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Study of mitral insufficiency through spatial vectorcardiography

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A STUDY OF MITRAL INSUFFICIENCY THROUGH SPATIAL VECTORCARDIOGRAPHY

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Since 1887, when Waller successfully recorded the electromotive changes accompanying the action of the heart, there have been many important developments in the theory and practice of electrocardiography. It is not the purpose of this paper to present the theory behind spatial vectorcardiography, but rather to take a clinical entity and try to determine whether there is a definite pattern which would help to diagnose this entity. For those who are interested in theory, a bibliography is presented at the end of this paper, which includes a paper by Grishman (1) which contains ninety-seven further references.

We first became interested in mitral insufficiency because we were impressed by the number of patients coming to surgery for mitral commissurotomy that had unsuspected insufficiency. Because insufficiency is directly correlated with the lack of favorable outcome in this operation, we have sought to determine whether vectorcardiography will be an aid in diagnosing this entity.

Our vectorcardiograph was designed and built by F. Lowell Dunn, M.D. and Jesse F. Crump, E.E., and utilizes miniature vacuum tubes and other features making it compact and portable. The instrument utilizes one cathode ray tube, and "self-developing" photographic paper for producing permanent records. By use of a selector switch, frontal, horizontal, and sagittal vectorcardiograms may be taken.

Only four electrodes are used, as described and diagrammed by Grishman (1). All vectorcardiograms were taken in the recumbent position.

In reading a vectorcardiogram, it must be remembered that it is a graph with voltage in the center being zero, and progressively more positive as one moves in any direction from the center. One millivolt is equal to one centimeter. Also, time on the vectorcardiogram is indicated by interrupting the graph by a certain frequency, usually four hundred times a second. This interruption of the graph produces tiny "blobs" of light which are teardrop in shape. The point of the teardrop indicates in which direction the graph is traveling.

Five patients were selected, who, it was felt, had "pure" or high grade mitral insufficiency. Selection was on the basis of auscultatory findings, heart fluroscopy, left heart catheterization, dye dilution curves, and operation. The vectorcardiograms are presented in the plates following this paper. After each is the electrocardiogram on the same patient.

The normal spatial QRS loop is directed to the left, inferiorly, and posteriorly. The normal QRS loop in the horizontal plane is characterized by an initial small deflection anteriorly and to the right. The remainder of the loop is then inscribed in a counterclockwise direction to the left and somewhat posteriorly. The loop is usually fairly narrow, and the voltage moderate in amount. The spatial T loop has an axis similar to the QRS loop. (See Figure 1, A.)

In the presence of left ventricular hypertrophy, the QRS loop in the horizontal plane is characterized by an initial small deflection anteriorly and somewhat to the right. The loop is then inscribed to the left and posteriorly in a counterclockwise direction. The long axis of the QRS loop is more posterior than in normal persons. In the frontal plane, the QRS loop is oriented more to the left than in normal persons. The T loop in each projection lies opposite the QRS loop. Voltage is increased over the normal. (See Figure 1, B.)

In mitral stenosis, the loop is dependent upon the degree of right ventricular hypertrophy. When the right ventricular preponderance is mild to moderate, the horizontal projection is characterized by a small initial deflection directed to the right and anteriorly, followed by a large deflection to the left and somewhat posteriorly, then sharply to the right and anteriorly with a clockwise return to the point of origin. When the right ventricular preponderance is marked, the horizontal projection is characterized by a small initial deflection to the right and anteriorly, followed by a small deflection to the left and posteriorly, then sharply to the right and anteriorly with a clockwise return to the point of origin. The QRS loop is oriented anteriorly, and the T loop may be oriented opposite the QRS loop. The voltage is increased over that of normal persons. (See Figure 1, C., D., and E.)

In the case of mitral insufficiency, we would expect a QRS loop which is fairly wide, and having a fairly large posterior component. The loop would be oriented leftward. In cases of long standing, with fairly severe insufficiency, we would expect to see some combined ventricular hypertrophy and a larger anterior component to the QRS loop. The voltage would be increased and the T loop oriented opposite to the QRS loop.

In Plate II and III (Mrs. C.), the electrocardiogram exhibits atrial fibrillation, left ventricular hypertrophy, possible mild right ventricular hypertrophy, and digitalis effect. The vectorcardiogram on this patient (Plate I) exhibits a QRS loop which is oriented to the left and posteriorly. The voltage is fairly high, and the T loop is opposite in orientation to the QRS loop. The loop starts posteriorly and to the left, then swings around sharply toward the right and anteriorly in a clockwise direction.

Plate V, the electrocardiogram on Miss. Y. W., exhibits atrial fibrillation, bilateral ventricular hypertrophy, and digitalis effect. The vectorcardiogram on this patient (Plate IV) exhibits a small QRS loop which has an initial deflection leftward and slightly posteriorly, and finally, to the right and anteriorly. The QRS loop is oriented toward the left and slightly posteriorly. The T loop is opposite to the QRS loop. Voltage appears fairly low because of the obesity and thick chest wall of the patient.

Atrial fibrillation, digitalis effect, and ventricular hypertrophy, mostly right, are demonstrated on the electrocardiogram found on Plate VII (Mr. B.). The vectorcardiogram on this patient, found on Plate VI, exhibits some interference from sixty-cycle electrical current, but the QRS loop can be seen to be oriented posteriorly and about forty-five degrees toward the left. The loop starts posteriorly and toward the left, and then, anteriorly and toward the right. The T loop is again oriented away from the QRS loop. This QRS loop swings more anteriorly than the previous two vectorcardiograms, indicating more right ventricular enlargement.

The electrocardiogram on Plate IX (Miss. G.) demonstrates atrial fibrillation, left or combined ventricular hypertrophy and strain, and vertical position of the heart. The vectorcardiogram, Plate VIII, on this patient is characterized by a QRS loop which has an initial deflection anteriorly and toward the left, and then, to the right and slightly posteriorly; the loop is very nearly in the frontal plane. The loop is thin and long, and counterclockwise in direction. The T loop is oriented opposite to the QRS loop.

The electrocardiogram of Miss. A. D. (Plate XI) exhibits atrial fibrillation, combined ventricular hypertrophy, mostly left, and digitalis effect. Plate X, the vectorcardiogram on this patient, exhibits tremendous voltage. The QRS loop has an initial deflection toward the left and slightly posteriorly, and then, swings sharply toward the right and slightly anteriorly. The entire QRS loop is oriented more anteriorly. The mean spatial QRS vector is oriented slightly posteriorly and about thirty degrees toward the left. The loop is clockwise in direction, and the T loop is oriented away from the QRS loop.

In none of the vectorcardiograms is there an appreciable alteration in the distances between the time markings which would indicate a bundle branch block.

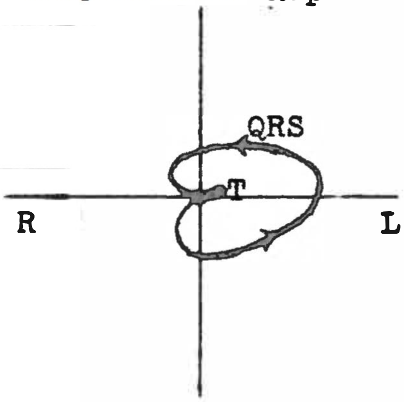
Summarizing then, in all the vectorcardiograms, the QRS loops are oriented between thirty and ninety degrees toward the left. The QRS loops are oriented between zero and forty-five degrees posteriorly, depending upon the degree of right ventricular enlargement present. The loops may be more anteriorly oriented also, depending upon the degree of right ventricular enlargement. the voltage was increased over the normal, and the T loops were all oriented opposite to the QRS loops. In all but one case, the loops were clockwise in direction in the frontal and horizontal planes. There was no indication of timing alteration to indicate bundle branch block.

SUMMARY: There has been felt a growing need for simple diagnostic tools with which to diagnose mitral insufficiency in the presence of mitral stenosis. We have attempted to use a spatial vectorcardiograph, which was made in our cardiovascular laboratory, for this purpose. With this machine, vectorcardiograms have been made on five selected patients. These patients were selected on the basis of auscultatory findings, cardiac fluroscopy, left heart catheterization, dye dilution curves, and operation. In all the vectorcardiograms, the QRS loops are oriented between thirty and ninety degrees toward the left. The QRS loops are oriented between zero and forty-five degrees posteriorly depending upon the degree of right ventricular hypertrophy present. The loops may be oriented more anteriorly also, depending upon the degree of right ventricular enlargement. The voltage was increased over the normal, and the T loops were all oriented opposite to the QRS loops. In all but one case, the loops were clockwise in direction in the frontal and horizontal planes. There was no indication of bundle branch block. The electrocardiograms, on these same patients, exhibited atrial fibrillation, left ventricular hypertrophy and strain, digitalis effect, and varying degrees of right ventricular hypertrophy.

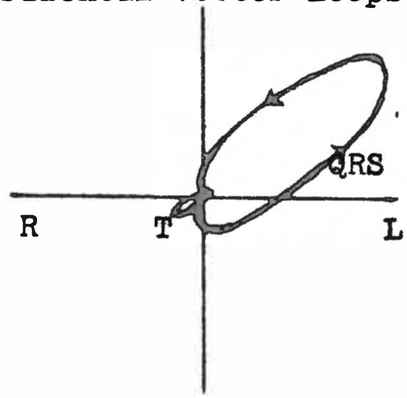
CONCLUSIONS: We have attempted to find, by vectorcardiography, a pattern with which to diagnose mitral insufficiency. In our very small series of five patients, we have discovered some semblance of a pattern, which has minor variations. The validity of this pattern will have to be tested by further clinical trial.

Figure 1.

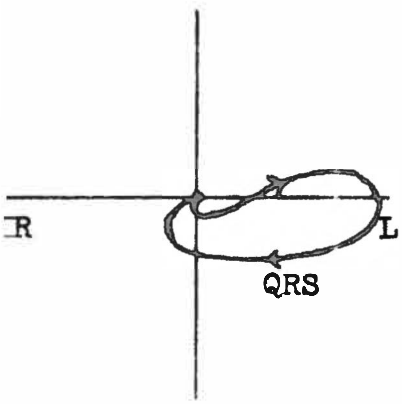
Diagrammatic Representation of Horizontal Vector Loops*



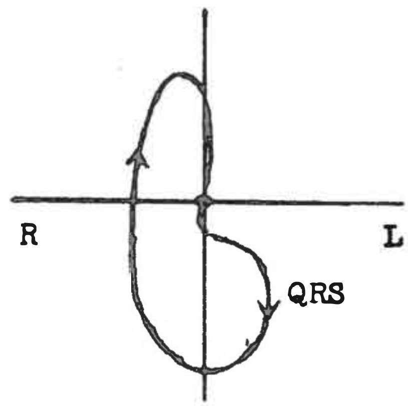
A. Normal



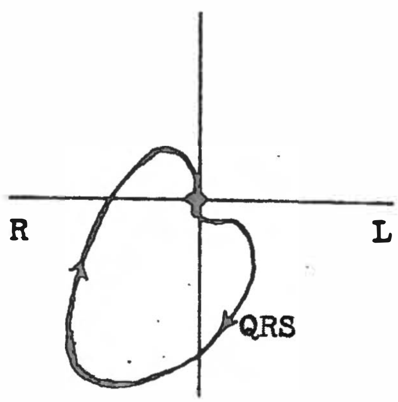
B. L.V.H.



C. R.V.H.-Mild



D. R.V.H.-Marked

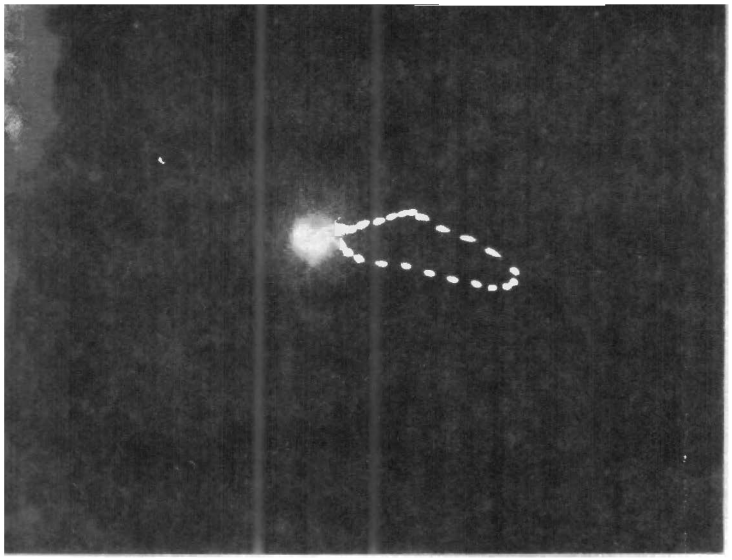


E. R.V.H.-Marked

* After Grishman

Mrs. C.
(Plate I)

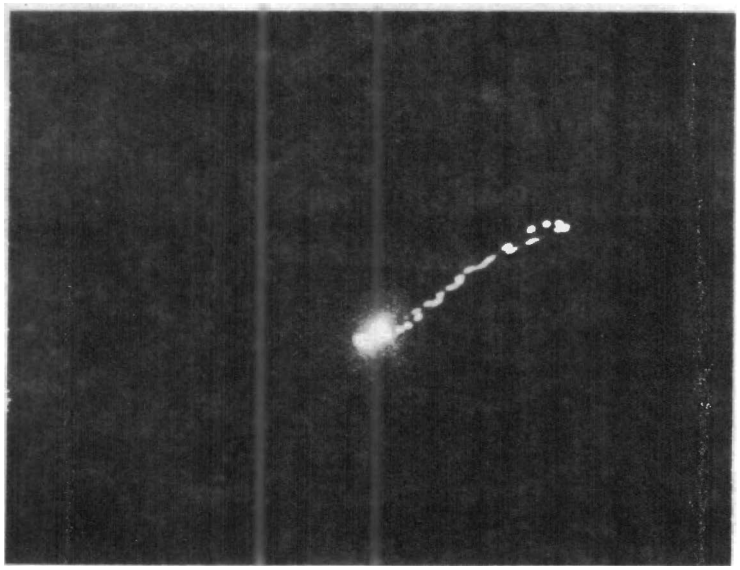
R



L

Frontal

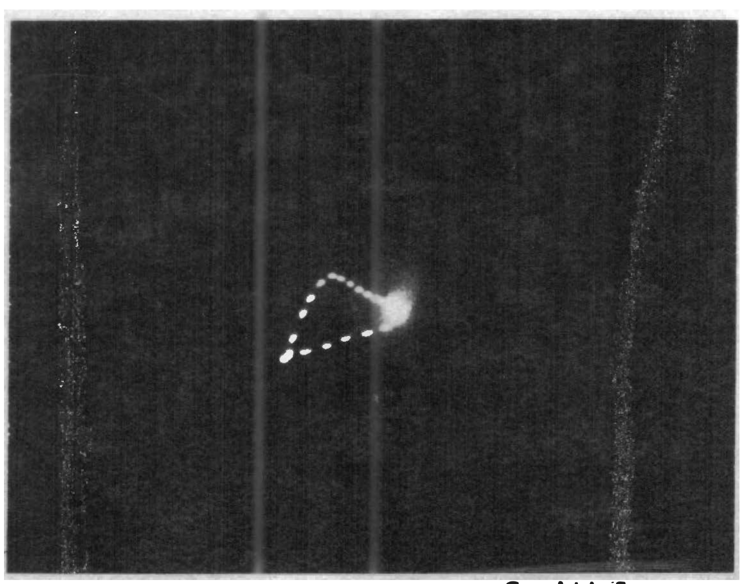
R



L

Horizontal

P

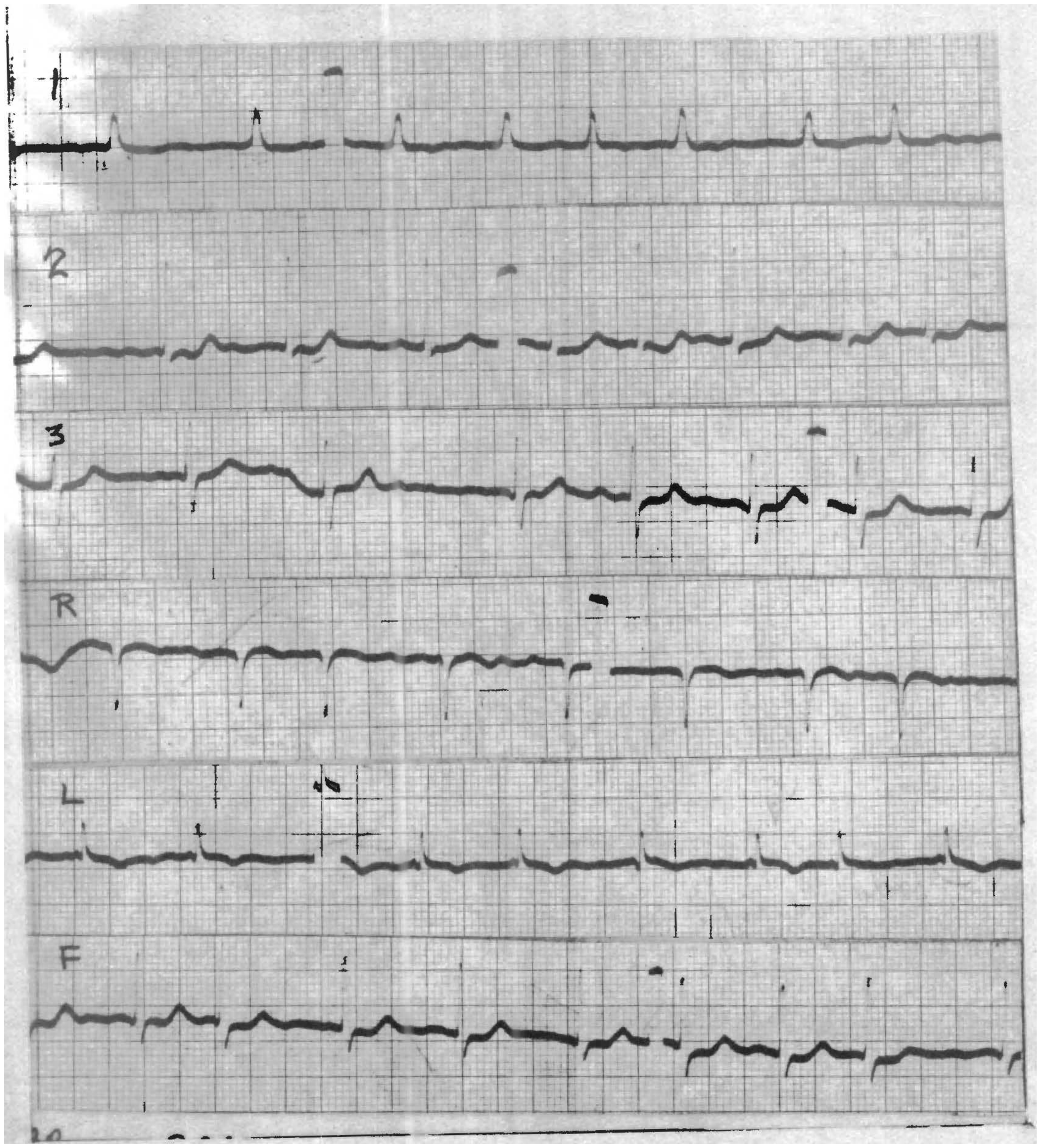


A

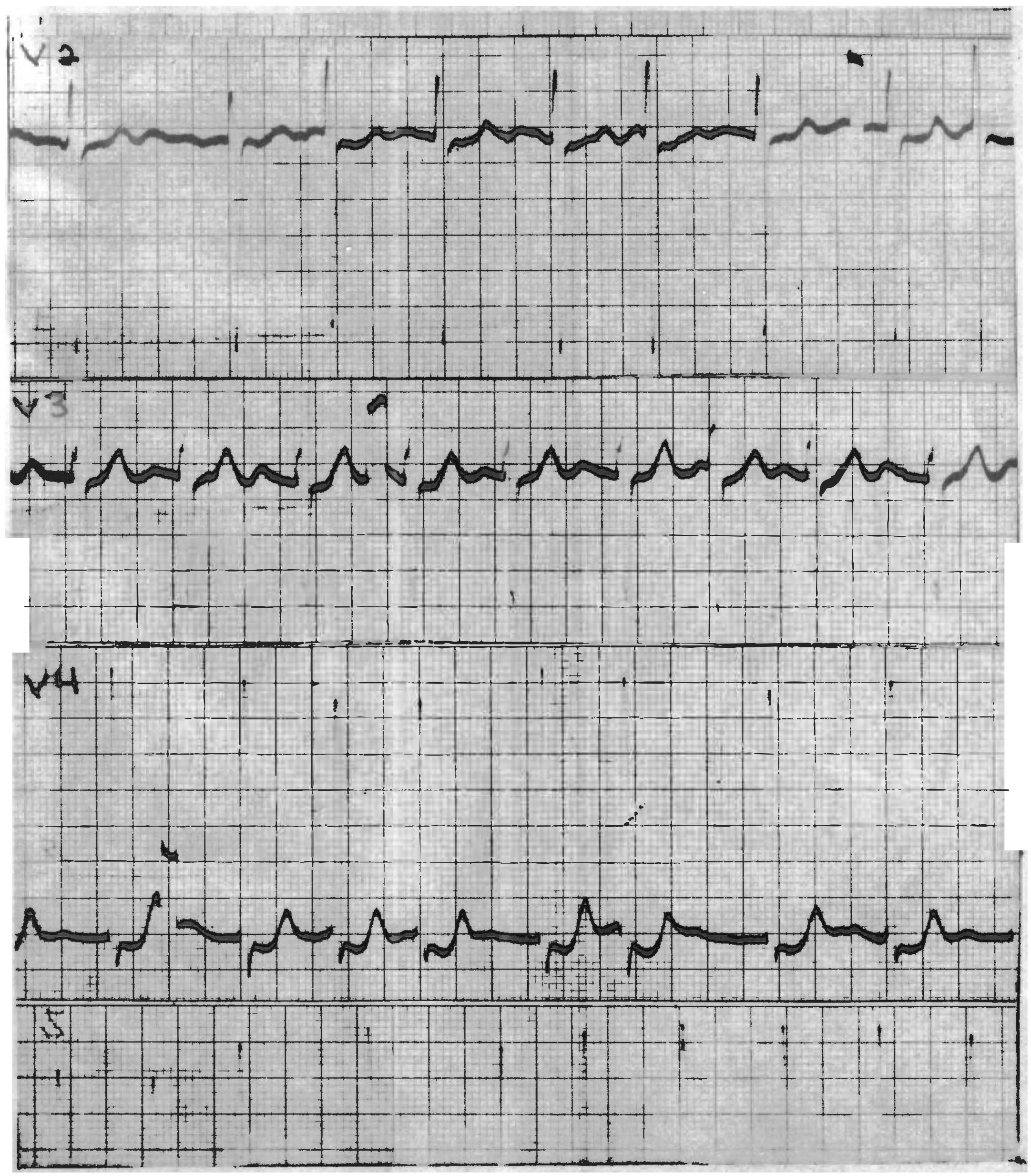
Sagittal

Mrs. C.

(Plate II)

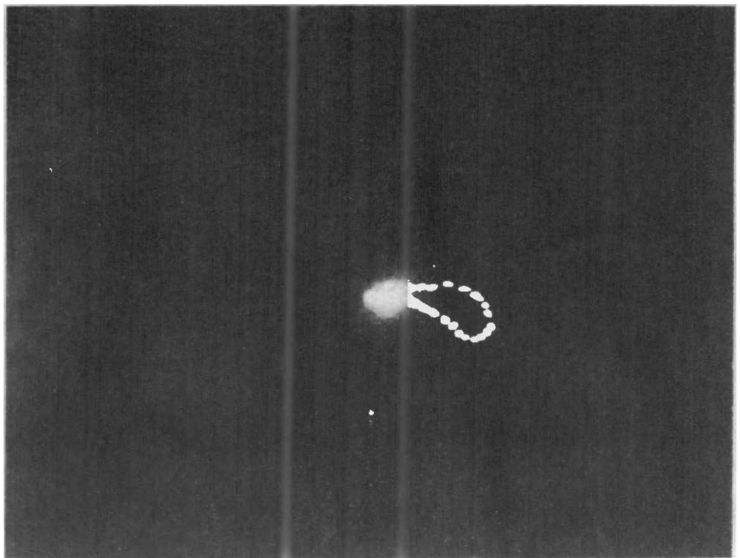


Mrs. C.
(Plate III)



Miss. Y. W.
(Plate IV)

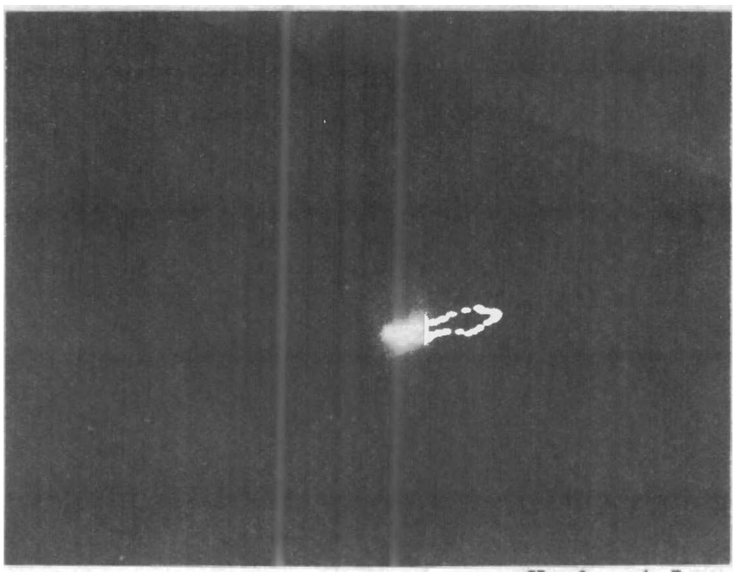
R



L

Frontal

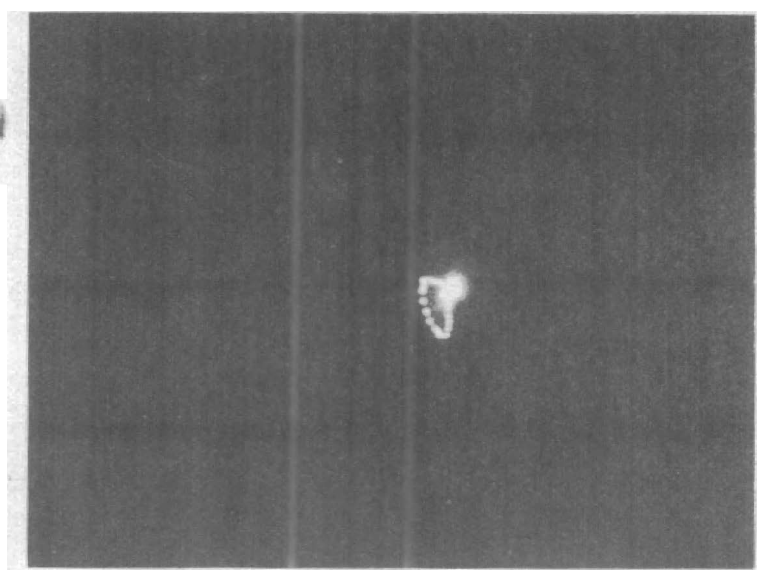
R



L

Horizontal

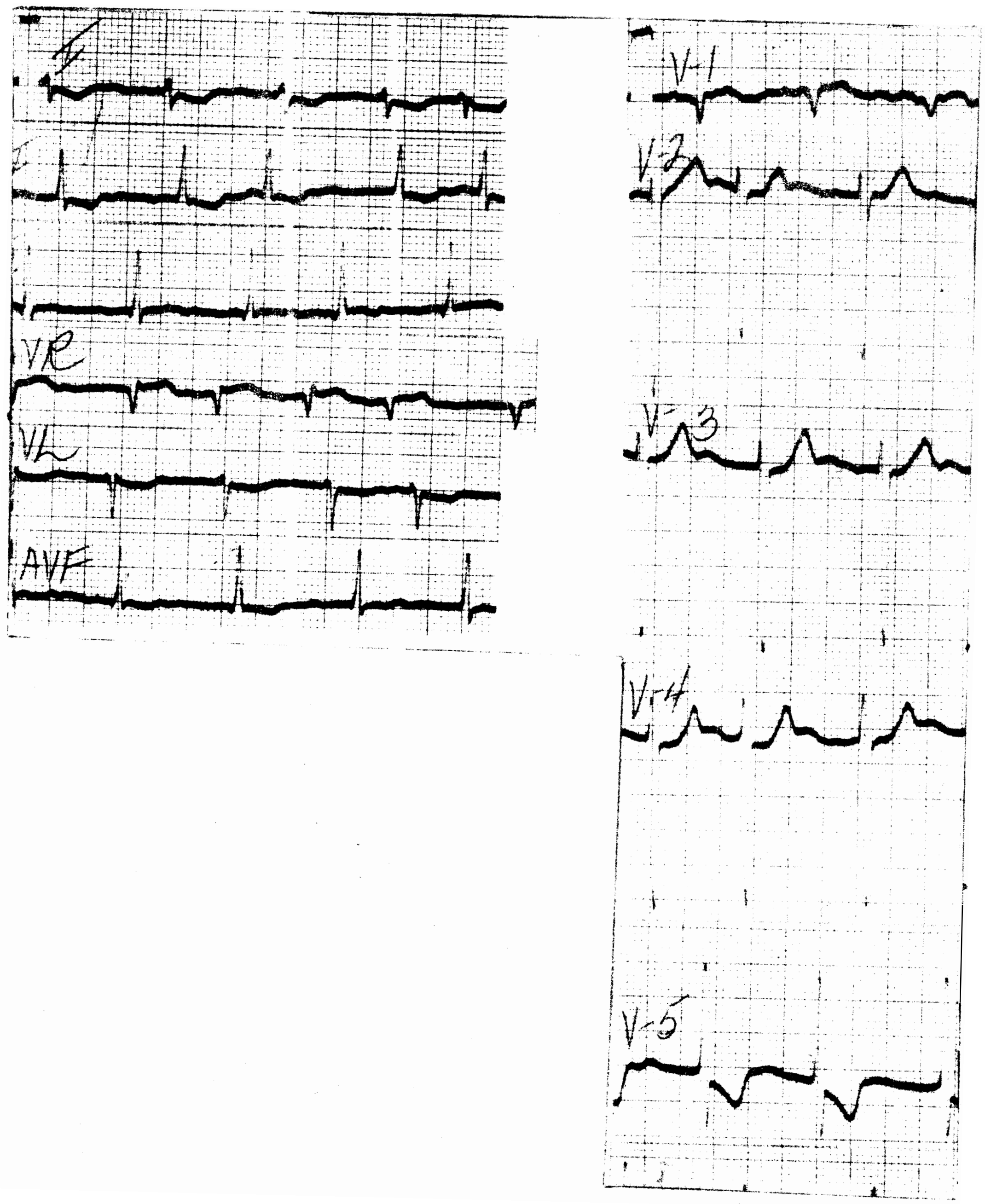
P



a

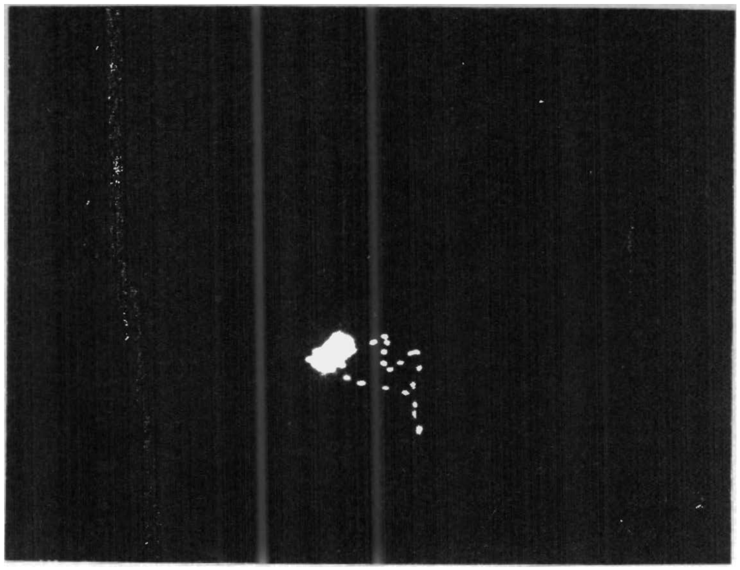
Sagittal

Miss. Y. W.
(Plate V)



Mr. B.
(Plate VI)

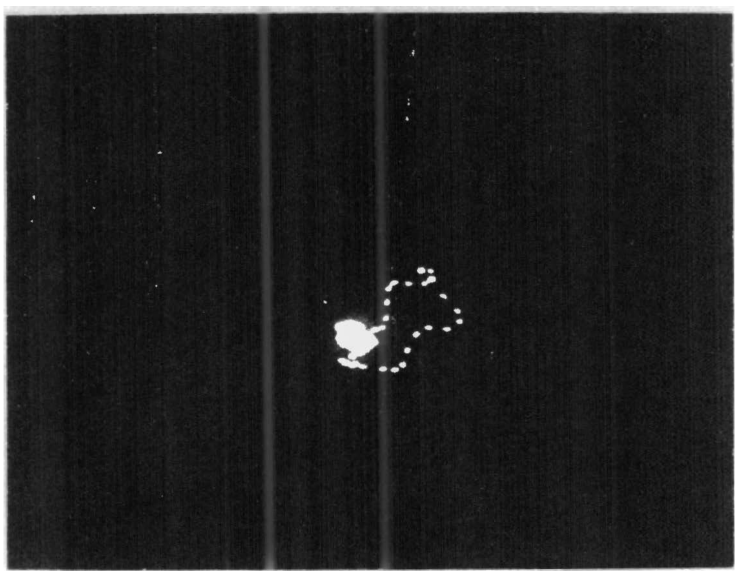
R



L

Frontal

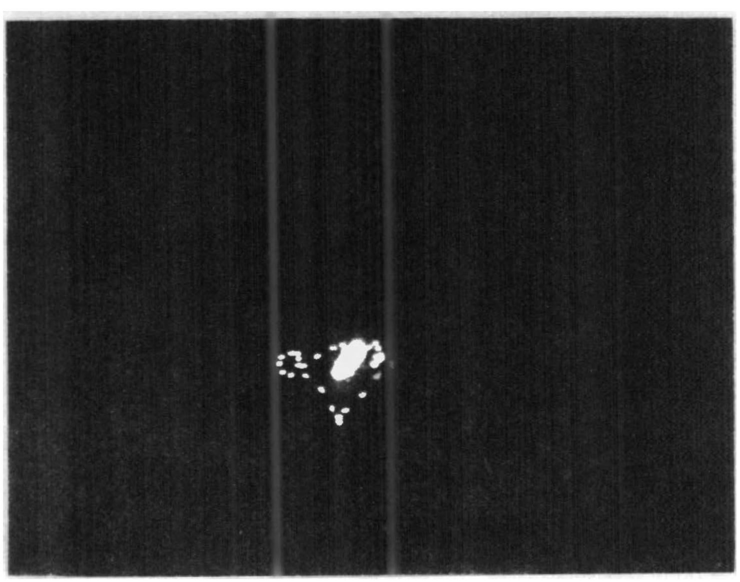
R



L

Horizontal

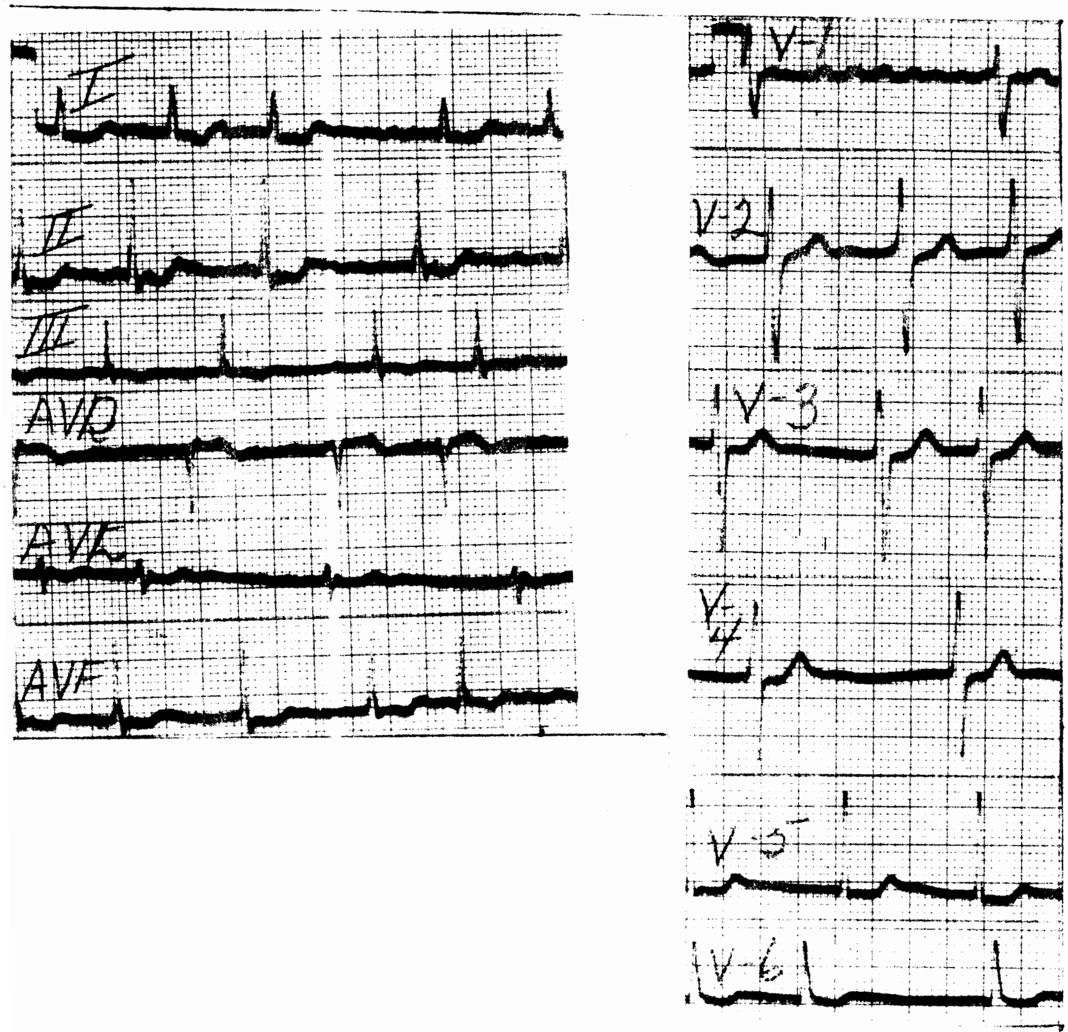
P



A

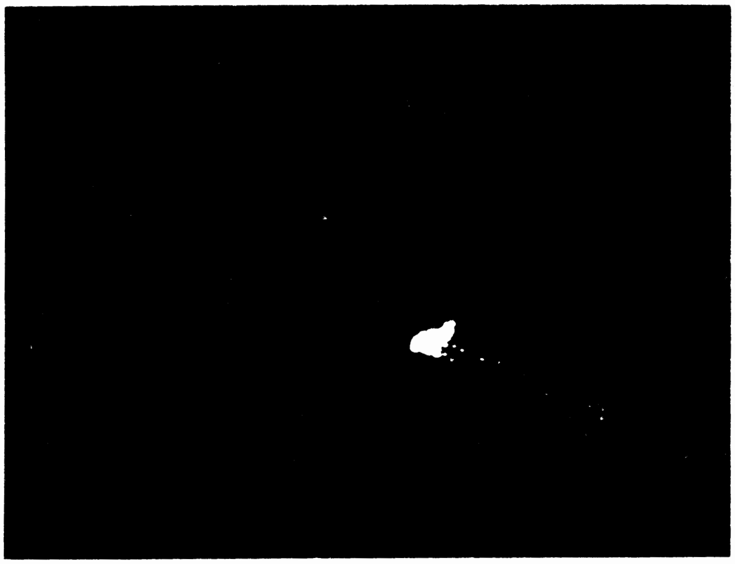
Sagittal

Mr. B.
(Plate VII)



Miss. C.
(Plate VIII)

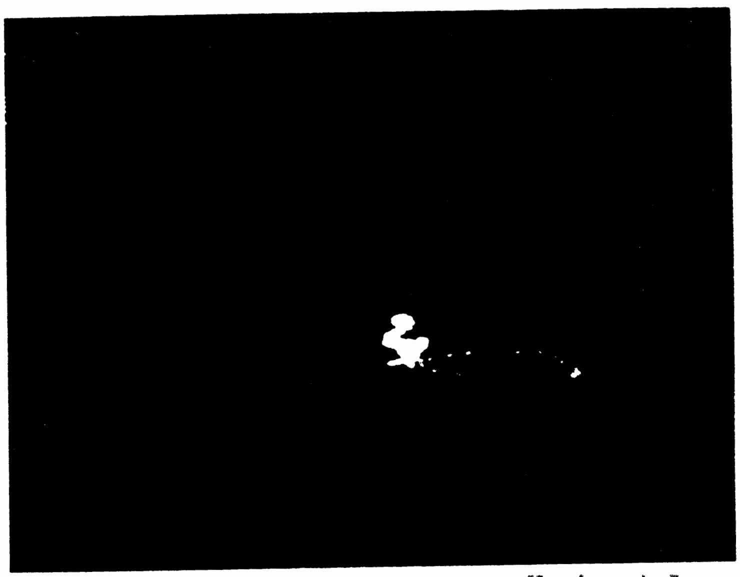
R



L

Frontal

R



L

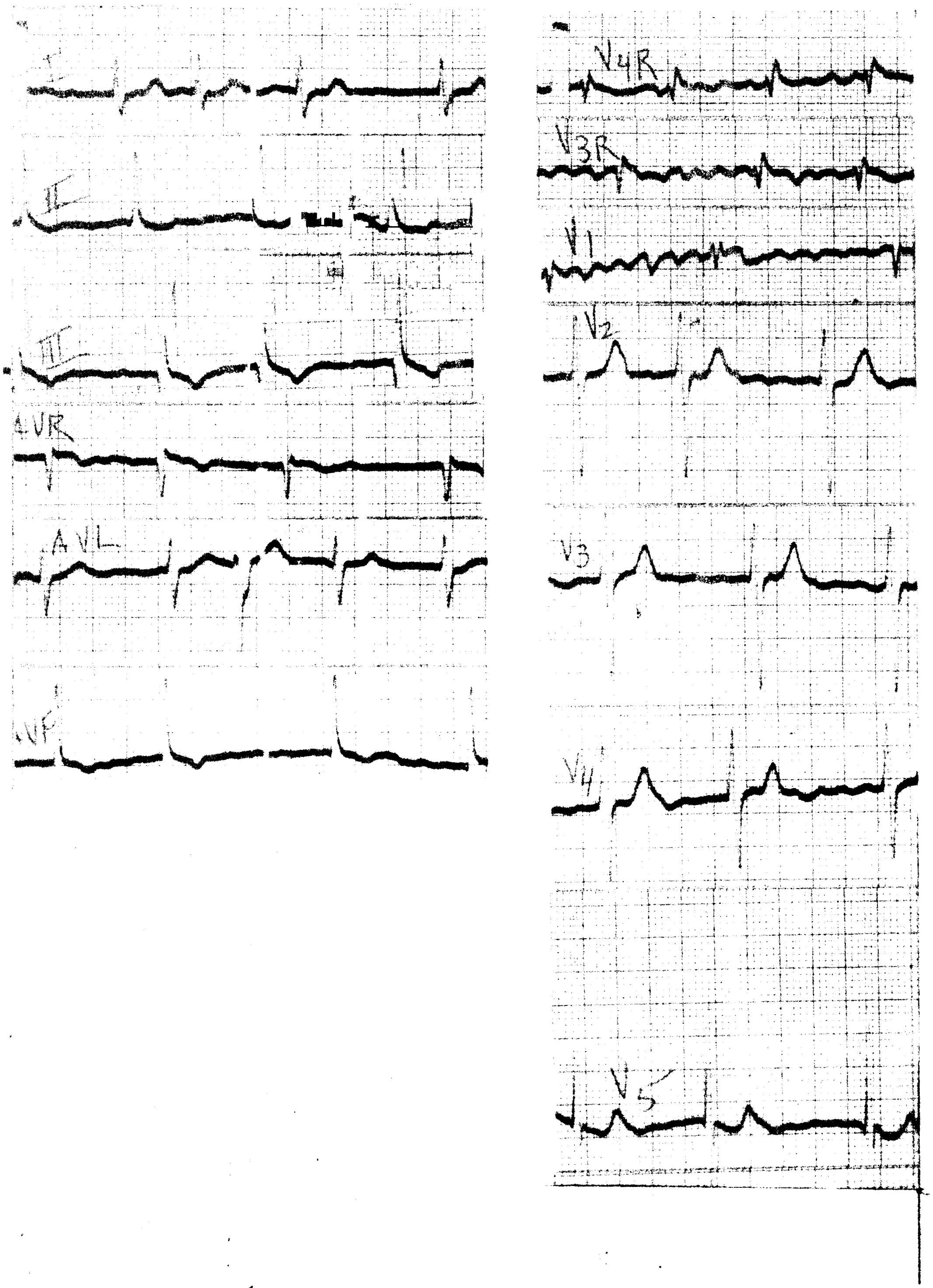
Horizontal

P

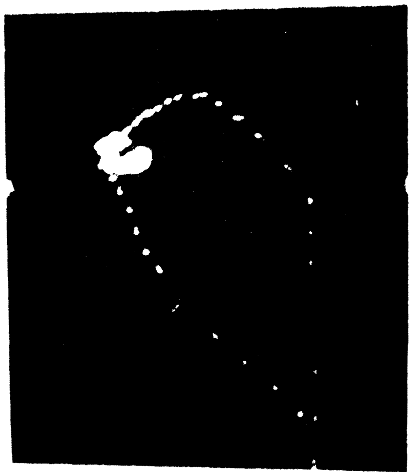
A

Sagittal

Miss. G.
(Plate IX)

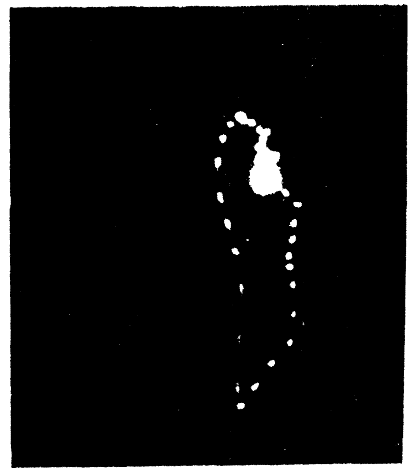


Miss A.D.
(Plate X)

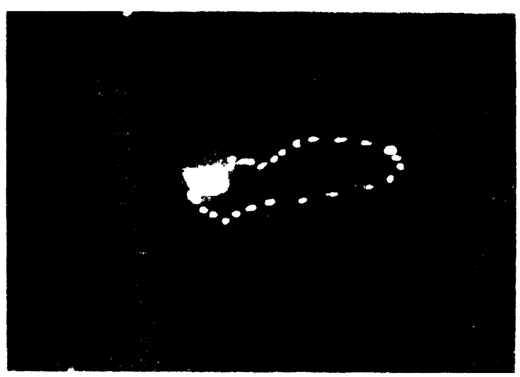
R  L

P

Frontal

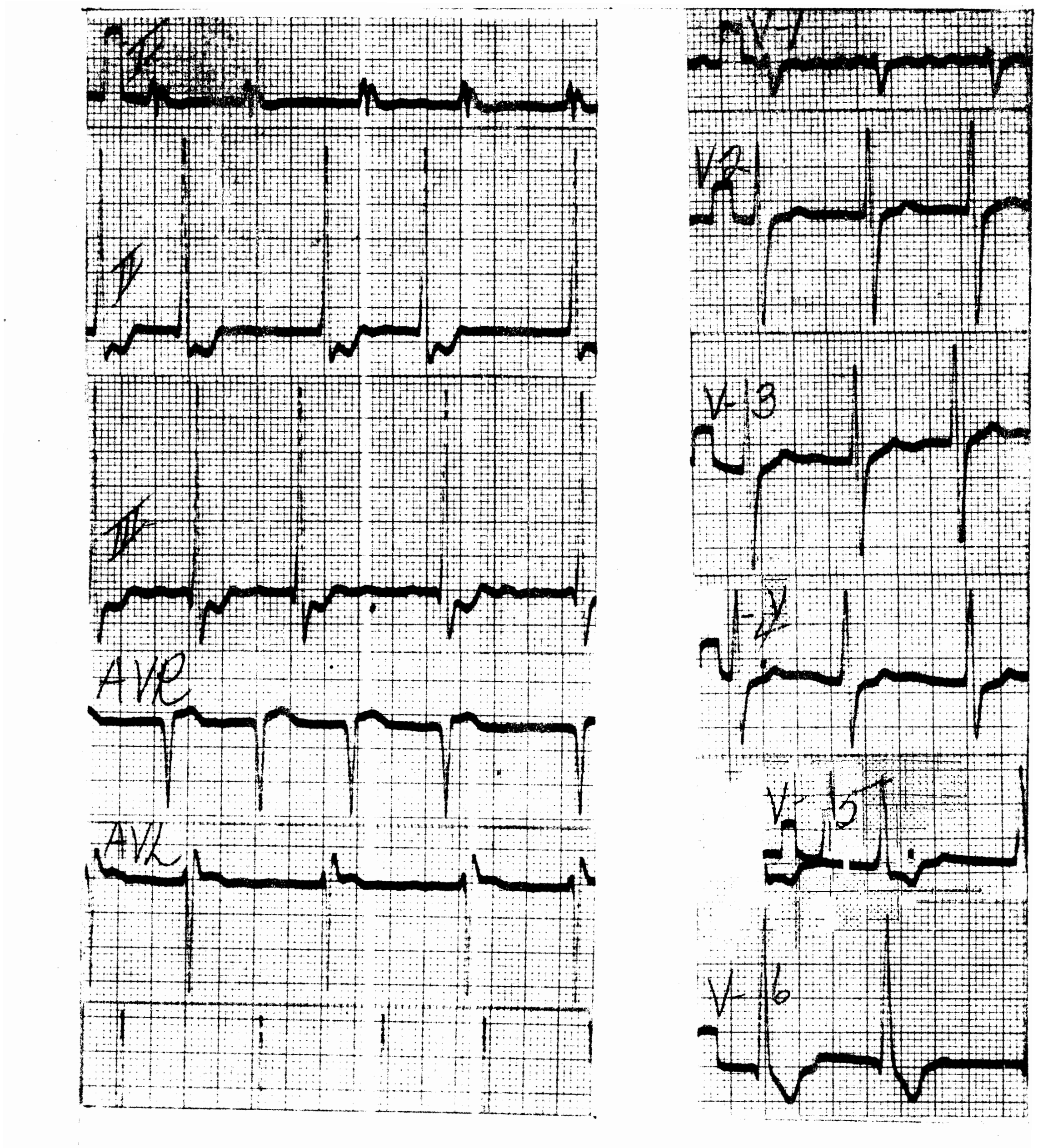
 A

Sagittal

R  L

Horizontal

Miss. A. D.
(Plate XI)



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