

PERSISTENT DISPLACEMENT OF THE RS-T SEGMENT IN A CASE OF METASTATIC TUMOR OF THE HEART

FRANCIS F. ROSENBAUM, M.D., FRANKLIN D. JOHNSTON, M.D., AND
VICTOR V. ALZAMORA, M.D.
ANN ARBOR, MICH.

TUMORS of the heart and pericardium have aroused considerable interest, if one may judge from the large number of cases that have been reported. In several instances the correct diagnosis has been made ante mortem.¹⁻⁵ There are also several extensive reviews of the literature⁶⁻⁸ which present data on many examples of both primary and secondary cardiac neoplasm. It is our present purpose to describe a patient with carcinoma of the esophagus which involved the heart and produced very unusual electrocardiographic abnormalities. The frequency of cardiac invasion in various neoplastic diseases is reported to range from 2.0 per cent⁹ to 10.9 per cent.¹⁰ Three different mechanisms leading to involvement of the heart are mentioned: (a) embolic metastases via the coronary arteries, (b) invasion through the lymphatic channels, and (c) direct extension from either a primary or secondary tumor in the lung or mediastinum. Metastases to the heart or pericardium have been observed in association with malignant tumors arising in many different organs, and carcinoma of the esophagus frequently involves these structures.

CASE REPORT

History.—J. K., Reg. No. 496456, a 53-year-old Austrian, was admitted to the University Hospital Jan. 14, 1942, complaining of progressive difficulty in swallowing over a period of two months. He had developed nausea and vomiting of undigested food shortly after eating, and for three days he had been unable to eat at all. There was an almost constant, dull ache and sense of fullness beneath the xiphoid process, aggravated by taking food. The resulting loss of weight amounted to 30 pounds (13.8 kg.). The past history and family history were essentially negative.

Physical Examination.—The patient appeared chronically ill and was obviously emaciated. The temperature, pulse rate, and respiratory rate were normal. The heart was normal in size, the cardiac sounds were normal in character, and no murmurs were heard. The blood pressure was 130/90. A few crepitant râles were present at both lung bases posteriorly. The remainder of the examination revealed no abnormalities.

Laboratory Examinations.—The blood Kahn reaction was negative. Examination of the blood disclosed a hemoglobin content of 90 per cent

This study was aided by a grant made to Dr. F. N. Wilson by the Horace H. Rackham School of Graduate Studies.

From the Department of Internal Medicine, University of Michigan Medical School, Ann Arbor, Michigan.

Received for publication May 3, 1943.

(Sahli) and 8,000 leucocytes per cubic millimeter. On admission the urine showed 8 to 10 leucocytes per high power field, but six days later it was negative. The total protein content and the chloride content of the blood were normal.

Roentgenographic Examinations.—Roentgenographic studies of the upper gastrointestinal tract revealed a carcinoma of the lower third of the esophagus. Roentgenograms of the thorax showed no evidence of metastases, and the heart was normal in size and shape.

Clinical Course.—An esophagoscopy was performed Jan. 19, 1942. A polypoid, pedunculated lesion, almost filling the esophageal lumen, was encountered 32 cm. from the teeth. Biopsy of this mass revealed a squamous-cell carcinoma.

During the following eleven months a series of surgical procedures was carried out for the purpose of removing the tumor and reconstructing the upper gastrointestinal tract (Drs. C. Haight and E. B. Kay). On January 28, a Beck-Jainu tube was constructed along the greater curvature of the stomach and the spleen was removed. On February 12, the esophagus was mobilized throughout its length and brought out through an incision in the neck, the tumor was resected, and a cervical esophagostomy was created. The neoplasm proved to be a cornifying squamous-cell carcinoma, grade II, with extensive infiltration of the periesophageal fibroadipose tissue and skeletal muscle. On February 24, a gastrostomy was performed, and the Beck-Jainu tube was brought out over the costal arch. Soon thereafter the patient was able to eat a soft diet by connecting the esophageal with the gastric stoma by means of a rubber tube. On May 28 and October 22, reconstructive plastic procedures upon the gastric stoma were done. On December 8, the first stage of an esophagoplasty to create an anterior thoracic esophagus was performed.

On December 15, a trigeminal pulse was noted and an electrocardiogram was ordered. On the following day, while being taken to the Heart Station in a wheel chair, the patient experienced a sudden, severe pain in the precordium with radiation to the left arm, lasting about ten minutes. While moving from the chair to a bed, before the tracing was made, he felt faint and there was momentary loss of consciousness. As soon as he assumed the supine position he was relieved of all symptoms. The electrocardiogram showed prominent Q waves, marked upward displacement of the RS-T segment, and terminal inversion of the T waves in Leads II and III and Lead V_F (Fig. 14). Examination of the heart on the following day showed no abnormalities; the blood pressure was 98/82. There were no significant changes in the temperature, pulse, or respiration, and, with the exception of slight, dull, precordial discomfort for a few days, no further symptoms. Treatment for acute myocardial infarction was instituted.

After this incident the patient did not regain his strength and became increasingly difficult to manage. It was frequently necessary to supplement gastrostomy feedings with fluids parenterally. On December 21, the blood nonprotein nitrogen was 68.5 mg. per cent, and examination of the urine showed albumin (1 plus), 8 to 10 leucocytes per high power field, and two to three hyaline and granular casts per low power field.

Early in January, 1943, the patient began to complain of dull pain in the lower left part of the chest anteriorly, and in the axilla. This was present intermittently thereafter until his death. Roentgenographic

examination of the chest on January 27 showed a bizarre protuberance along the lower left cardiac border and at the apex, which gave the heart a boot-shaped ("coeur en sabot") outline.

On Feb. 16, 1943, the patient was allowed up in a chair for the first time after his attack of pain in December. At this time his mental status was much improved and he took liquid nourishment well. Two days later, however, he had a sudden attack of pain in the precordium, associated with cyanosis, shallow respirations, and loss of consciousness for about one minute. The blood pressure fell within the next 24 hours to 76/40, but after 48 hours it rose to 90/60. Examination of the heart revealed a gross cardiac irregularity, but no other significant changes from previous findings. Except for persistence of occasional, dull pain

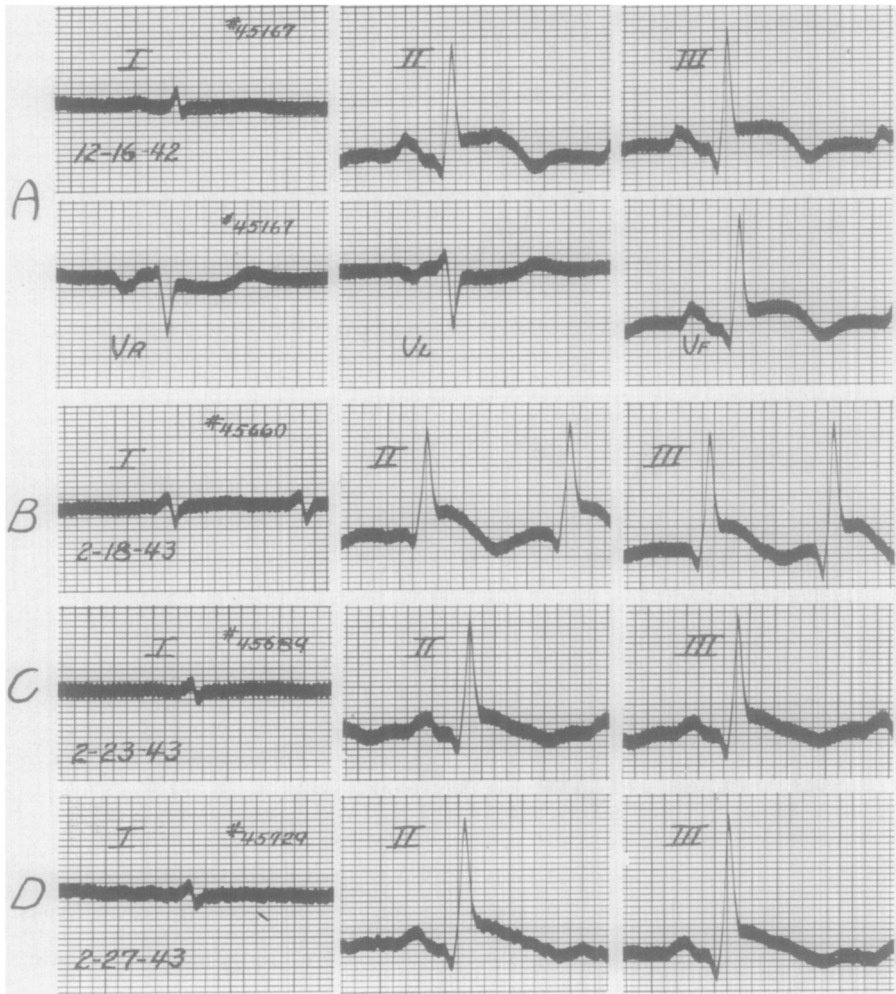


Fig. 1.—A. Standard leads and extremity potentials on Dec. 16, 1942. Note prominent Q waves, elevation of the RS-T segment, and terminal inversion of the T wave in Leads II, III, and Vf.

B. Standard leads on Feb. 18, 1943. RS-T displacement is present and auricular fibrillation has appeared.

C. Standard leads on Feb. 23, 1943. Normal sinus rhythm now present.

D. Standard leads on Feb. 28, 1943, show persistent RS-T displacement.

in the left lower anterior and lateral chest region, all symptoms quickly disappeared.

The electrocardiograms taken Feb. 18, 1943, immediately after this attack, show auricular fibrillation with a ventricular rate of 150 per minute. There is pronounced upward displacement of the RS-T segment in Leads II and III (Fig. 1*B*) and V_F , such as occurs in fresh posterior infarction. In this respect these tracings are much like those taken Dec. 16, 1942. Similar, but even more striking, displacement of the RS-T segment is present in several of the unipolar precordial leads;

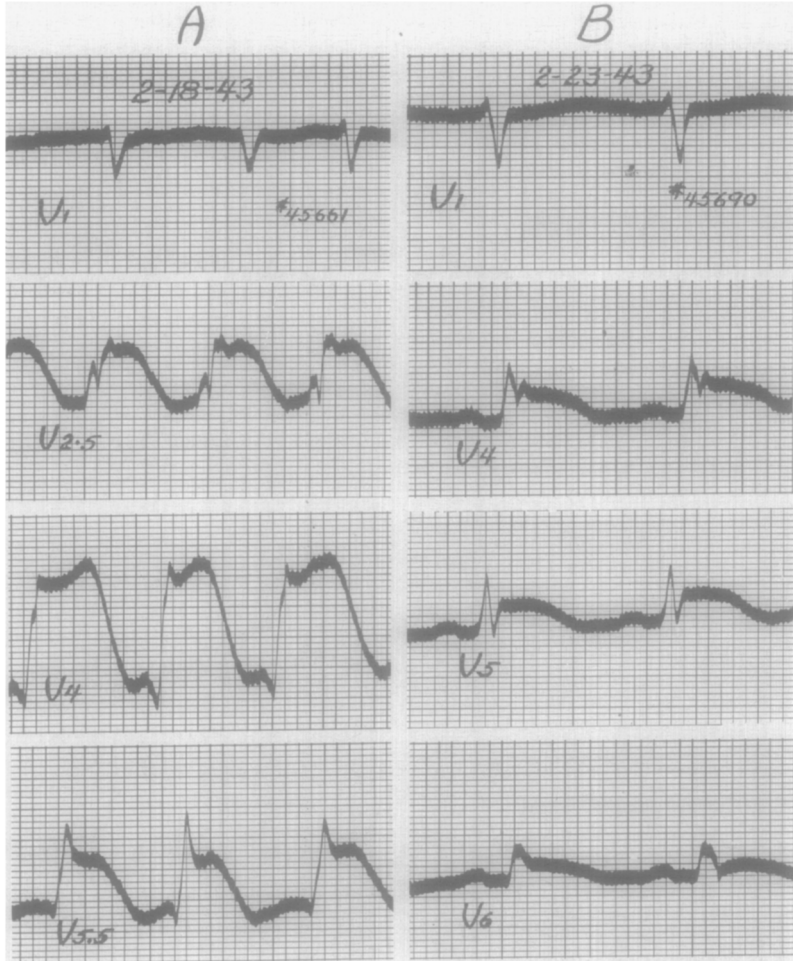


Fig. 2.—A. Unipolar precordial leads on Feb. 18, 1943. Note striking elevation of RS-T segment in all leads taken from points to the left of the sternum. Leads could not be taken from the usual six precordial points because of the operative wounds and dressings $V_{2.5}$ and $V_{5.5}$ represent leads from points midway between V_2 and V_3 and V_5 and V_6 respectively.
B. Unipolar precordial leads on Feb. 23, 1943. RS-T displacement still present, although less conspicuous.

this change is more characteristic of a very recent anterior myocardial infarction (Fig. 2*A*). The standard and precordial curves taken five days later (Figs. 1*C* and 2*B*) are essentially the same, except that the RS-T displacement in the latter is somewhat less conspicuous and normal rhythm is present. The standard leads taken ten days after the

second attack of pain show persistent displacement of the RS-T segment in Leads II and III (Fig. 1D).

The patient became progressively more depressed, unruly, and lethargic. He had a moderately productive cough, but exhibited no other manifestations of congestive heart failure. On March 3, the blood pressure was 88/58. On the following day his condition was not greatly changed until midday, when he was found unconscious in his bed. He had Cheyne-Stokes respiration and the pulse was imperceptible. He died within a few minutes.

Post-mortem Examination (Performed by Dr. W. A. Stryker).—The heart appeared to be a firm, white mass of neoplastic tissue; it weighed 550 grams. The entire apical portion was replaced by carcinomatous



A.

B.

C.

Fig. 3.—Transverse sections of the heart, showing extensive neoplastic invasion. A. From midportion; cavity of left ventricle and normal myocardium seen above. B. From point midway between A and C. C. From cardiac apex.

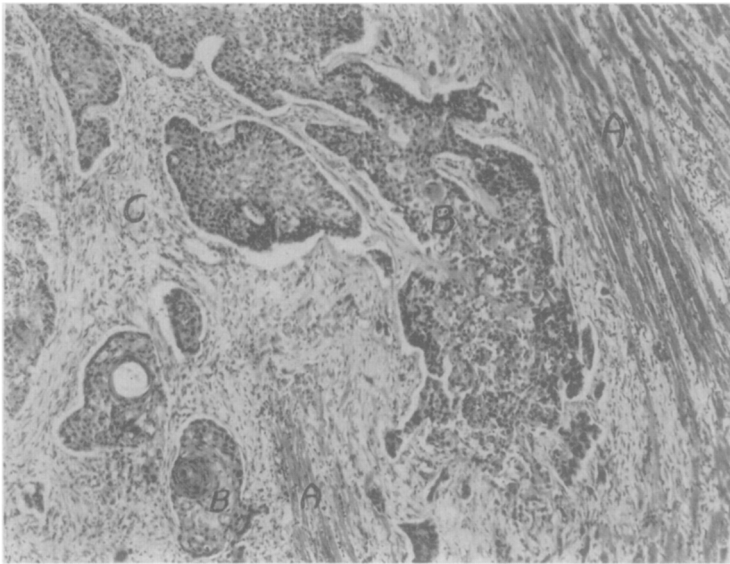


Fig. 4.—Microphotograph of section of heart. At points A, myocardium shows necrosis and atrophy. Infiltrating neoplasm is seen at points B. Stroma of neoplasm shown at C.

tissue in which there were small foci of necrosis. In the middle portion there was carcinomatous replacement of the lateral and posterior aspects of the left ventricle, the interventricular septum, and nearly all of the right ventricle, so that the only normal appearing myocardium was that of the anterior wall of the left ventricle adjacent to the interventricular septum (Fig. 3). The neoplasm extended to within 2 cm. of the aortic ring, and involved the papillary muscles, as well as the chordae tendineae, of the mitral valve. The auricles and all valve cusps were essentially normal. The anterior descending branch of the left coronary artery could be identified throughout one-half its course; it showed only slight atherosclerosis. Metastases were present in the mediastinal, tracheobronchial and peripancreatic lymph nodes, the liver, the right kidney, and both lungs.

Microscopic study of the heart revealed a metastatic, heavily cornifying, squamous-cell carcinoma (Fig. 4). The myocardium showed focal areas of necrosis and atrophy, as well as patchy interstitial fibrosis. Serous atrophy of adipose tissue and focal aggregations of lymphocytes were present in the epicardium. The neoplasm displayed necrosis, with surrounding polymorphonuclear and foreign-body giant-cell reaction. There was an adhesive fibrous pericarditis, but no evidence of direct extension of the neoplasm in the mediastinum to the myocardium was found.

DISCUSSION

The electrocardiographic abnormalities that occur in tumor of the heart are in no way distinctive, and depend upon the location of the neoplasm.^{10, 11} Right bundle branch block has been described in patients with involvement of the interventricular septum¹⁻³; partial heart block¹² and complete atrioventricular block¹³ have been observed when the region of the atrioventricular node and His bundle has been affected; and tumors extending into the cavity of the right auricle have been accompanied by significant changes in the P waves.¹⁴ Paroxysmal auricular flutter, atrioventricular nodal rhythm, or paroxysmal auricular fibrillation, which occurred in our patient, have been reported frequently,^{2, 4, 5, 15} but have not proved very helpful in locating the neoplasm. Electrocardiograms characterized by small QRS complexes in all leads have also been recorded, but are of little value in diagnosis because they occur in a variety of conditions.^{7, 8}

Inversion of the T wave of the type usually seen in acute myocardial infarction occurred in three of the previously reported cases of primary or secondary neoplasms of the heart or pericardium. In none of them was it accompanied by characteristic alterations of the QRS complex. In the case described by Boman¹⁶ there was slight elevation of the RS-T segment over a period of twenty-nine days. The patient was found to have a primary sarcoma of the pericardium, with only superficial infiltration of the myocardium. Pronounced and persistent RS-T displacement comparable to that observed in the case reported here has not been described heretofore in any case of cardiac neoplasm. Barnes and his co-workers¹⁷ have stated that such an elevation of the level of the

take-off of the RS-T segment is not to be anticipated from tumorous invasion of the left ventricle.

Strong evidence supports the view that RS-T displacement is the result of acute myocardial injury, whether produced by general anoxemia,¹⁸ by vasospastic drugs,¹⁹ by acute pericarditis,²⁰ by physical or chemical means,²¹ or by coronary arterial vasospasm²² or occlusion with resulting ischemia.²³ Mechanical or thermal injury to the subepicardial ventricular muscle produces RS-T displacement which persists for about thirty minutes. The displacement subsides either because the injured muscle dies or because new cell membranes are formed by protoplasmic condensation. When the agent producing the injury acts over a longer period, it may continue much longer. In coronary occlusion it seldom lasts for more than a few days, but in rare instances it may persist for weeks or months. On the basis of our present knowledge it seems logical to attribute long-continued RS-T displacement to maintained or repeated injury which prevents the formation of new cell membranes or continuously spreads to previously unaffected muscle. Nevertheless, this explanation of persistent RS-T displacement seems incompatible with the history of uninterrupted recovery in some of the cases of myocardial infarction in which it is observed. In two cases of this kind which have come to our notice, myocardial infarction was followed by the development of an aneurysm of the left ventricle,²⁴ but the association of ventricular aneurysm and persistent RS-T displacement may have been a coincidence. Because of these previous observations, aneurysm of the left ventricle was suspected in the present case because of the long-lasting RS-T displacement and the changes in the contour of the cardiac silhouette, as demonstrated by serial roentgenograms. Neoplastic invasion of the heart was also considered, but it seemed doubtful that it could explain the unusual electrocardiographic changes.

The persistent elevation of the RS-T segment in our patient might conceivably be accounted for in several ways: (a) constant or intermittent compression of one or more of the coronary arteries by the large tumor mass, with resultant myocardial ischemia, (b) direct extension into the lumina of the coronary arteries, or coronary embolism due to fragments of the tumor, (c) neoplastic invasion of the pericardium acting in the same way as other forms of pericarditis, or (d) almost continuous myocardial injury by pressure or by physicochemical action, or by interference with the blood supply as the malignant tissue invaded the heart. The microscopic observations (Fig. 4) tend to support this last hypothesis.

A puzzling feature of the electrocardiograms taken after the second attack of pain was the association of changes in Leads II and III that suggested a recent posterior myocardial infarct (Fig. 1B) with changes in the precordial leads, taken at the same time, which were characteristic

of fresh anterior infarction (Fig. 2A). Simultaneous, acute anterior and acute posterior infarction can occur but is certainly unusual. A large anterior infarct involving the cardiac apex in a person with a vertically placed heart could theoretically explain the electrocardiographic changes and could account for the resemblance of the potential variations of the left leg (V_F) to those that occur at the epicardial surface of an infarct. At the post-mortem examination the distribution of the neoplasm, which involved the anterior, apical, and posterior walls of the left ventricle, satisfactorily explained the simultaneous presence of upward RS-T displacement in the chest leads and in Leads II and III.

In view of the massiveness of the cardiac tumor at autopsy, the absence of congestive cardiac failure during life is surprising. The failure of extensive neoplastic invasion of the heart to induce cardiac failure has been noted repeatedly,^{6, 13, 25, 26} and is felt to be particularly characteristic of metastatic tumors of the heart. Other instances of practically complete replacement of the heart by metastatic carcinoma, accompanied by surprisingly few or mild symptoms, have been reported.^{27, 28} Precordial pain was the most significant symptom experienced by our patient. It was not characteristic of angina pectoris in many respects. Yater⁶ and Lisa, et al.,⁸ have pointed out that anginal attacks are common in patients with cardiac tumors. One of the patients observed by Fishberg² was in status anginosus for sixteen days; the autopsy disclosed a mass of tumor surrounding and constricting the circumflex branch of the left coronary artery. This was considered a possible explanation of the pain. In the cases described by Auerbach, et al.,¹⁵ and Boman¹⁶ there was also discomfort suggestive of angina pectoris, but in both of these instances the cause was probably neoplastic invasion of the pericardium. The distress experienced by the patient reported here may have resulted from myocardial ischemia due to interference with the coronary arterial flow, from invasion of the cardiac nerves or other mediastinal structures, or from the associated pericarditis.

SUMMARY

A case of carcinoma of the esophagus with massive metastases to the heart is reported. Serial electrocardiograms displayed persistent upward displacement of the RS-T segment in Leads II, III, and Lead V_F , and in a number of the unipolar precordial leads. It was probably caused by almost continuous acute myocardial injury as the neoplastic tissue infiltrated the cardiac musculature.

The authors wish to acknowledge their appreciation of the valuable suggestions and assistance of Dr. Frank N. Wilson in this study.

REFERENCES

1. Willius, F. A., and Amberg, S.: Two Cases of Secondary Tumor of the Heart in Children, in One of Which the Diagnosis Was Made During Life, *M. Clin. North America* **13**: 1307, 1930.

2. Fishberg, A. M.: Auricular Fibrillation and Flutter in Metastatic Growths of the Right Auricle, *Am. J. M. Sc.* **180**: 629, 1930.
3. Shelburne, S. A.: Primary Tumors of the Heart. With Special Reference to Certain Features Which Led to a Logical and Correct Diagnosis Before Death, *Ann. Int. Med.* **9**: 340, 1935.
4. Schnitker, M. A., and Bailey, O. T.: Metastatic Tumor of the Heart. A Case Diagnosed During Life, *J. A. M. A.* **108**: 1787, 1937.
5. Smith, D. S.: Neoplastic Involvement of the Heart. Two Cases Diagnosed Before Death, *J. A. M. A.* **109**: 1192, 1937.
6. Yater, W. M.: Tumors of the Heart and Pericardium. Pathology, Symptomatology and Report of Nine Cases, *Arch. Int. Med.* **48**: 627, 1931.
7. Mead, C. H.: Metastatic Carcinoma of the Heart Secondary to Primary Carcinoma of the Lung, *J. Thoracic Surg.* **2**: 87, 1932.
8. Lisa, J. R., Hirschhorn, L., and Hart, C. A.: Tumors of the Heart; Report of Four Cases and Review of Literature, *Arch. Int. Med.* **67**: 91, 1941.
9. Pollia, J. A., and Gogol, L. J.: Some Notes on Malignancies of the Heart, *Am. J. Cancer* **27**: 329, 1936.
10. Scott, R. W., and Garvin, C. F.: Tumors of the Heart and Pericardium, *AM. HEART J.* **17**: 431, 1939.
11. Siegel, M. L., and Young, A. M.: Electrocardiographic Findings in Tumors of the Heart, With Report of a Case, *AM. HEART J.* **8**: 682, 1933.
12. Lloyd, P. C.: Heart Block Due to Primary Lymphangio-Endothelioma of Atrio-Ventricular Node, *Bull. Johns Hopkins Hosp.* **44**: 149, 1929.
13. Lymburner, R. M.: Tumours of the Heart: Histopathological and Clinical Study, *Canad. M. A. J.* **30**: 368, 1934.
14. Strouse, S.: Primary Benign Tumor of the Heart of Forty-Three Years' Duration, *Arch. Int. Med.* **62**: 401, 1938.
15. Auerbach, O., Epstein, H., and Gold, H.: Metastatic Carcinoma of the Heart. A Case Presenting Auricular Flutter, Symptoms of Coronary Thrombosis and Congestive Heart Failure, *AM. HEART J.* **12**: 467, 1936.
16. Boman, P. G.: Primary Sarcoma of the Pericardium; Report of a Case, *Ann. Int. Med.* **12**: 258, 1938.
17. Barnes, A. R., Beaver, D. C., and Snell, A. M.: Primary Sarcoma of the Heart. Report of a Case With Electrocardiographic and Pathological Studies, *AM. HEART J.* **9**: 480, 1934.
18. Kountz, W. B., and Gruber, C. M.: The Electrocardiographic Changes in Anoxemia, *Proc. Soc. Exper. Biol. & Med.* **27**: 170, 1929.
19. Gruber, C. M., and Kountz, W. B.: The Effect of Pitressin (Vaso-pressin) Upon the Heart, *Proc. Soc. Exper. Biol. & Med.* **27**: 161, 1929.
20. Noth, P. H., and Barnes, A. R.: Electrocardiographic Changes Associated With Pericarditis, *Arch. Int. Med.* **65**: 291, 1940.
21. a. Wilson, F. N., Hill, I. G. W., and Johnston, F. D.: The Interpretation of the Galvanometric Curves Obtained When One Electrode Is Distant From the Heart and the Other Near or in Contact With the Ventricular Surface. Part I. Observations on the Cold-Blooded Heart, *AM. HEART J.* **10**: 163, 1934.
- b. Wilson, F. N., Johnston, F. D., and Hill, I. G. W.: The Interpretation of the Galvanometric Curves Obtained When One Electrode Is Distant From the Heart and the Other Near or in Contact With the Ventricular Surface. Part II. Observations on the Mammalian Heart, *AM. HEART J.* **10**: 176, 1934.
22. Wilson, F. N., and Johnston, F. D.: The Occurrence in Angina Pectoris of Electrocardiographic Changes Similar in Magnitude and in Kind to Those Produced by Myocardial Infarction, *AM. HEART J.* **22**: 64, 1941.
23. Wilson, F. N.: Diseases of the Coronary Arteries and Cardiac Pain, New York, 1936, The Macmillan Company, p. 281.
24. a. Langendorf, R.: Personal communication.
- b. Cameron, J. D.: Personal communication.
25. Morris, L. M.: Metastases to the Heart From Malignant Tumors, *AM. HEART J.* **3**: 219, 1927.
26. Ritchie, G.: Metastatic Tumors of the Myocardium. A Review of Sixteen Cases, *Am. J. Path.* **17**: 483, 1941.
27. Hamilton, R. L.: Metastatic Carcinoma of the Heart, *Am. J. Cancer* **16**: 205, 1932.
28. Napp, O.: Ueber sekundäre Herzgeschwülste, *Ztschr. f. Krebsforsch.* **3**: 282, 1905.