Objective Assessment of Pericardial Tamponade; Right Heart Catheterization at the Bedside*

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A technique is described for rapidly obtaining right ventricular pressure pulses at the bedside of the critically ill patient in whom pericardial tamponade is clinically suspected. A delicate flexible nylon catheter is introduced into the venous system and advanced centrally. Constant monitoring of pressure pulses signals cannulation of the right ventricle. Clinically suspected tamponade can be confirmed or rejected by analysis of the pressure pulse contour and the ratio of systolic to diastolic pressure. This technique has proved useful in helping us to decide whether or not to perform pericardiocentesis. Several unnecessary pericardiocenteses have been avoided. Illustrative cases are included.

Clinical evaluation of pericardial effusion or tamponade is based on the physician's interpretation of a variety of bedside observations.1 Signs of pericardial restriction, such as venous hypertension, distension of neck veins during inspiration, muffled heart sounds, reduced apical impulse, third heart sound, hypotension, narrowed pulse pressure and paradoxical pulse are nonspecific.2 Other conditions such as advanced right heart failure, pulmonary emphysema or pulmonary embolism may simulate pericardial tamponade.3 An angiogram may document the presence of pericardial effusion4,5 but provides little help in evaluating the hemodynamic significance of the fluid accumulation. Percutaneous pericardiocentesis may be both diagnostic and therapeutic but is not without risk.6

Accurate hemodynamic evaluation of the degree and significance of pericardial restriction through analysis of right ventricular pressure pulses has been achieved in the cardiac catheterization laboratory for many years.7-9 Cannulation of the right ventricle at the bedside of the acutely ill patient with suspected cardiac tamponade would provide the clinician better objective data than has hitherto been available. This paper describes such a technique and illustrates its usefulness in evaluating the seriously ill patient at the bedside.

Materials and Methods

Following appropriate skin cleansing and draping, a No. 3 nylon* catheter (OD 1.4 mm, ID 1.0 mm) approximately 100 cm long is introduced into the antecubital vein via Seldinger technique. Alternatively we have inserted the catheter through a 14 gauge cannula** directly into a subclavian vein. The catheter is connected to a pressure transducer and both pressure and electrocardiogram are inscribed on a suitable recorder or monitor. While the analog signals are being displayed on the monitor system, the catheter is advanced centrally until a right ventricular pressure pulse is obtained. It may be necessary to advance and withdraw the catheter a few times before the flow of venous blood carries the supple catheter through the tricuspid valve into the right ventricle. Because ventricular ectopic beats may occur despite the flexibility of the catheter, constant observation of a monitor during the catheter manipulation is mandatory.

When meticulous attention is given to sterile techniques the catheter may be withdrawn back across the tricuspid valve and reintroduced later into the ventricle if needed. Two cases are reported to illustrate the usefulness of the procedure.

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FIGURE 1. Serial right ventricular pressure pulses and ECGs from case 1. Prior to pericardiocentesis (left) the pressure was 36/15 mm Hg. After removal of 250 ml of pericardial fluid the pressure was 25/4 mm Hg (center panel). Two weeks later the pressure was 22/5 mm Hg (right panel) and pericardiocentesis was not indicated.

CASE 1 consideration of a second pericardiocentesis.

A 46-year-old woman was admitted to the hospital because of increasing shortness of breath and dyspnea on exertion for the preceding two months. Indirect blood pressure was 130/80 mm Hg without pulses paradoxus. The heart rate was 140 per minute and respirations were 22 per minute. Neck veins were distended but collapsed with inspiration. Bilateral pleural effusions, rales and wheezes were noted. The cardiac border was percussed at the anterior axillary line and there was a poorly localized apical impulse. There were no murmurs, gallops or rubs heard. The liver was slightly enlarged. No ascites or peripheral edema was present. A chest x-ray film showed bilateral pleural effusions and enlarged cardiac silhouette. An electrocardiogram revealed sinus tachycardia and low amplitude QRS complexes. A venous angiogram documented the clinically suspected pericardial effusion. Hypotension and increased dyspnea later that day prompted pericardiocentesis, from which 180 ml of bloody fluid with a hematocrit of 22 percent was obtained. The patient transiently improved, but on the fifth hospital day respiratory difficulty, fever and tachycardia suggested consideration of a second pericardiocentesis.

A nylon catheter was passed into the right ventricle from a left antecubital vein. Right ventricular pressure was 36/15 mm Hg with a prominent diastolic dip (Fig 1). This hemodynamic evidence of pericardial tamponade confirmed the need for a second pericardiocentesis: 250 ml of bloody fluid was removed. Right ventricular pressure dropped to 25/4 mm Hg (Fig 1, second panel) and central venous pressure decreased from 13 to 5 cm H2O during the pericardiocentesis.

Clinical improvement continued for several days, but on the 12th day increasing tachycardia, tachypnea and a 20 mm Hg decrease in indirect blood pressure during inspiration suggested recurrent tamponade. A catheter passed into the right ventricle at the bedside revealed a pressure of 32/6 mm Hg. The hemodynamic data did not indicate recurrent tamponade and a third pericardiocentesis was avoided. The patient improved spontaneously within a few hours. One week later similar signs and symptoms developed. Right ventricular pressure measured a third time was 22/5 mm Hg and pericardiocentesis was not done (Fig 1, third panel).

FIGURE 2. Right ventricular pressure pulses and ECG from case 2. Pressure was 41/7 mm Hg with no evidence of tamponade.

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Bilateral pleural effusions were present and the patient improved following thoracentesis.

The patient has been observed for more than a year in the outpatient department. Although a definitive diagnosis has not been established, her clinical course is compatible with scleroderma.

**CASE 2**

A 23-year-old white woman with systemic lupus erythematosus was transferred from another hospital for evaluation and treatment of pericarditis. In the weeks preceding transfer serial chest x-ray films demonstrated progressive increase in transverse cardiac diameter. On the day of admission the patient became acutely short of breath and developed severe chest pain, nausea and light-headedness.

At examination she appeared acutely ill and was semiconscious. Indirect blood pressure was 70/40 mm Hg with a 15 mm pulsus paradoxus. The heart rate was 120 per minute, and respirations were 40 per minute. Neck veins were full with inspiratory distention. Left pleural effusion, rales, and distant heart sounds were noted. No murmurs, gallops or rubs were heard. One hundred fifty ml of serosanguinous fluid were removed during an emergency pericardiocentesis. Blood pressure immediately rose, the respiratory rate slowed, and the patient became fully responsive. One hour later she became confused and blood pressure and pulse became unobtainable. A second emergency pericardiocentesis yielded 400 ml of fluid and produced immediate clinical improvement. Symptoms increased over the next eight hours. A third pericardiocentesis produced 590 ml of fluid and was again followed by clinical improvement.

Over the next few hours, recurrent hypotension and poor urine output suggested recurrence of tamponade. However, central venous pressure of 5 cm H$_2$O and a rise of hematocrit from 23 to 51 percent suggested the development of hypovolemia. To determine whether the hemodynamic abnormalities of pericardial restriction were present, a nylon catheter was passed into the right ventricle from the right subclavian vein. Right ventricular pressure was 41/7 mm Hg (Fig 2) and the pressure pulse did not suggest pericardial restriction. The patient was treated with fluids and arterial pressure rose from 98/40 to 100/50 mm Hg.

The patient gradually improved on large doses of prednisone and is clinically well one year later.

A total of seven patients have been evaluated with the bedside technique described in this report. In addition to the two cases reported herein, three acutely ill hospitalized patients have been catheterized and the presence of pericardial tamponade was confirmed hemodynamically prior to pericardiocentesis. Two other patients in whom recurrent constrictive pericardial disease was suspected underwent right ventricular cannulation in the outpatient department without difficulty. In neither case was there evidence of recurrent restriction.

**DISCUSSION**

The passage of a catheter into the right ventricle at the bedside provides a safe and rapid method for estimating the hemodynamic significance of tamponade and evaluating the necessity for therapeutic pericardiocentesis. Catheterization is facilitated by fluoroscopy but the present technique is employed because it may be difficult to move a critically ill patient to and from the fluoroscopy room.

Percutaneous catheterization of the right heart with flow-guided catheters has been used for many different purposes. Temporary transvenous pacing after acute myocardial infarction is frequently performed with “floating” electrode catheters. Flow-guided catheters have been employed for the diagnosis of arrhythmias, the detection of intracardiac shunts and for continuous monitoring of intracardiac pressures. These techniques are now routine in many centers.

The diagnosis of pericardial effusion is often made by clinical observation, echocardiography, radioactive isotope scanning or angiography. None of these methods evaluates the hemodynamic significance of pericardial effusion. Direct observation of right ventricular pressure pulses provides important additional information.

We have employed the widely accepted criteria of Yu and associates for the diagnosis of restrictive cardiac disease. The ratio of right ventricular end-diastolic to systolic pressure is rarely greater than one to three in conditions other than pericardial disease. The atrial (and jugular) pulse often demonstrates steep “x” and “y” descents with a deep “y trough” when pericardial restriction is present.

There are, however, occasional exceptions to the general rule that only pericardial disease produces disproportionate elevation of right ventricular diastolic pressure. Other conditions in which ventricular compliance is diminished show similar physiologic effects. Pressure pulses similar to those obtained in pericarditis have been reported for endocardial fibrosis, cardiac amyloidosis, cardiac hemochromatosis and diffuse myocardial fibrosis secondary to coronary artery disease. In most instances these conditions can be distinguished clinically. The pressure pulse in acute pericarditis (restriction due to fluid) and chronic constrictive pericarditis (restriction due to fibrous tissue) are indistinguishable since the hemodynamic mechanisms are similar. Interpretation of the wave forms must be related to the clinical setting.

In case 1 clinical signs suggested recurrent tamponade on three occasions. During the first study right ventricular end-diastolic pressure was more than one-third of the systolic pressure, providing strong hemodynamic evidence of pericardial tamponade. The hemodynamic improvement following pericardiocentesis supported this conclusion. During the second and third studies direct measurement of right ventricular pressure did not suggest tamponade despite a confusing clinical picture. On both occasions the clinical course supported the hemodynamic findings. In the second patient who pre-
viously had had severe tamponade, direct measurement of right ventricular pressure indicated that pericardial restriction was not the main cause of hypotension and oliguria. In both patients the technique described proved a useful aid to clinical management.

The technique presented herein cannot determine the cause of cardiac restriction but does provide hemodynamic data useful as an adjunct to emergency care. The nylon catheter employed is flexible and damage to cardiac structures is unlikely. The constant presence of a physician is advisable when the catheter is within the right ventricle because of the possibility of arrhythmias, but no serious problems have been encountered in patients with pericarditis. We have used this technique in over 50 patients with acute myocardial infarction; although transient arrhythmias are frequent when the right ventricle is entered, no sequelae have been observed. Others have confirmed the safety of similar flexible “floating” catheter systems.11,18

Pericardiocentesis is not without hazard. The dangers of indirect percutaneous pericardiocentesis were examined in 53 patients who underwent 84 pericardiocenteses at the New York Hospital. There was one death (right ventricular tear), nine instances when blood was aspirated, one case of transient asystole and one hydropneumothorax. Complications occurred in patients with pericardial disease of varied etiology and in patients in whom pericardial fluid was demonstrated radiologically.

The unreliability of clinical signs of tamponade and the possibility of rapidly progressive restriction mandate therapeutic intervention on many occasions when some uncertainty as to the hemodynamic importance of an effusion exists. Diagnostic accuracy in this dangerous clinical situation is increased by hemodynamic data quickly obtained without interruption of patient care.

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