling the corresponding vessel in the matched patient when the distal extent of a vessel could not be visualised (see Methods), there was a higher prevalence of diseased distal vessels in diabetic patients (24 vessels in the diabetic group, 10 in the control group; $P < 0.05$). However, this method introduces potential bias because more diabetic vessels could not be seen distally than in controls, hence more control vessels were cancelled. If the total number of visualised diseased distal vessels are counted in the two groups and no adjustment is made for non-visualised vessels, diabetics tended to have a higher prevalence (27 versus 18 diseased distal vessels) than controls, but the

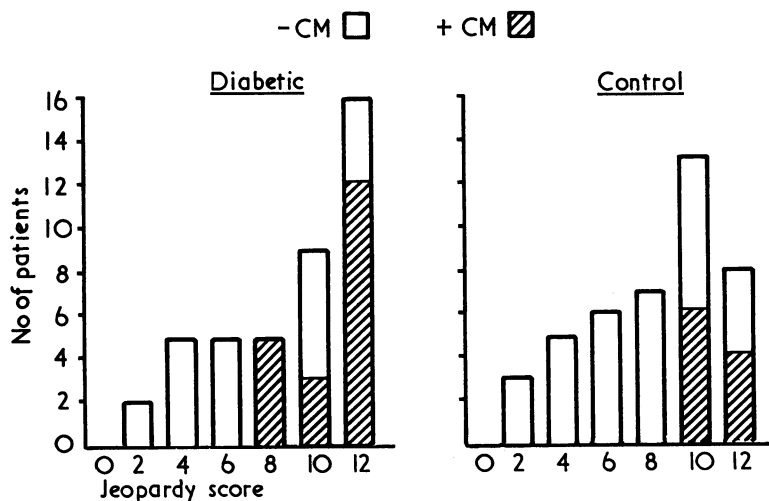


Figure Jeopardy score histograms for diabetic and control groups. Note that the distribution of jeopardy scores is approximately the same in diabetics and controls, but that a larger fraction of the angiographic subpopulation with jeopardy score ≥ 8 had the cardiomyopathic syndrome in the diabetic group.

Table 5 Number of diseased distal segments per patient

	Diabetic	Control
Patients with cardiomyopathy	0.6 ± 0.2	0.3 ± 0.2
Patients without cardiomyopathy	0.6 ± 0.2	0.2 ± 0.1

difference was not statistically significant. There was no relation of distal disease to cardiomyopathy in either diabetics or controls, even when adjustment was made for non-visualised vessels (Table 5).

There were no differences in the frequency of use of oral hypoglycaemic agents or insulin in diabetic patients with and without cardiomyopathy.

Discussion

Patients with diabetes mellitus have a higher incidence of hyperlipidaemia than occurs in the general population. Consequently, a study measuring the effect of diabetes on manifestations of coronary artery disease must have controls matched for serum lipids, as it is well known that lipid disorders are risk factors for premature coronary artery disease. The same is true of hypertension, since some studies have found diabetics to have raised blood pressure more frequently than non-diabetics (Pell and D'Alonzo, 1967). The present study is a comparison of two groups of patients with coronary disease, one diabetic and one non-diabetic, individually matched for age, sex, blood pressure, and serum lipids. The results show that in the patients with coronary artery disease who come to angiography at our institution there is an increased prevalence of a cardiomyopathic syndrome due to coronary artery disease, anterior myocardial infarction, and multiple myocardial infarcts in diabetic patients.

It is uncertain whether the findings of this study would extend to all diabetic patients with coronary artery disease, including those who do not undergo angiography. Conceivably, bias exists in the referral for angiography of diabetic patients compared with the referral of non-diabetic patients. However, the similarity of diabetic and control groups in the present study for the prevalence of stable and unstable angina makes the existence of a referral bias unlikely. It appears probable that the diabetics in this study are no less representative of diabetics with coronary artery disease at large than patients with coronary artery disease who undergo angiography are representative of patients with coronary artery disease in general. The degree to which the latter is the case is unknown.

This is a retrospective study even though a matched control group is used. The process of

individually matching two groups of patients with coronary artery disease for each of several risk factors involves a series of approximations; it is not possible to find pairs of patients who share quantitatively identical values for all of these factors. Even so, the striking similarity in group mean values for the matched characteristics (Table 1) makes it very likely that differences found between the two groups are attributable to the presence or absence of diabetes and that they exist independently of hypertension or hyperlipidaemia.

The increased prevalence of anterior myocardial infarcts and of multiple myocardial infarcts among diabetic patients is related to their increased prevalence of cardiomyopathy. It has been shown previously that depression of the left ventricular ejection fraction in patients with coronary artery disease is related to the extent of wall motion abnormality (Hamilton *et al.*, 1972; Feild *et al.*, 1972). In general, the extent of wall motion abnormality is greater for anterior than for inferior myocardial infarction (Amsterdam, 1973; Hamby *et al.*, 1974; Lewis *et al.*, 1974). Since significant depression of the resting left ventricular ejection fraction is one of the defining features of the cardiomyopathic syndrome, it is not surprising that the prevalence of both anterior and multiple myocardial infarcts would be higher in a population with an increased prevalence of the syndrome. This line of reasoning assumes that the cause of the cardiomyopathy is the same in both diabetics and non-diabetics; that this is so is directly supported by the finding that cardiomyopathy was specifically related to the extent of proximal coronary disease, as expressed by the jeopardy score, in both diabetic and control patients. In addition, the association between cardiomyopathy and multiple myocardial infarcts, which has been shown elsewhere for the total study population (Dash *et al.*, 1977), was shown here to apply to the diabetic patients considered as a subpopulation.

Even though a high jeopardy score (8 or greater) was prerequisite for the occurrence of cardiomyopathy in both diabetics and controls, the increased prevalence of cardiomyopathy in diabetic patients did not occur because of an increased prevalence of high jeopardy scores in diabetics. There was no significant difference in mean jeopardy score between diabetic and control groups as a whole. However, an increased fraction of the diabetic subpopulation with high jeopardy scores developed cardiomyopathy compared with the control subpopulation with high jeopardy scores. There are two possible explanations for this finding—both are based on the thesis that extensive coronary artery disease is simply a requisite condition for the occurrence of multiple myocardial infarcts, which,

in turn, is the cause of the cardiomyopathic syndrome (Dash *et al.*, 1977). First, if the degree of atherosclerotic narrowing of large coronary vessels were more severe in diabetic patients than in control patients, infarction would be more likely to occur in the diabetic patients. The degree of arterial narrowing would be imprecisely reflected in the jeopardy score, since this score only requires that a lesion be angiographically 'significant' to be counted. But the prevalence of completely occluded vessels did not differ between diabetic and control groups. Thus, a second explanation is perhaps more likely—that diabetic patients may be more prone to infarction than non-diabetic patients with the same degree of coronary arterial narrowing.

The results also suggest that the prevalence of distal coronary disease may be increased in diabetic patients generally. Reservation must be exercised in drawing this conclusion from our data, however. In order to compare diabetic and control pairs, it was necessary to 'cancel' vessels from consideration where the corresponding vessel in the matched patient was occluded or imperfectly visualized in its distal extent. As mentioned, it is possible that bias was introduced by this procedure. Other studies of the prevalence of distal disease in patients with diabetes have provided conflicting results (Chychota *et al.*, 1973; Verska and Walker, 1975). Whether or not distal disease is more prevalent in diabetic patients, this study shows that distal disease is not related to the presence or absence of cardiomyopathy (Table 5).

In conclusion, the results of the present study show that the prevalence of the cardiomyopathic syndrome is increased in diabetic patients with coronary artery disease who come to angiography, and that the difference is not the result of serum lipid or blood pressure abnormalities sometimes associated with diabetes mellitus. Recent reports (Rubler *et al.*, 1972; Kannel *et al.*, 1974; Regan *et al.*, 1974) have postulated the existence of a cardiomyopathy in diabetics that is not the result of coronary disease. This study does not address itself to such an entity, since all of the patients had coronary artery disease by design. However, these results strongly suggest that cardiomyopathy in most diabetic patients who have had some manifestation of coronary artery disease is the result of large vessel, proximal coronary disease. Explanatory factors independent of proximal coronary disease (distal disease, 'small-vessel' disease within the myocardium, metabolic factors, 'diabetic cardiomyopathy' unrelated to coronary disease) need not be invoked. This was shown by the finding that the angiographic extent of coronary disease was the same in diabetic and control patients with cardio-

myopathy and by the finding that cardiomyopathy was related to the occurrence of multiple myocardial infarctions in diabetic patients. The increased prevalence of cardiomyopathy in diabetics occurred because a larger fraction of the angiographic subpopulation with extensive coronary disease had suffered multiple infarcts in the diabetic group, not because the number of patients with extensive coronary disease was increased. While the reason for this latter finding remains to be elucidated, it is possible that diabetics are more prone to myocardial infarction than non-diabetics with the same degree of coronary artery stenosis.

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