Abnormalities of Myocardial Depolarization in Overt, Subclinical and Prediabetes

A Vectorcardiographic Study

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SUMMARY

Vectorcardiograms were performed on fifteen diabetic patients, and all were found to have either the vectorcardiographic criteria for myocardial infarction or "bites."

Twenty adults with normal fasting blood sugars and not known to be diabetics were found to have bites; eleven (55 per cent) had an abnormal glucose tolerance test; four of the remaining nine were tested further and three (75 per cent) had an abnormal cortisone glucose tolerance test.

Four apparently normal children, age four to twelve, from two families were studied. In both families, the mother had insulin-dependent diabetes and the father had subclinical diabetes. All four children had vectorcardiographic abnormalities.

This pilot study indicates that if the vectorcardiographic criteria for myocardial damage are correct, then it exists at an earlier stage in diabetes than has previously been recognized. Alternatively, if a morphologic abnormality cannot be demonstrated then a physiologic explanation must be advanced to account for these vectorcardiographic abnormalities. DIABETES *23*:572-78, July, 1974.

High frequency notching and slurring in the electrocardiogram (ECG) has been reported in association with diabetes and has been interpreted to represent myocardial scarring.[1-3] The vectorcardiogram (VCG) equivalent of these are "bites," which are defined as deviations from a smooth contour of the VCG loop exceeding 6 milliseconds (ms.) in duration and 0.1 millivolt (mv.) in magnitude.[4] Autopsy and angiographic studies have shown the VCG to be a more reliable indicator of myocardial wall disease than the twelve-lead ECG in that the VCG will show evidence of microinfarcts and identify multiple areas of damage which are frequently not seen in the ECG. In addition, the localization of the area of damage is more accurate by the VCG technic than by ECG.[5-8]

When bites were observed in the VCGs of patients known not to have overt diabetes, it was hypothesized that the VCG might be a diabetic case-finding tool and these studies were undertaken.

METHODS

All VCGs were recorded on an Instruments For Cardiac Research Model 1A Vectorcardiograph and were subjected to manual analysis. This instrument is a direct writing vectorcardiograph with a frequency response of 500 cps. and produces the X, Y and Z scalar as well as the transverse, frontal and sagittal loops from one cardiac depolarization, thus eliminating inaccuracies that might result from loops of different depolarizations. The Frank-lead system with placement in the fourth intercostal space as recommended by Langner was used for all tracings.

The diagnosis of diabetes, chemical diabetes, or subclinical diabetes was made on the basis of a 100 gm. Glucose Tolerance Test (GTT) or a Cortisone Glucose Tolerance Test (CGTT) (12.5 mg. prednisone eight and one-half and two hours prior to the GTT); dosages were adjusted for children. Glucose was determined as true plasma glucose and the fasting, one-half hour, one hour, two hour and three hour normals were considered to be less than 121, 161, 181, 141 and 121 mg./100 cc. respectively. Realizing that the normals for the CGTT are valid only for ages below fifty years, the eight people in whom CGTTs were performed were 4, 7, 9, 12, 25, 26, 37 and 38 years old. Normal values for the CGTT were considered as in the GTT adjusted upward by 17 mg./100 cc. for

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each decade of life for the eight people so tested.[9]

For this study, bites were defined as deviations, not necessarily concave, from a smooth VCG loop of 10 ms. or longer in duration and of a magnitude of 0.1 mv. or greater, but not meeting the accepted criteria for transmural myocardial infarction. See figure 1. Note the smooth curves of this VCG done on a fifty-five year old male with angina in whom no family history of diabetes existed. Coronary cine-angiography and ventriculography were normal. The irregularity of loop contour at the lower apex of the sagittal plane does not meet the criteria of 0.1 mv. and 10 ms. duration.

RESULTS

Study 1. VCGs were performed on fifteen patients with overt diabetes who had no clinical history compatible with recent or remote myocardial infarction or angina pectoris. Eight were found to have one or more VCG criteria of transmural myocardial infarction. The remaining seven had one or more bites in the VCG. Figure 2 illustrates the VCG bite and ECG of one patient of this group.

Study 2. In a study of 389 consecutive VCGs, twenty adult patients with no history of angina, recent or remote myocardial infarction or of diabetes, were found to have bites in their VCG. Eighteen (90 per cent) had a family history of diabetes in a sibling, parent, grandparent, parental sibling or a family history of coronary artery disease. Eleven (55 per cent) were found to have an abnormal CGTT. Figure 3 illustrates the VCG and ECG of one such patient.

Study 3. Four of the remaining nine were further tested by CGTT and three (75 per cent) had an abnormal result. Figure 4 is the VCG and ECG of a twenty-five year old female whose mother has insulin-dependent diabetes. The patient's carbohydrate studies were:

	Fasting	½ hour	1 hour	2 hour	3 hour
GTT	80	105	158	127	107
CGTT	126	165	183	217	157

Study 4. Two apparently healthy children, age nine and eleven, were found to have VCG bites. They are the children of an insulin-dependent diabetic mother and a father with VCG bites, normal GTT, abnormal CGTT and a paternal history of diabetes. One child had a normal GTT and CGTT, the other a normal GTT and abnormal CGTT.

Two apparently healthy children, age four and twelve, from another family of similar parental background were also studied. The twelve-year-old had the VCG criteria for diaphragmatic wall infarction (superior placement of the 25 and 30 ms. vector). See figure 5. The four-year-old was also found to have a bite. Both children had a normal CTT and CGTT.

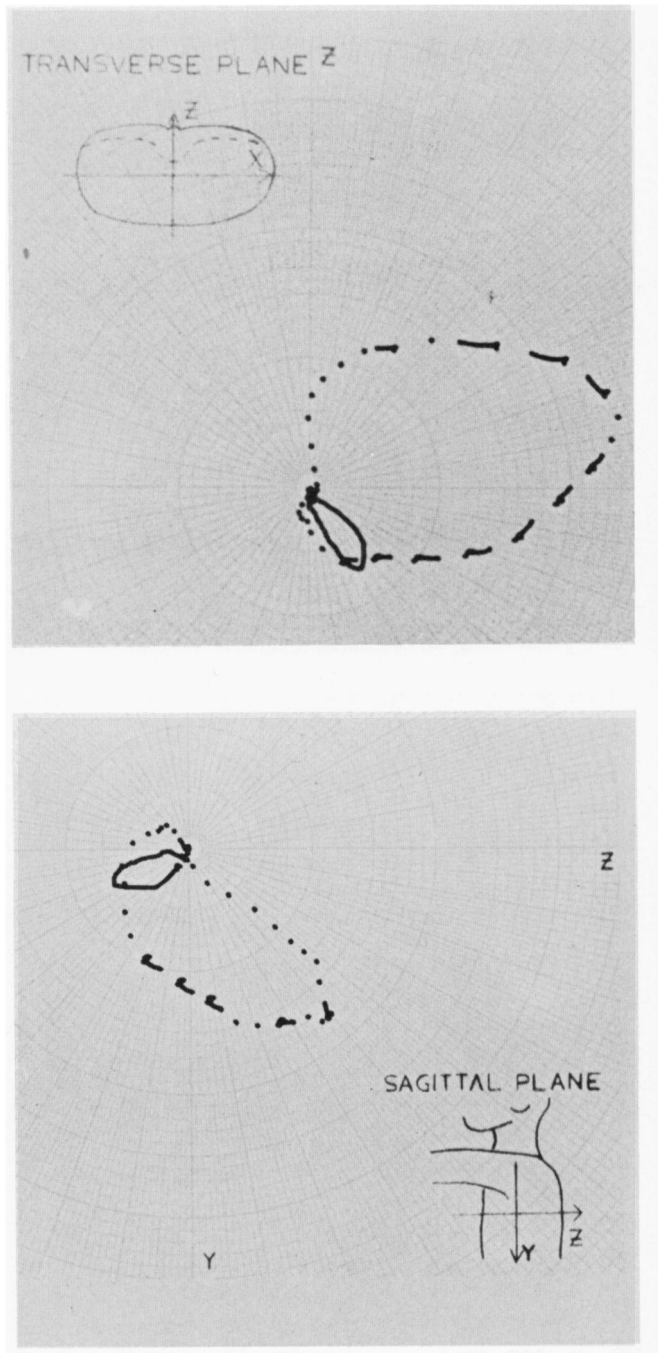


FIG. 1A. Normal transverse and left sagittal plane VCG loop. Dash interval is 2.5 ms. Direction of rotation is opposite the hook of the inscribed dash. Standardization: 40 mm./mv.

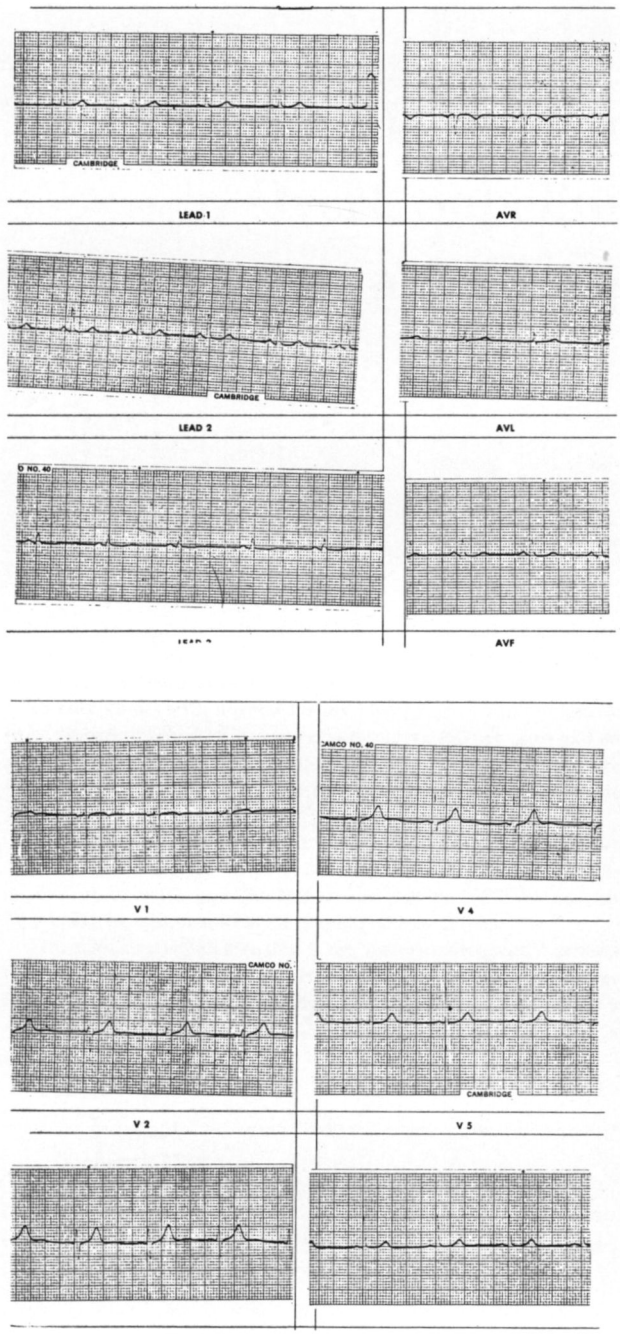
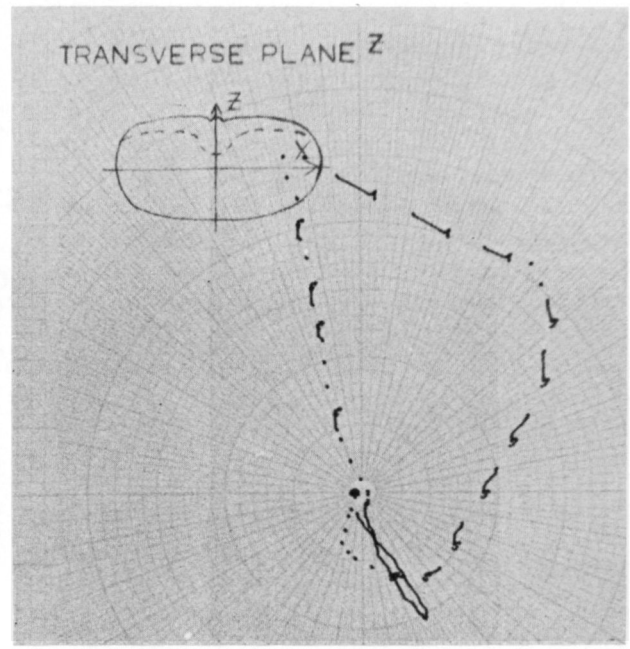


FIG. 1B. ECG of the same patient, 10 mm./mv., 25 mm./sec.



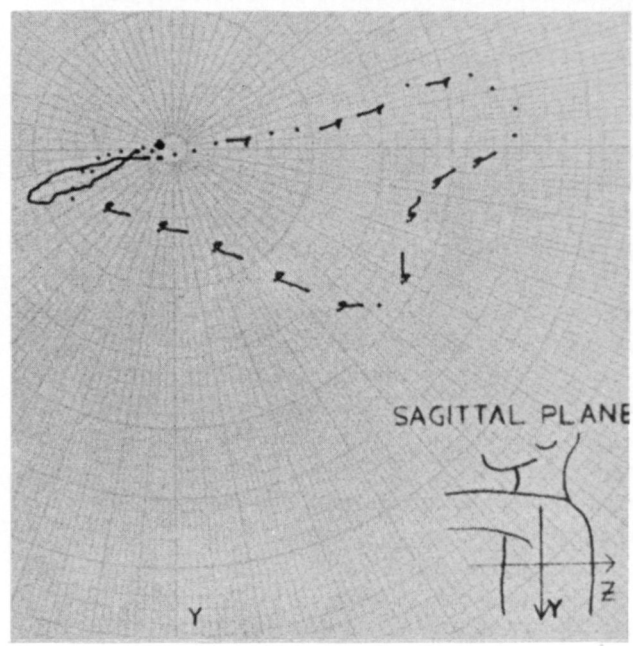


FIG. 2A. Transverse and left sagittal plane VCG loop of a twenty-year-old white male with noninsulin-dependent diabetes of one year's duration; note the bite in the mid-segment of the sagittal loop, seen in the transverse plane as a straightening of the same segment in time. Standardization: 40 mm./mv.

DISCUSSION

The study of the fifteen overt diabetics was undertaken to familiarize the authors with bites as seen with the direct writing vectorcardiograph; previous reported studies have used photography of oscilloscopic vector loops. The appearance of bites visualized with our instrumentation is similar to those reported by Selvester.[9] The finding that 53 per cent of the overt diabetics had the VCG criteria for myocardial infarc-

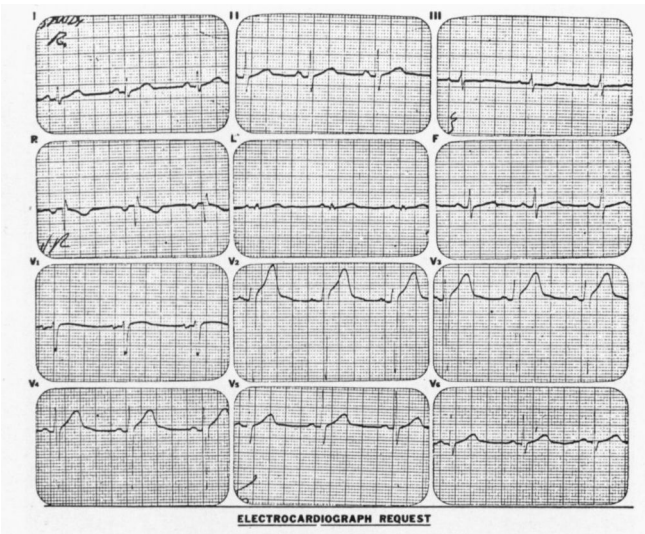
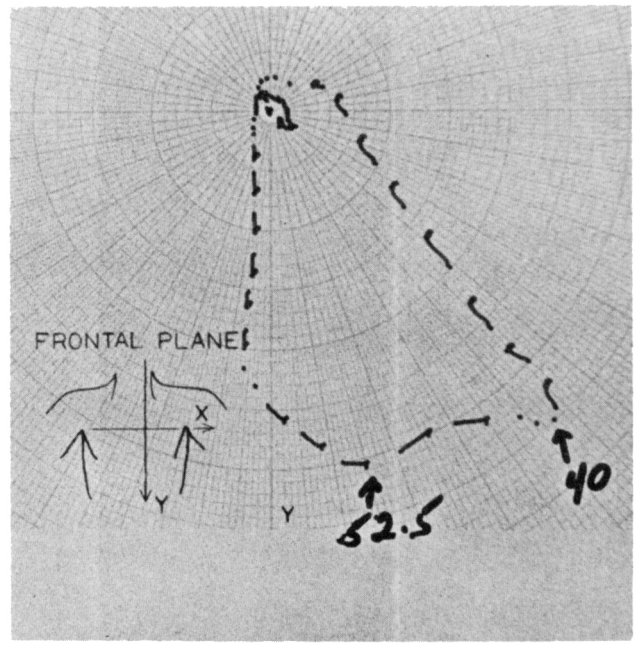


FIG. 2B. ECG of the same patient, 10 mm./mv., 25 mm./sec.



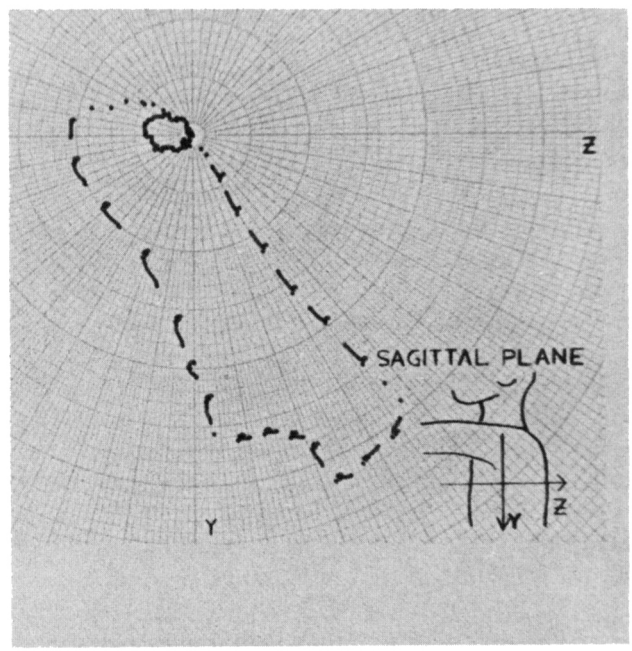


FIG. 3A. Frontal and left sagittal plane VCG loops of a forty-eight year old white female with moderate hypertension found to have chemical diabetes. The bite extends from 40 to 52.5 ms. Standardization: 40 mm./mv.

tion was not unexpected, in view of the report of Roberts and Buja[11] in which 35 per cent of the patients dying of acute myocardial infarction were found to have diabetes and the finding of severe coronary atherosclerosis in 45-74 per cent of diabetics studied at post mortem.[12]

The 389 adult patients, in which twenty VCGs with bites were discovered, were not a true random population. All subjects were hospital patients or office outpatients who had a medical problem under active medical care. The problems varied from admissions for elective hemorrhoidectomy to suspected myocardial infarction, to evaluation of hypertension or general office physical examination. It was not the intent of this study to determine the incidence of bites in a random population nor to determine the incidence of unsuspected diabetes. The study of twenty adult patients in this population with bites and no personal history of diabetes known to the patient or to the physician, who at the time of ordering the VCG frequently had reports of normal fasting blood sugars; two-hour p.c. blood sugars and normal morning urine analyses is the raison d'etre for this portion of this report. The 90 per cent correlation of bites with family history, the 55 per cent correlation of bites with chemical diabetes (normal fasting blood sugar, abnormal GTT) and the 75 per cent correlation of bites with subclinical diabetes (normal fasting blood sugar, normal GTT and abnormal CGTT) indicated that the presence of bites in the VCG is sufficient reason to suspect diabetes or subclinical diabetes in the patient.

The study of the children, three of whom might reasonably be suspected to have prediabetes, demonstrated typical VCG bites in the absence of measurable metabolic abnormality by the GTT or CGTT. The fourth child with the abnormal CGTT would be classified as having subclinical diabetes.

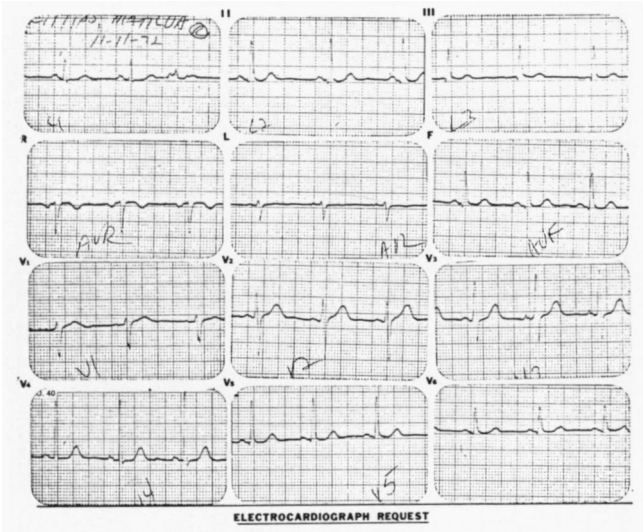
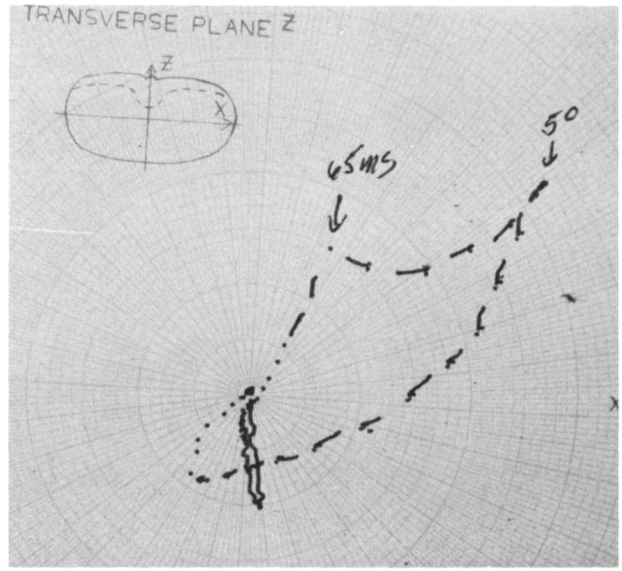


FIG. 3B. ECG of the same patient, 10 mm./mv., 25 mm./sec.



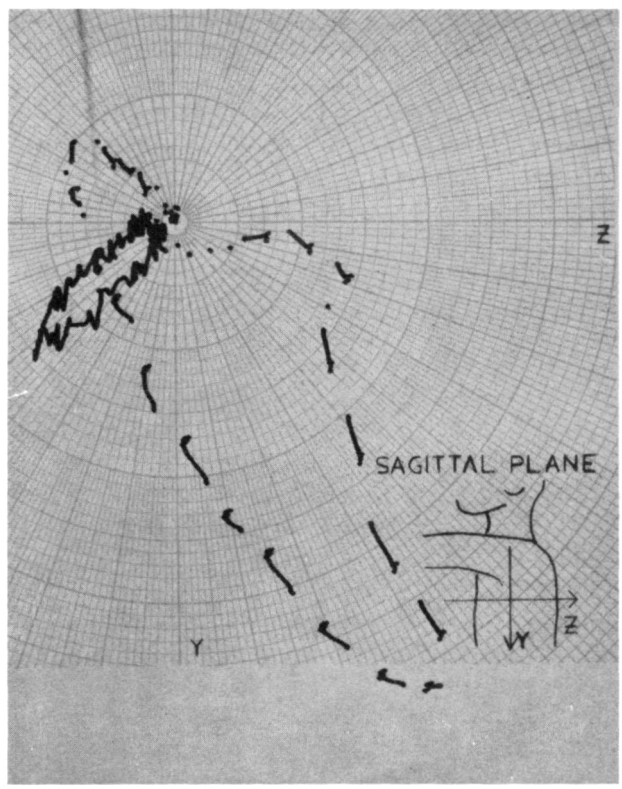


FIG. 4A. Transverse and left sagittal plane VCG loops of a twenty-five year old white female with subclinical diabetes. The bite extends from 50 to 65 ms. Standardization: 80 mm./mv.

The mechanism responsible for the creation of these bites is unknown. A possible explanation is an abnormality in ventricular depolarization due to an unidentified mechanism (biochemical, electrochemical, membrane disease, etc.). Another possible explanation is that these bites represent areas of focal fibrosis or microinfarcts (necrosis or fibrosis 0.5 to 1.5 cm.). While there is a paucity of literature relating to studies of the myocardium in diabetes other than major vessel atherosclerotic disease, Blumenthal reports an increased incidence of proliferative lesions of the medium-sized coronary arteries in diabetics irrespective of the age of the patient or coexisting hypertension.[13] James reports in a study of five patients dying with the juvenile form of diabetes, three had significant occlusions in the large coronary arteries; one, dying of renal insufficiency, had minor involvement of the large and smaller vessels, and a fifth patient had extensive degenerative and occlusive disease of the small coronary arteries.[14] Hamby et al. reported three autopsied diabetic patients with primary myocardial disease all of whom had no extramural coronary artery disease and all of whom had "small vessel changes in the myocardium".[15] Pearce et al. reported that of eight patients with maturity-onset diabetes subjected to right heart catheterization and myocardial biopsy, all showed focal myocardial fibrosis and varying degrees of intimal proliferation of small myocardial arterioles (30-100 microns). Similar changes were found in only two of fifty-nine nondiabetic patients.[16]

The literature abounds with reports of alterations in the basement membrane, PAS positive material and hyalinization changes in the microvasculature of patients with diabetes, and recently one finds reports of

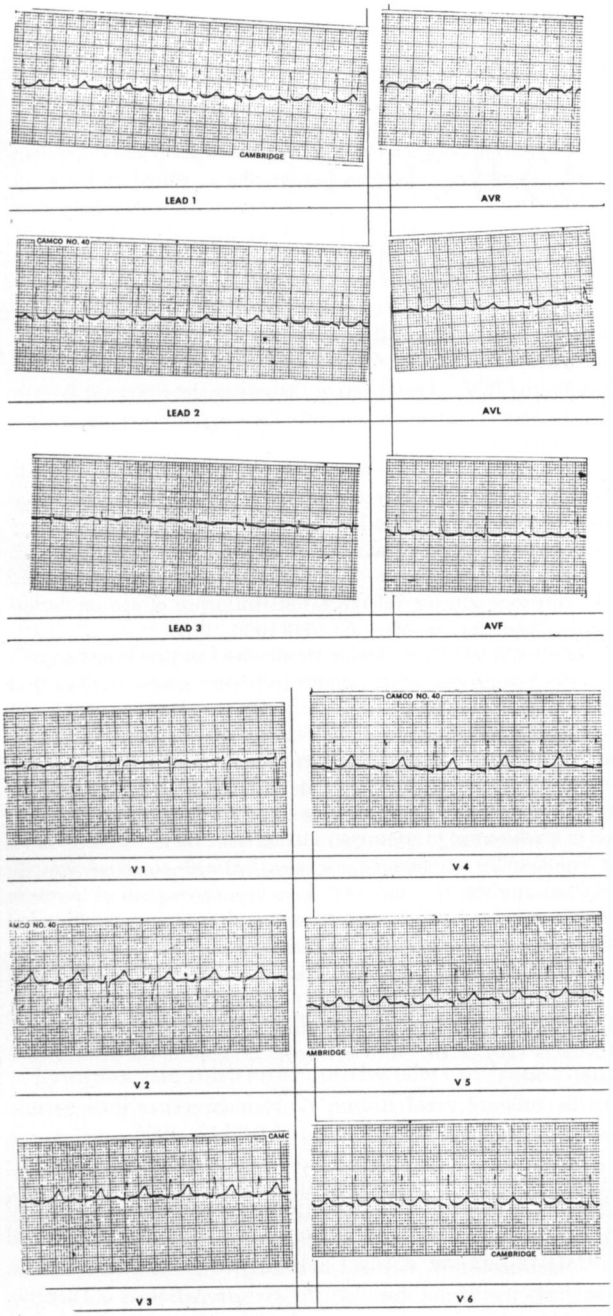


FIG. 4B. ECG of the same patient, 10 mm./mv., 25 mm./sec.

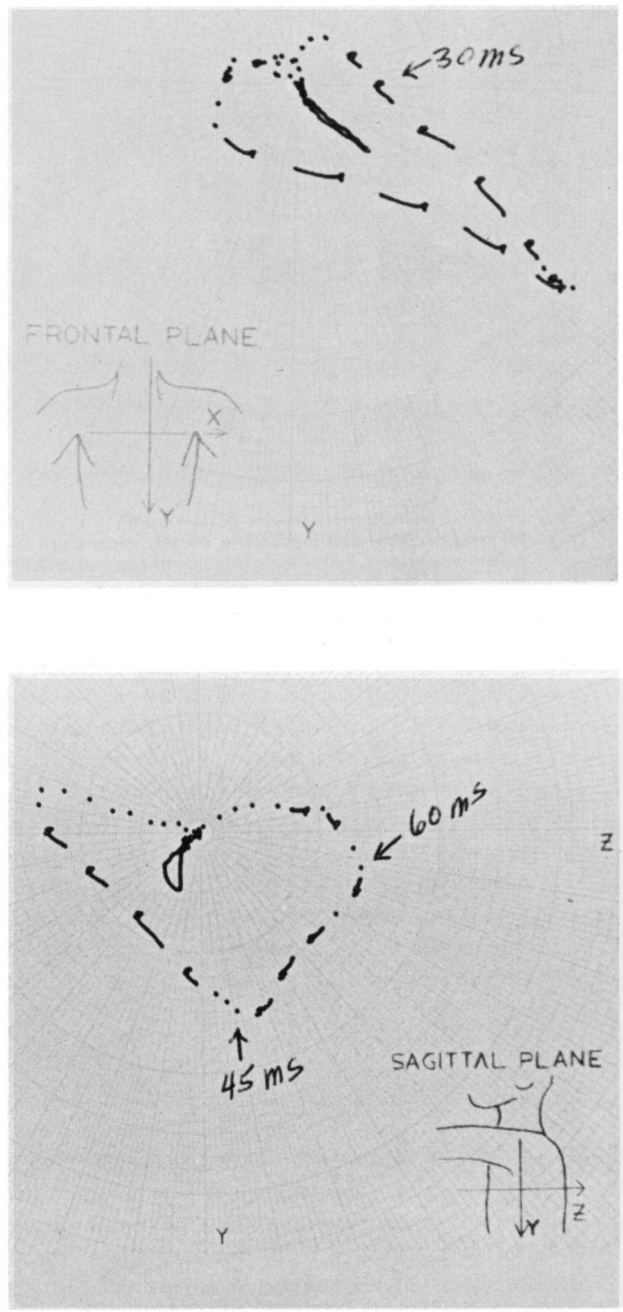


FIG. 5A. Frontal and left sagittal plane VCG loops of a twelve year old white male whose mother has insulin-dependent diabetes and whose father has subclinical diabetes. The patient's CHO studies were normal. Standardization: 40 mm./mv.

biochemical abnormalities of the basement membrane in diabetes.[17-20] But these reports are limited to the glomerulus, dermis, retina, renal tubules, striated muscle, nerves, conjunctival venules and other tissues, but not the myocardium. In view of these depolarization changes as registered by the VCG one cannot help but wonder if such myocardial studies are not indicated.

The finding of bites in the VCG loops of "prediabetic" children (if these bites represent changes of a vascular insult) lends support to the proponents of the proposition that the vascular disease of diabetes exists at an early stage of the disease.[21,22]

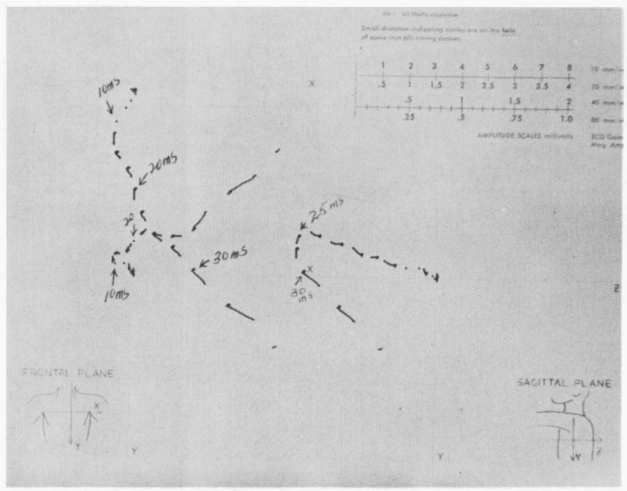


FIG. 5B. Initial depolarization forces of the same patient at 80 mm./mv. Note that the 25 and 30 ms. vectors are located superiorly, a criteria for diaphragmatic wall myocardial infarction.

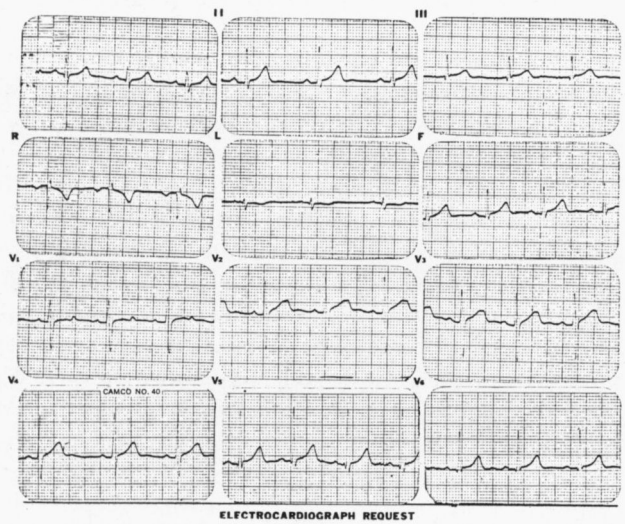


FIG. 5C. ECG of the same patient, 10 mm./mv., 25 mm./sec.

ACKNOWLEDGMENT

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