voltage, otherwise within normal limits. The patient was asymptomatic.

**DISCUSSION**

This patient was under the influence of large amounts of catecholamines, primarily norepinephrine. From the history, the secretion seems to have shown no wide fluctuations but to have increased in the course of five or more years. Myocardial damage was suggested by the severity of cardiac failure on admission, in the absence of longstanding or severe hypertension, and later by the abnormal hemodynamic status during moderate tachycardia—the left ventricular pressure was elevated and the cardiac index was slightly lower than expected for comparable heart rate. In animals, there is considerable evidence for myocardial muscle damage following infusion of catecholamines. In man, most of the evidence for myocardial muscle damage by catecholamines is derived from autopsy studies. The incidence of detection of myocardial muscle necrosis at autopsy appears to depend upon how avidly lesions were looked for. Szakacs and Cannon found marked association between catecholamines and pathologic myocardial lesions. Their survey of autopsy material yielded 17 cases of pheochromocytoma, myocarditis being found at autopsy in all of them. Van Vliet, Burchell and Titus found evidence of active carditis microscopically in 15 of 22 patients who were found at autopsy to have functioning pheochromocytoma. In two additional patients, fibrosis was found and thought to represent healed carditis.

The incidence of clinically significant myocarditis is probably far less than in the autopsy material. Occasionally, carditis is evident clinically, as exemplified by one of 22 patients of Van Vliet et al, the one patient of Engelman and Sjoerdsma with malignant pheochromocytoma and probably the one patient of Engelman et al. Kline states that two of his seven patients studied at autopsy had clinical evidence of myocarditis. More recently, two patients have been reported presenting with cardiomypathy without impressive elevation in blood pressure due to oversecretion of epinephrine rather than norepinephrine.

The incidence of exertional dyspnea and congestive heart failure in patients with pheochromocytoma also varies. No detailed clinical study is available of the 22 patients of Van Vliet, Burchell and Titus; other than that of the 15 patients with active myocarditis at autopsy; 11 had symptoms and signs of acute left ventricular failure. A clinical report from the same medical center in which the clinical features of 76 patients were examined (the diagnosis of 89 patients was confirmed at operation) showed that dyspnea was present in 11 patients (14 percent) and cardiomegaly or congestive heart failure or both in 9 patients (12 percent).

**REFERENCES**

9 Szakacs JE, Mehmlan B: Pathologic changes induced by 1-Norepinephrine. Am J Cardiol 5:619-627, 1960

**Paradoxic Coronary Embolism in a Patient with Mid-Systolic Click Syndrome**

**John W. Schatz, Maj, MC, and James A. Fischer, Maj, MC**

Embolic coronary artery disease is an uncommon cause of death. A paradoxic thromboembolism to the left coronary artery was the reason for death in a 53-year-old man who presented with a mid-systolic click syndrome and chest pain. His clinical course and postmortem findings are presented. Paradoxic coronary artery embolism is reviewed. An unusual etiologic of systolic click syndromes is suggested. Thoughts about therapy are presented.

Coronary embolism is an unusual form of coronary artery disease. Most cases are associated with bacterial endocarditis. However, intracardiac thrombus, luetic aortitis, atherosclerotic disease of the aorta, proximal coronary artery thrombus, pulmonary vein thrombus, calcified valves, parasites, cardiac bypass, tumor, coronary angiography, air and paradoxous venous thrombus have been reported as etiologic agents of embolic coronary disease. We recently participated in the management of a man with paradoxic coronary embolism and the unusual association of a mid-systolic click. His case is presented below.

**CASE REPORT**

A 53-year-old Caucasian man was well until November 11, 1964...
1972 at which time he experienced the onset of a constant vague pressure sensation over the left anterior aspect of his chest, accompanied by mild dyspnea. Exertion and deep breathing increased the intensity of this discomfort.

There was no history of hypertension, rheumatic heart disease, or diabetes. The patient had never had a heart murmur to his knowledge. Chronic complaints of dyspnea, edema and nocturia were denied, as were cough, hemoptysis and calf pain.

A venous ligation and stripping procedure had been performed on his left leg for varicose veins ten years prior to this admission. Physical examination revealed an obese man with no signs of acute distress. His blood pressure was 150/106 mm Hg and pulse rate was 88 per minute. He was afebrile. Funduscopic examination demonstrated arteriolar narrowing, no hemorrhages or exudates and normal optic discs. Venous pulsations in the jugular system appeared normal. The chest was clear to auscultation and percussion. No rubs were present. Cardiac findings revealed the point of maximal impulse at the fifth left intercostal space in the mid-clavicular line. A presystolic gallop sound was present at the apex. The second sound was physiologically split and both components were of normal intensity. A mid-systolic click was appreciated at the apex. No murmurs were heard. Abdominal examination was unremarkable. Stasis dermatitis was present on the left lower leg with trace edema. Varicose veins were easily seen, but there were no signs of active phlebitis. Results of neurologic examination were normal.

The initial impression was coronary artery insufficiency and mitral valve apparatus dysfunction.

An electrocardiogram performed on the day of admission was normal (Fig 1). A portable chest x-ray film demonstrated a heart of normal size and uncoiling of the thoracic aorta. Phonocardiogram confirmed the clinical findings of a mid-systolic click and presystolic gallop (Fig 2). Serum glutamic oxalacetic transaminase (SGOT) was 55 on the day of admission and 90 on the following day (upper limits of normal is 40 units). Lactic dehydrogenase (LDH) was 225 and 265 units for the first two days respectively (upper limits of normal being 200 units). Total bilirubin was 1.1 mg percent and did not change. Hemoglobin was 16.9 gm percent and white blood cell count was 8,300 mm³. Serology was nonreactive. The electrocardiogram on the second day demonstrated T wave inversion in lead V₃. On the third morning of hospitalization the patient called to the nurse complaining of crushing anterior wall chest pain. The telemetry unit recorded ST segment elevation which slowed within seconds to sinus bradycardia and further progressed to an idioventricular rhythm, ventricular tachycardia and fibrillation. Attempts at resuscitation were unsuccessful.

Postmortem examination revealed an obese man with increased pigmentation of the left lower extremity. The lungs were hyperemic and atelectatic. Left and right main pulmonary arteries were largely occluded with thromboembolic material. Distal branches also contained variable amounts of thrombus. The heart weighed 570 gm, was diffusely enlarged and demonstrated biventricular dilatation. Left ventricular wall was 2 ml thick. A patent foramen ovale was present, straddled by a long string-like thrombus. This material projected into the left ventricle across the mitral valve (Fig 3). A thrombus was also demonstrated entering and occluding the left coronary artery. The remainder of the coronary anatomy was free of significant atherosclerosis. No focal lesion was seen in the myocardium. The cardiac valves were normal. No mural thrombi were present. Aortic root examination showed minimal atherosclerotic change. Microscopic examination of the left coronary artery demonstrated a well-organized thrombus totally occluding its lumen (Fig 4).

The initial impression was coronary artery insufficiency and mitral valve apparatus dysfunction.

An electrocardiogram performed on the day of admission was normal (Fig 1). A portable chest x-ray film demonstrated a heart of normal size and uncoiling of the thoracic aorta. Phonocardiogram confirmed the clinical findings of a mid-systolic click and presystolic gallop (Fig 2). Serum glutamic oxalacetic transaminase (SGOT) was 55 on the day of admission and 90 on the following day (upper limits of normal is 40 units). Lactic dehydrogenase (LDH) was 225 and 265 units for the first two days respectively (upper limits of normal being 200 units). Total bilirubin was 1.1 mg percent and did not change. Hemoglobin was 16.9 gm percent and white blood cell count was 8,300 mm³. Serology was nonreactive. The electrocardiogram on the second day demonstrated T wave inversion in lead V₃. On the third morning of hospitalization the patient called to the nurse complaining of crushing anterior wall chest pain. The telemetry unit recorded ST segment elevation which slowed within seconds to sinus bradycardia and further progressed to an idioventricular rhythm, ventricular tachycardia and fibrillation. Attempts at resuscitation were unsuccessful.

Postmortem examination revealed an obese man with increased pigmentation of the left lower extremity. The lungs were hyperemic and atelectatic. Left and right main pulmonary arteries were largely occluded with thromboembolic material. Distal branches also contained variable amounts of thrombus. The heart weighed 570 gm, was diffusely enlarged and demonstrated biventricular dilatation. Left ventricular wall was 2 ml thick. A patent foramen ovale was present, straddled by a long string-like thrombus. This material projected into the left ventricle across the mitral valve (Fig 3). A thrombus was also demonstrated entering and occluding the left coronary artery. The remainder of the coronary anatomy was free of significant atherosclerosis. No focal lesion was seen in the myocardium. The cardiac valves were normal. No mural thrombi were present. Aortic root examination showed minimal atherosclerotic change. Microscopic examination of the left coronary artery demonstrated a well-organized thrombus totally occluding its lumen (Fig 4).

**Discussion**

Approximately 130 cases of paradoxic emboli have been recorded in the medical literature. About 50 percent are proved by demonstration of an embolism in situ (4e, crossing from pulmonary to systemic circulation as in Fig 3). The remainder are diagnosed by finding systemic emboli, an anatomic shunt between greater and lesser circulations, systemic venous embolic material and lack of a primary arterial or intracardiac site for embolic propagation. Twenty-two cases of paradoxic emboli to coronary arteries have been described. Of these, 15 are "definite," examples and the remainder are "probable." A "definite" diagnosis can be made when (1) embolic material is seen occluding a coronary artery, (2) an anatomic shunt between venous and arterial circulation exists, and (3) a source of venous emboli or demonstrable pulmonary emboli exist. A "probable" diagnosis may be ventured when criteria one and two are fulfilled and no source of embolic material is

![Figure 1. Electrocardiogram on day of admission—normal.](image1)

There was no evidence of endothelial reaction between thrombus and coronary artery.
Paradoxic coronary emboli are most often associated with a patent foramen ovale. However, atrial septal defect, ventricular septal defect, common ventricle and truncus arteriosus have all been reported to be associated with this entity. Most commonly the left coronary artery is involved. Occasionally the right coronary artery is the site of occlusion. Pulmonary emboli have been demonstrated in 45 percent of the cases. Systemic emboli to brain, kidney or extremities accompanied coronary embolism in 27 percent of the cases. The embryologic material is usually venous thrombus. However, Abrikossoff described avulsed cerebellar tissue obstructing the left coronary artery in a neonate. Thompson and Evans demonstrated testicular teratoma embolism occluding both right and left coronary arteries in a 25-year-old patient. Most often such patients present to the physician as unexpected sudden death which follows an episode of chest pain. However, symptoms of pulmonary emboli may precede sudden death, as well as physical findings referable to systemic emboli (ie, seizure disorder, hemiplegia, or a pulseless extremity). All diagnoses were made at postmortem examination with one exception. Steiger, Libanoff and Springer described a 23-year-old woman with a myocardial infarction, normal coronary arteries and an atrial septal defect. At the time of their report she was doing well. In most case reports, little note is made of auscultatory events. Normal heart sounds have been described, as well as two cases with systolic murmurs.

The mid-systolic click present in our patient deserves mention. Mitral valve apparatus dysfunction is the usual cause of these sounds. A variety of etiologies of mitral dysfunction have been associated with systolic clicks including coronary artery disease, Marfan's syndrome, rheumatic heart disease, traumatic heart disease, obstructive cardiomyopathy, postoperative mitral valve surgery, and hypertension. Clicks have also been described with atrial myxomas. In our patient, thrombotic material extended across the mitral valve as may occur with a pedunculated myxoma. The mitral valve leaflets, chordae structures and papillary muscles were normal upon examination. Therefore, movement of thrombus from ventricle towards atrium during systole may have played a role in the genesis of this mid-systolic click.

The demonstration of a thrombus in situ crossing from pulmonary to systemic circulation in approximately 50 percent of paradoxic emboli suggests that this is more than a transient event. The passage of thrombus from lesser to greater circulation may require several days. Thus, in the appropriate setting, the natural history of this disease may be potentially interrupted. Those patients requiring surgical intervention for pulmonary embolism should also have intracardiac shunts corrected. The indications for cardiotomy in patients with pulmonary and systemic emboli not requiring embolectomy is speculative at this time.

ACKNOWLEDGMENTS: We are thankful to Dr. Rashid Massumi for his helpful comments on this report. We also wish to express appreciation to Michael Anderson, Arlene Burston, Carol Kerr, Ronald Lenick, Vicki Taylor and Irma Wells for their assistance in preparation of this manuscript.

REFERENCES

10. Jacobi M, Kenlter M, Silverman I: Paradoxical embolism

**Systemic-to-Pulmonary Fistula in Intrapulmonary Hodgkin's Disease***

Robert F. Dunn, M.D.,** and Lewis Wexler, M.D.†

A patient with a systemic-to-pulmonary arteriovenous fistula associated with intrapulmonary Hodgkin's disease is presented. Shunting of blood from an internal mammary artery into the pulmonary arterial system via a highly vascular tumor mass was demonstrated.

Pulmonary arteriovenous fistulae are not uncommon. Their etiology is varied and includes congenital, infectious, and iatrogenic causes. Pulmonary arteriovenous fistulae involving chest wall vessels are rare. This report presents a patient with a systemic-to-pulmonary arteriovenous fistula associated with intrapulmonary Hodgkin's disease. It is the eighth report of a pulmonary arteriovenous fistula involving chest wall vessels and the first demonstration of an arteriovenous fistula of the lung secondary to malignant tumor.

**REVIEW OF THE LITERATURE**

Burchell and Clagett presented the first case of a pulmonary arteriovenous fistula with collateral circulation involving the thoracic wall. Six additional reports of systemic-to-pulmonary fistulae involving chest wall vessels were found in the English literature.2-7

Pulmonary arteriovenous fistulae may be either congenital or acquired in origin, the former being the most common. Of the seven reported cases involving chest wall vessels, five were felt to be congenital and two acquired. Other reports have implicated pulmonary tuberculosis, longstanding cirrhosis, and schistosomiasis.10 We were unable to find a previous demonstration of pulmonary arteriovenous fistula secondary to malignant tumor. Pierce et al reported a cyanotic patient with multiple pulmonary metastases from a thyroid carcinoma, but were unable to demonstrate an arteriovenous fistula radiographically or surgically and could not exclude the possibility "that multiple pulmonary arteriovenous fistulas existed on a congenital basis."

**CASE REPORT**

A 36-year-old physician had experienced good health until two months prior when he developed generalized myalgia, malaise, and a flu-like syndrome, which improved with rest. One month later he developed a cough with only slight production of sputum, pleuritic pain of the left anterior chest, with underlying tenderness of the chest wall and temperature elevation. Self-auscultation of the chest at that time revealed a continuous murmur over the left anterior chest which had not been present on previous physical examinations. Chest roentgenograms demonstrated a large anterior mediastinal mass and left hilar density which pulsed at fluoroscopy, suggesting the diagnosis of an arteriovenous fistula.

There was no family history of telangiectasis or arteriovenous malformation. He had not experienced constitutional symptoms prior to the present illness. On physical examination the blood pressure was 126/84 mm Hg, pulse rate 92/min, temperature 36.5° C, with a respiration rate of 18/min. Sclerae and oral mucous membranes were normal with no evidence of telangiectases. There was no cyanosis or clubbing of the digits. The thyroid gland was normal and there was no lymphadenopathy. A grade 2/4 continuous murmur was heard best in the second left intercostal space at the sternal border, with no radiation.

Laboratory data were as follows: Hgb, 11.8 gm percent; Hct, 35.1 percent; platelet level, 480,000/mm³; erythrocyte sedimentation rate, 55; white blood cell count 19,700/mm³, with a shift to the left. Serum electrolyte, calcium, phosphorus, blood urea nitrogen, creatinine, uric acid, fasting blood sugar, cholesterol, protein, bilirubin, alkaline phosphatase, lactate dehydrogenase and serum glutamic oxalo-

**FIGURE 1. Plain chest roentgenogram showing intrapulmonary mass involving anterior segment of left upper lobe.**

Downloaded From: http://journal.publications.chestnet.org/pdfsaccess.ashx?url=data/journals/chest/20958/ on 06/26/2017