A Test for Evaluation of Peritoneo-Venous Shunt Function: Concise Communication

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A simple imaging procedure has been devised for patients with peritoneo-venous shunts when ascites reaccumulates and a decision must be made on whether or not to revise the shunt. A dose of ^{99m}Tc-sulfur colloid is injected into the peritoneal cavity and imaging of the abdomen and chest is performed 30 and 60 min later. After checking for tracer distribution throughout the peritoneal cavity, one looks for radioactivity in the liver and spleen and in the anterior chest tube. With a properly functioning shunt and effective breathing exercises, these are easily identifiable. If the shunt is obstructed, tracer activity will remain in the peritoneal cavity and thus cannot be identified in the liver or spleen.

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With the increasing use of peritoneo-venous (LeVeen) shunts for medically intractable ascites, a need has developed for a test to determine whether or not a shunt is functioning. This report describes a gamma-imaging procedure that seems to satisfy this need.

BACKGROUND

Portal cirrhosis is frequently complicated by ascites. Although knowledge about the interplay of several causative mechanisms is still incomplete, obstruction of blood flow in the venous circulation of the liver, leading to increased intraportal pressure, is thought to be a significant factor (*1*). Therefore, LeVeen et al. (*2*) devised and evaluated a surgically implantable silicone and polypropylene duct to get ascitic fluid back into the circulatory system. Equipped with a pressure-demand one-way valve, this shunt relieves excessive accumulations of ascitic fluid whenever intra-abdominal pressure reaches 3–5 cm of water above that in the thoracic vena cava.

The device consists of a perforated collecting tube which, with the valve, is inserted into the peritoneal cavity through a small abdominal incision. From the cranial side of the valve, silicone tubing is tunneled subcutaneously to the neck and inserted into the internal or external jugular vein with the tip in the superior vena cava. With proper function, the valve permits only cephalad flow. Any backward leakage would allow blood to enter the distal end of the venous tube, coagulate, and obstruct the tubing.

In patients with massive intractable ascites and poor risks for the portocaval shunt operation, LeVeen et al. achieved long-term relief in 26 of 34 patients and transient relief in an additional seven (*2*). After improvement of the valve mechanism, the shunt failure rate dropped to 8% (*3*). When this complication occurs, the patient demonstrates decreased urine output with increased abdominal girth and body weight from reaccumulation of ascites. However, the same clinical change may result from greater severity of the hepatic disorder, progressive cardiac failure, or ineffective breathing exercises. Since the bedside diagnosis is often difficult to make, a test for shunt patency would be valuable.

TECHNIQUE

The ideal radiotracer for this purpose should be inexpensive and readily available in appropriate form for intraperitoneal injection. It should ordinarily remain in the peritoneal space for at least 4 hr except for exit through the peritoneo-venous shunt. Once in the blood, the tracer should become readily localized in some easily detectable site. The characteristics of its radioactive emission should enable external detection of an acceptable count rate in a brief time with no worrisome absorbed radiation dose. These

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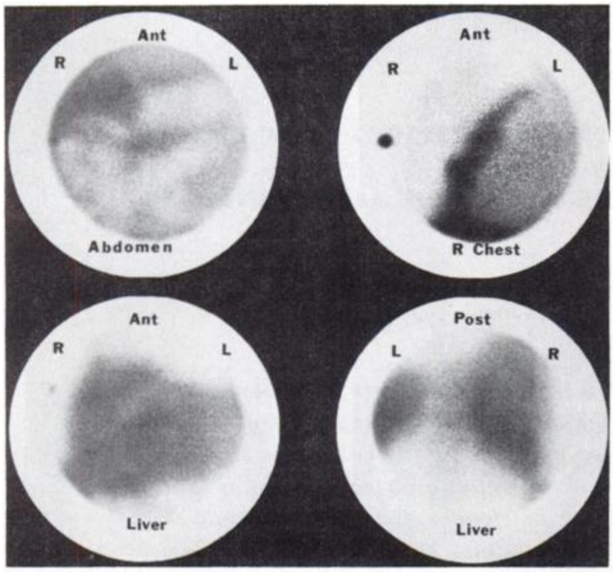

FIG. 1. (Upper left) Anterior abdominal scintigram at 30 min after intraperitoneal tracer administration reveals widespread distribution of radioactivity except in several gas-filled loops of bowel. (Upper right) Right anterior chest view reveals tracer in subcutaneous tubing entering circulation through external jugular vein. Note diffuse background activity in pulmonary and cardiac blood pools. (Lower left and right) At 1 hr, clearly recognizable radioactive tracer throughout liver and spleen is demonstrated, indicating patent peritoneo-venous shunt. Dark spot at margin is radioactive source used to mark patient's right side.

criteria are reasonably well satisfied by ^{99m}Tc-sulfur colloid in a dose range in which it is widely administered for static and dynamic hepatic, splenic, and bone-marrow imaging.

The following procedure was devised for patients with suspected peritoneo-venous shunt failure. Five millicuries of ^{99m}Tc-sulfur colloid are injected through a needle entering the peritoneal cavity through the abdominal wall. After 30 min and again 1 hr, scintillation camera or scanner imaging of the anterior abdomen and thorax is performed. Additional posterior or lateral views of the upper abdomen may be helpful for better identification of the liver and spleen. In case of uncertainty, repeat imaging 2 or 3 hr after tracer administration may provide helpful information. Standard instrumental procedures are used.

Every 20–30 min during the test period, the patient should perform the respiratory exercises routinely prescribed for maintaining peritoneo-venous shunt function (*2*). These involve inhalation against a resistance of 5 cm of water pressure. This provides enough pressure differential to operate a patent shunt.

INTERPRETATION

In the early scintigrams one should check for tracer distribution throughout the abdomen. With this prerequisite satisfied, one may assume that the tracer in the ascitic fluid would enter the multiple perforations of the collecting tube if the shunt is functioning and if the necessary pressure difference between abdomen and thorax exists.

If the collecting and venous tubes are patent and the diaphragm valve is operative, the gamma images will clearly show the venous tubing in the anterior thoracic wall, and the liver and spleen will be obviously recognizable in the abdomen (Fig. 1). Whenever these are observed, the procedure may be terminated and causes other than shunt occlusion should be sought to explain increasing ascites. This list includes excessive salt intake, insufficient diuretic therapy, increased severity of cirrhosis, hepatoma, or progressive congestive heart failure. The liver scan obtained in this procedure may be used to evaluate the possibility of a hepatoma, especially if additional posterior and right lateral views are obtained.

On the other hand, if the later films fail to reveal the liver and spleen (Fig. 2), a malfunctioning LeVeen shunt (or ineffective breathing exercises) is suspected. The obvious treatment then is to replace the valve or possibly either of the tubes. The thoracic wall tubing is usually unrecognizable with complete obstruction but may contain small amounts of radioactivity with minimal but inadequate shunt function.

This test cannot determine the cause of shunt dysfunction, but usually the problem is one of backflow

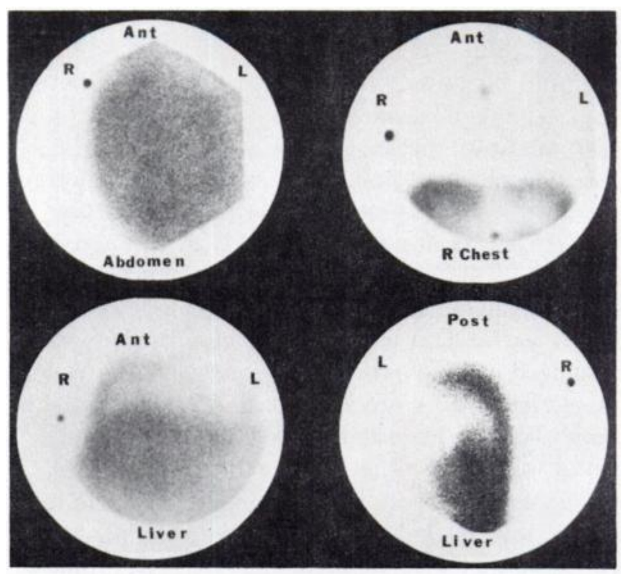

FIG. 2. (Upper left) Anterior abdominal scintigram at 30 min reveals well-distributed tracer throughout peritoneal cavity. (Upper right) Anterior chest view at 1 hr fails to show any tracer in chest tubing or in pulmonary and cardiac blood pools. (Lower left and right) Anterior and posterior scintigrams of upper abdomen indicate total absence of tracer in liver, causing it to appear as void surrounded by ascitic radioactivity. Dark spot at margin is source marking patient's right side. Additional dark spots in upper right scintigram mark suprasternal notch and xiphoid process.

through the valve. Other causes seem to be very rare. One case was reported in which the venous tubing was advanced too far; it entered the abdominal inferior vena cava, precluding a pressure differential in the shunt (*3*).

Strictly speaking, a natural pathway exists for the egress of radioactive ascitic fluid-borne colloid, namely, through the diaphragmatic lymphatics. This transit is relatively slow, however, with only small amounts of radioactivity detected in mediastinal and supraclavicular lymph nodes 2 hr after intraperitoneal administration of ^{99m}Tc-sulfur colloid (*4,5*).

EXAMPLES OF CLINICAL STUDIES

Case 1. A 49-year-old man with portal cirrhosis had a LeVeen shunt implanted 3 weeks previously because of massive ascites responding poorly to dietary salt restriction and diuretics and requiring frequent paracenteses. Dramatic improvement, with decreased abdominal girth and increased urinary output, lasted 1 week and then was followed by recurrence of symptoms. Indications of cardiac failure or renal dysfunction were lacking. Doppler flowmeter studies for fluid motion through the venous tubing were inconclusive.

The radionuclide imaging test (Fig. 1) indicated a properly functioning LeVeen shunt and effective respiratory exercises. Therefore, the shunt was not altered, but diuretic therapy was increased and sodium restriction tightened. Definite improvement followed.

Case 2. A 51-year-old man with portal cirrhosis, ascites, esophageal varices, and renal dysfunction required repeated paracenteses because of poor response to other therapy. Insertion of a peritoneovenous shunt was followed by marked and prolonged diuresis, disappearance of most of his ascites, and decline of blood urea nitrogen and serum creatinine levels to normal. After 4 months, gradual rise in body weight, abdominal girth, and blood urea nitrogen began and progressed for the next 2 months.

Hospitalization for re-evaluation included gamma imaging, which indicated shunt failure (Fig. 2). Surgical replacement of nonoperative valve was followed by excellent diuresis and marked reduction in abdominal girth and body weight.

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