Evaluation of Peritoneovenous Shunt Patency with Tc-99m Labeled Microspheres

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The LeVeen peritoneovenous shunt (PVS) was investigated in 40 cirrhotic patients with refractory ascites. Five millicuries of Tc-99m-tagged human albumin microspheres (15–36 μm) were injected into the peritoneal cavity between the umbilicus and the left anterior superior iliac spine. The radiotracer was always detectable by scintigram in the lungs when the shunt was patent. In case of malfunction, by contrast, the radioactivity was either restricted to the venous tube or confined below the diaphragm for at least 4 hr. In the presence of complete obstruction, whereas the tube was not visualized after peritoneal injection, it was outlined by direct injection of 2 mCi of Tc-99m albumin microspheres into its subcutaneous tract, where it crossed the 12th rib, immediately above the valve. This technique sufficed to establish whether the site of obstruction was at the valve or in the tubing itself. In one patient, poor visualization of the tube and a delayed image of the lungs was caused by partial occlusion of the valve with fibrinoid debris. This radiotracer method proved simple, quick, and led to an immediate selective replacement when the shunt was not patent. Therefore, the use of this test is recommended for a definitive diagnosis, since there were neither false negatives nor false positives. No complications such as embolism or bacterial infection were encountered with Tc-99m human albumin microspheres, which are excellent tracers.

J Nucl Med 24: 302–307, 1983

The LeVeen peritoneovenous shunt (PVS) provides safe and effective therapy in cases of refractory ascites (*1–5*).

The PVS diverts the ascitic fluid from the peritoneal cavity into the venous circulation. The drainage system consists of a one-way polypropylene valve, a silicone connecting segment and silicone venous tubing. The valve opens for a pressure gradient exceeding 3–5 cm of water between the peritoneal cavity and the intrathoracic superior vena cava.

Initially, the LeVeen shunt was used exclusively in patients suffering from alcoholic or posthepatitic cirrhosis, but was later extended to other types of ascites such as malignant ascites, chylosis, Budd-Chiari syndrome, nephrogenic ascites, and other rare diseases. The PVS also prevents the sequelae and complications of ascites such as hydrothorax, hepatorenal syndrome, reflux oesophagitis, and malnutrition with inanition. Hepatic encephalopathy, alcoholic hepatitis with jaundice, and severe coagulopathy are relative contraindications.

Occlusion or malfunction of the shunt occurs in 5–15% of patients. The failure is often caused either by deposition of fibrinoid material (possibly an inflammatory exudate) in the valve or by clots in the distal venous tubing or vena cava. Caval thrombi can be visualized either by cavogram or by injection of the venous tubing. These maneuvers are semi-invasive and may not be de-

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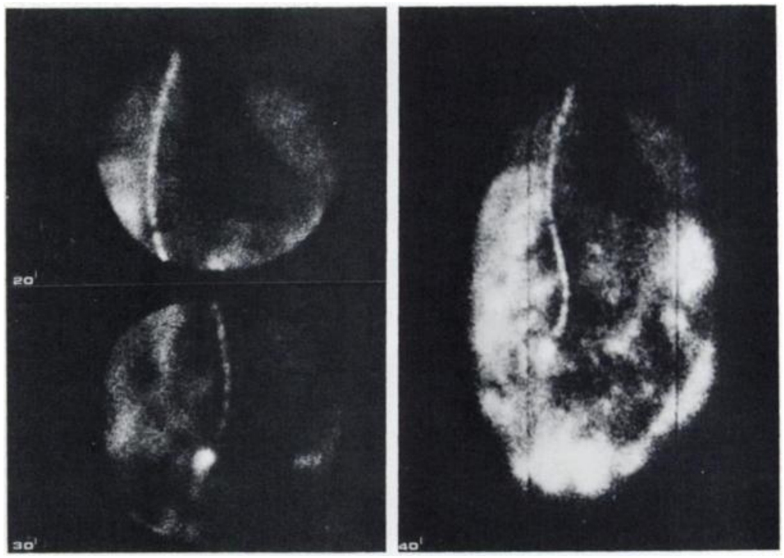

FIG. 1. LeVeen shunt patency study after abdominal injection of Tc-99m microspheres (left). Prompt accumulation of tracer in the lungs is visible. The same study analyzed by whole-body scan (right).

sirable in critically ill patients, but direct injection into the shunt line should be considered the preferred technique that can yield an unequivocal diagnosis. Injection of large volumes into the venous tubing, for instance of contrast agents (*6*), may cause complications such as fatal pulmonary embolization, if a clot is present in the superior vena cava.

Doppler ultrasound has also been advocated as a possible aid in demonstrating PVS patency (*7*). This technique requires great skill to discriminate between nearly similar flow sounds, and many false negatives and false positives limit its usefulness. The patency of the shunt has been successfully determined by radioactive tracers injected directly either into the peritoneal cavity (*8–14*) or into the subcutaneous part of the catheter (*15*); the tracer is transported through the tube and easily reaches the target organ if the shunt is patent.

In this study, the radionuclide method was performed by the direct injection of Tc-99m albumin microspheres into the peritoneal cavity and/or venous tubing in cirrhotic patients.

MATERIAL AND METHOD

During the past two years, 40 cirrhotic patients, aged 41 to 68 yr, 5 female and 33 male, were treated for refractory ascites with the LeVeen PVS. Thirty-four had alcoholic, and 6 posthepatitic cirrhosis. Encephalopathy was not present; 10% of cases had at least one significant episode of G.I. bleeding. All patients had esophageal varices, spider nevi, and palmar erythema. The average plasma albumin concentration was 2.5 g/dl, and pseudocholinesterase 2800 units/ml.

Seven days after shunt insertion the patients were repeatedly studied by injecting 5 mCi of Tc-99m human albumin microspheres,* 15 to 36 μm in diameter, directly into the abdominal cavity.

With the patient lying on his left side, a 20-gauge needle was inserted, under strict aseptic conditions, midway between the umbilicus and the left anterior iliac spine. No local anesthesia was used. If the patient's conditions suggested occlusion of the system, its patency was rechecked.

After the injection, the patients were instructed to inhale against a resistance. With a little training this sucking maneuver raised the intra-abdominal and lowered the intrapleural pressure, producing a gradient of 10 to 15 cm of water across the diaphragm. These pressure differences are suitable to facilitate the drainage of ascites through the shunt and into the veins. This technique, previously described by one of us (*4*), involves breathing through a blow bottle partially filled with water. The rise in intra-abdominal pressure was augmented by elastic banding of the abdomen with an appropriate girth.

Using a gamma scintillation camera† equipped with a high-resolution, low-energy, parallel-hole collimator centered over the chest and neck, scintiphotos were made in anterior and lateral projection at 10, 20, 30, 40, 50, and 60 min after injection. Delayed images were also obtained at 120 and 180 min and, if necessary, at 240 min.

The patency of the shunt was demonstrated by the presence of radioactivity in the venous tubing and then

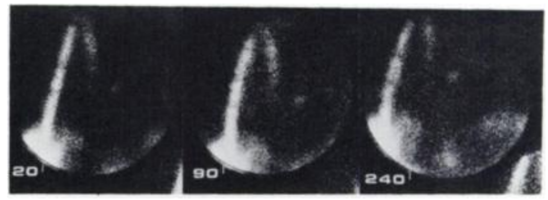

FIG. 2. Thorax, frontal projection. Tracer outlines venous tubing, but is not detected in lungs.

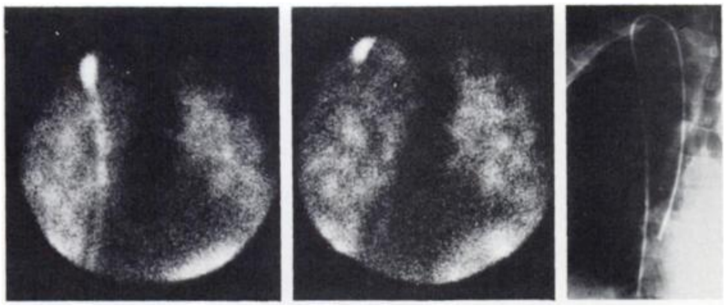

FIG. 3. Persistent accumulation of microspheres is present just proximal to loop of terminal segment of tube (left). This image persisted even in standing position (center). Injection of contrast medium shows site of obstruction by securing surgical tie (right).

in the lungs, where the tracer is trapped in the capillaries and in the precapillary arterioles.

If the passage of the microspheres through the valve into the venous tubing could not be visualized, a second tracer injection of 2 mCi was made 4 hr later, directly into the venous tube, to locate the site of obstruction. This injection was performed with a 26-gauge needle at the crossing of the 12th rib, where the tube becomes accessible. The volume was always less than 0.5 ml and was injected slowly to avoid generating a significant pressure inside the tubing.

None of the patients treated with PVS had evidence of heart diseases. Since no relapse of shunt obstruction was recorded, the present paper refers only to the first obstructive episode.

RESULTS

The tests were performed one week after the insertion of PVS. The Tc-99m albumin microspheres were found to pass through the drainage system into the lungs in all patients (Fig. 1). The average transit time between abdominal injection and lung detection of the tracer was 25 min.

The patency of the system unequivocally ruled out any possibility of malposition of the shunt at the time of surgery, which is one of the more frequent causes of early malfunction. The tests where patency was demonstrated were invariably accompanied by loss of weight, increased mean urine flow, and reduction of abdominal girth. Thus, the result of shunt studies was satisfactorily correlated with the clinical outcome of surgery.

Although the scintigraphic results were not superimposable in all patients, the evidence of the patency of the tubing and the details of the lung images was unequivocal in all. There was a slight individual variability in transit time due to differences in pressure gradients, in the volume and pressure of ascites, and to the patient's compliance in breathing through the blow bottle.

Six patients out of 40 underwent a second test, 8 to 14 mo after insertion of PVS, because of clinical signs of malfunction. Since the clinical symptoms developed only in these 6 patients, no others underwent a radionuclide followup study. In two of the six patients the microspheres were detected within the venous tubing, but failed to appear in the lungs, not even in delayed scintiphotos (Fig. 2). Both patients were explored surgically and incompletely occluding thrombi were found in the distal part of the venous tubing. Since the valve was functioning well, only the distal part of the venous tube had to be replaced.

The scintiscan of the third patient showed a large concentration of microspheres within the preterminal part of the shunt, immediately before the terminal loop, at the level of the cephalad convexity ending in the jugular vein (Fig. 3, left center). The progress of the tracer was delayed, so that the lungs were visible only in the later photos. The injection of contrast medium revealed a stenotic segment caused by the surgical tie securing the shunt to the jugular vein (Fig. 3, right).

In the fourth and fifth patients the albumin microspheres remained largely confined to the abdominal cavity, although in the fifth one a ill-defined stump of the initial portion of the tube could be appreciated (Fig. 4

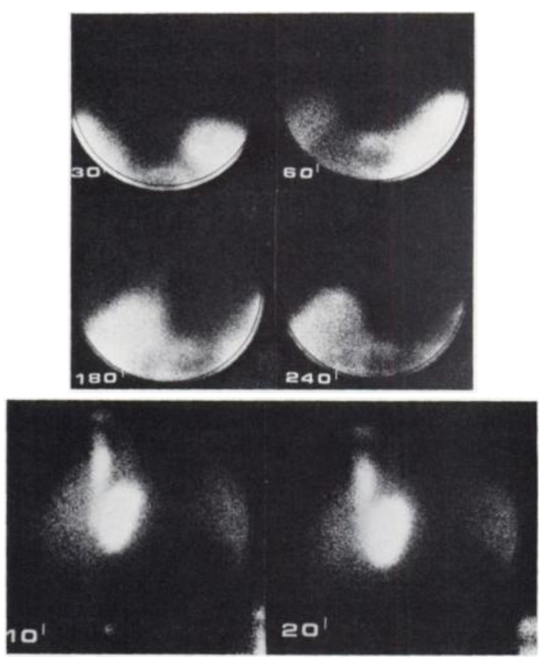

FIG. 4. Tracer is retained within peritoneum and fails to appear in lungs (upper). Microspheres, injected directly into proximal end of tubing, progressed rapidly into lungs, demonstrating valvular obstruction (lower).

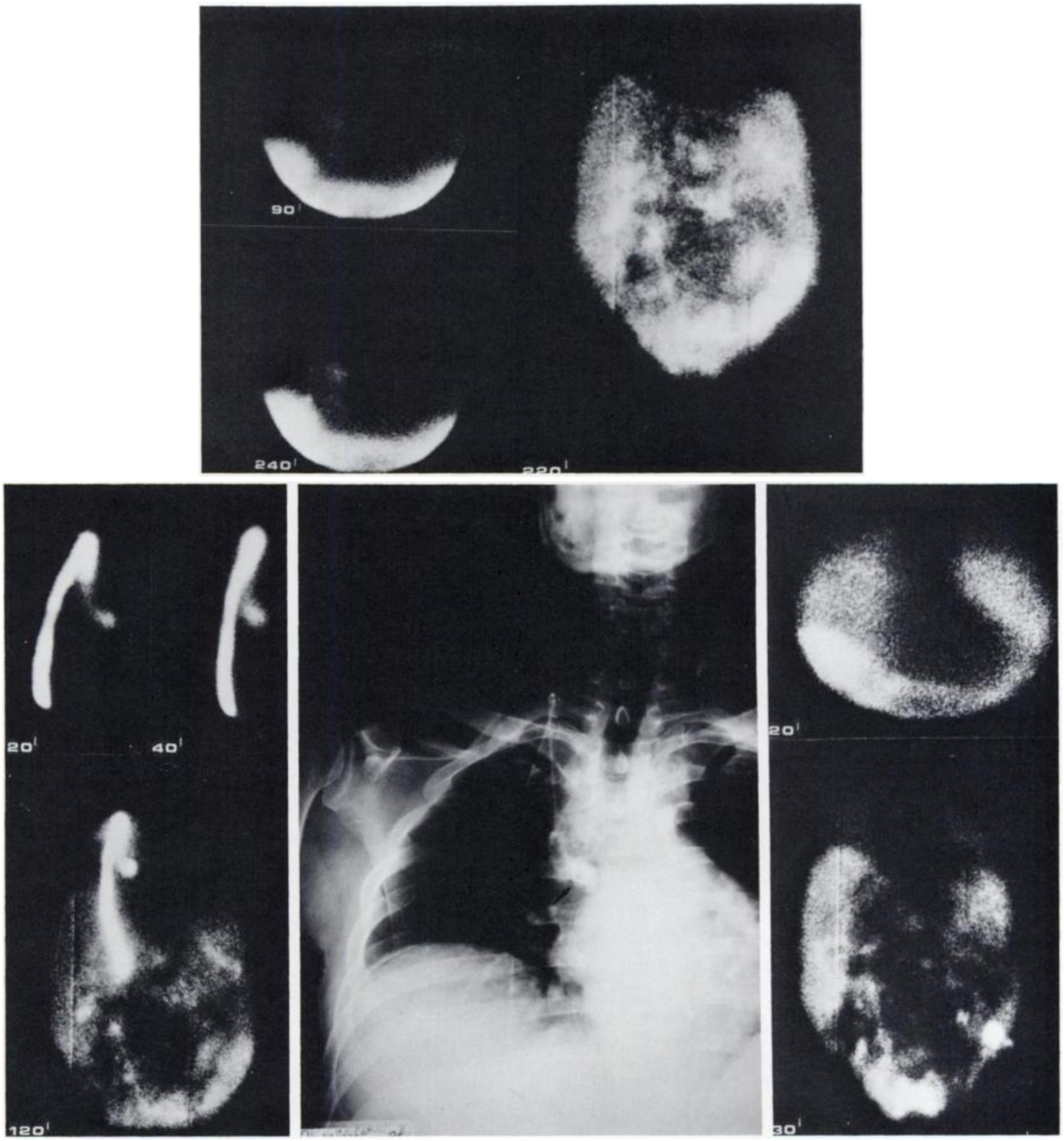

FIG. 5. Patient 5. Radioactivity is retained within peritoneal cavity and only initial stub of tube is barely visible (upper). After direct injection above valve, radioactivity fills shunt without progressing beyond the terminal obstruction (lower left). Lungs were never visible. Injection of contrast medium demonstrates presence of terminal occluding thrombus (lower center). Abdominal injection of microspheres shows that patency is restored after urokinase injection directly into tubing (lower right).

upper, 5 upper). Four hours after the abdominal injection, a second 2-mCi dose of microspheres was injected directly into the proximal part of the venous tubing of these two subjects. The radioactive tracer immediately appeared in the lungs of the fourth patient (Fig. 4 lower). The valve was explored, was found obstructed by fibrinoid material, and was replaced. Fibrin deposition might possibly have represented an inflammatory exudate, although frank peritonitis was not present.

In the fifth patient the direct injection of microspheres into the tubing visualized the full length of the stem, which terminated abruptly beyond the venous insertion (Fig. 5 (lower left)). The lungs were never seen. The picture was confirmed by shuntogram, all of which suggested an occluding clot (Fig. 5, lower center). After two days of heparin treatment, urokinase was slowly infused directly into the tubing (200.000 I.U. in 200 ml of normal saline). The clot was lysed and the shunt regained its patency within 24 hr of the urokinase injection, as demonstrated by a repeat scintigram (Fig. 5 (lower right)).

The sixth patient showed a poor visualization of the

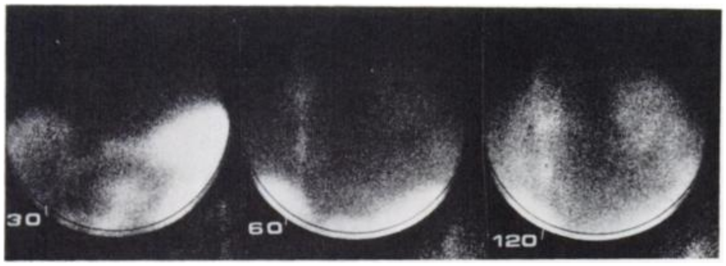

FIG. 6. Patency study shows slow migration of microspheres through shunt, with delayed passage into lungs.

venous tubing, with delayed passage of the tracer into the lungs (Fig. 6). The finding persisted despite all the maneuvers to facilitate the drainage of the ascitic fluid into PVS (breathing exercises, abdominal compression, etc.).

Heart disease had been ruled out. At surgery, it was seen that the clots and fibrinoid material found in the valve were impeding the free flow of fluid.

No adverse reactions, such as allergy to albumin microspheres, bacterial infection, or bleeding were encountered.

DISCUSSION

The radionuclide technique used in the present study must be considered extremely valuable, since there were no false negatives in 40 tests with a functioning valve. Moreover, six patients with shunt failure were correctly diagnosed. The absence of both false negatives and false positives had not been previously demonstrated. Tc-99m human albumin microspheres always reached the lungs, permitting good visualization when the shunt was patent. The test should be considered of great importance in settling a question of shunt patency immediately in the postoperative period in patients who fail to exhibit a diuresis.

A second injection of the tracer directly into the subcutaneous portion of the tube, immediately above the valve, was very useful in establishing whether the obstruction was valvular or within the tubing itself. Since less than 0.5 ml of solution is injected, there was no danger of pulmonary embolism from clot dislodgement. Albumin microspheres must reach the lungs in order to demonstrate shunt patency; visualization of the venous tubing is not sufficient for this purpose.

The early visualization of the tube indicates a normal valvular flow; a poor image of the tube, with delayed accumulation of the tracer in the lungs, indicates a malfunctioning valve. In this situation, however, associated heart disease must be ruled out. More accurate information could be obtained by quantitative measurements of shunt flow.

The radionuclide technique outlined permitted early surgical revision when the shunt was not patent. Although the exact site of interruption can not be pinpointed, the method discriminated between valve and tube shut-off. This represents a most important information for the surgeon, since it can locate the obstruction either at the valve or in the intravenous portion of the tubing, and restrict surgery to the appropriate site. An additional consideration is that it avoids the necessity for replacement of the whole apparatus when only one portion of the system is the cause of malfunction.

The radionuclide method should be used routinely to demonstrate the patency of peritoneovenous shunt in cirrhotic patients, both postoperatively and at times of recurrence of the ascites.

This technique, though slightly invasive, is simple, time-saving and safe. Moreover, it has never caused either embolism or bacterial infection.

In the present study, six patients out of 40 developed clinical symptoms suggesting obstruction, which was demonstrated in all of them. It seems unlikely that the test will prove 100% sensitive in a larger series. However, the demonstration of an open shunt in the presence of symptoms compatible with obstruction will immediately call the attention of the clinician to alternative possibilities, such as cardiac failure, renal failure, and hepatic cancer, that can be identified by appropriate procedures.

FOOTNOTES

* Sorin Biomedica.

† KR6-Selo.

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