Embolization of Hepatic Arteriovenous Malformations Using Radiolabeled and Nonradiolabeled Polyvinyl Alcohol Sponge in a Patient with Hereditary Hemorrhagic Telangiectasia: Case Report

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Polyvinyl alcohol sponge (PVA) radiolabeled with ^{99m}Tc-sulfur colloid was used to evaluate a large hepatic arteriovenous malformation (AVM) in a 71-yr-old white female prior to embolization. The patient had hereditary hemorrhagic telangiectasia (Osler-Weber-Rendu) with severe left-to-right shunting through the hepatic AVM which resulted in high-output congestive heart failure. The patient also had severe pulmonary hypertension. Scintigraphic imaging of the embolized radiolabeled PVA particles allowed us to be certain that the particles did not flow through the liver and inadvertently embolize the lungs; with the patient's already poor pulmonary status, embolization could have been fatal.

J Nucl Med 1992; 33:260–262

Hepatic arteriovenous malformations (AVMs) are often treated by transcatheter embolization with polyvinyl alcohol sponge (PVA) (*1–8*). Embolization therapy, however is not benign (*3,5,9–11*). Inadvertent embolization of the patient's lungs (flow of PVA through the AVM into the lungs) and reflux migration of PVA to distal vascular sites with subsequent embolization can occur (*1,2,5,6,10, 12*).

The precise location of PVA particles can be determined scintigraphically during and after embolization by radiolabeling them with ^{99m}Tc-sulfur colloid (SC) (*12,13*). Scintigraphic monitoring has been instrumental in preventing complications from inadvertent pulmonary and peripheral embolization (*5,12*). We present a case in which ^{99m}Tc-SC-PVA was used to evaluate the vascular integrity of a hepatic AVM prior to embolization in a patient with severe pulmonary hypertension in whom inadvertent pulmonary embolization could have been life threatening.

Received Jun 6, 1991; revision accepted Aug. 27, 1991.

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CASE REPORT

A 71-yr-old white female with a history of hereditary hemorrhagic telangiectasia (Osler-Weber-Rendu), pulmonary hypertension, and right ventricular failure was admitted with exacerbation of her chronic congestive heart failure and atrial fibrillation following Argon laser photocoagulation treatment. She had a history of multiple episodes of severe bleeding from facial, nasal, and oral telangiectasias that required Argon laser photocoagulation. Her high-output congestive heart failure and pulmonary hypertension had been attributed to chronic left-to-right shunting through peripheral AVMs.

A cardiac catheterization demonstrated severe pulmonary hypertension and right heart failure. Mixed venous oxygen saturations indicated left-to-right shunting in the middle portion of the inferior vena cava. A hepatic arteriogram was performed and revealed multiple large intrahepatic AVMs (Fig. 1). It could not be determined whether they were cavernous or had a capillary bed. In light of the patient's severe pulmonary hypertension, which would have been worsened by inadvertent pulmonary embolization, a hepatic embolization procedure was cancelled until AVM integrity could be defined.

PVA particles were radiolabeled with ^{99m}Tc-SC by the method of Jack et al. (*13*). The reported tagging efficiency of this procedure ranges between 26%–31% (*12,13*); ours was 29%. The midportion of the right hepatic artery was selectively catheterized; a test injection demonstrated opacification of the right lobe of the liver without reflux into the gastroduodenal or left hepatic artery. Twenty of the larger (1000–2000 μm) radiolabeled PVA particles were then injected into the right hepatic artery while a portable gamma camera was positioned over the patient's chest. Images demonstrated activity confined to the right upper quadrant of the abdomen. This was followed by injecting approximately 20 of the smaller (700–1000 μm) labeled PVA particles. Postinjection imaging again showed that all particles were confined to the right lobe of the liver (Fig. 2A-B). Therapeutic embolization of the right hepatic artery was then performed using the smaller nonradiolabeled PVA particles (700–1000 μm) and multiple embolization coils. Approximately 1 g of PVA particles were used. After embolization, right hepatic artery flow was markedly decreased without affecting other segmental branches.

Following embolization, the patient returned to the nuclear

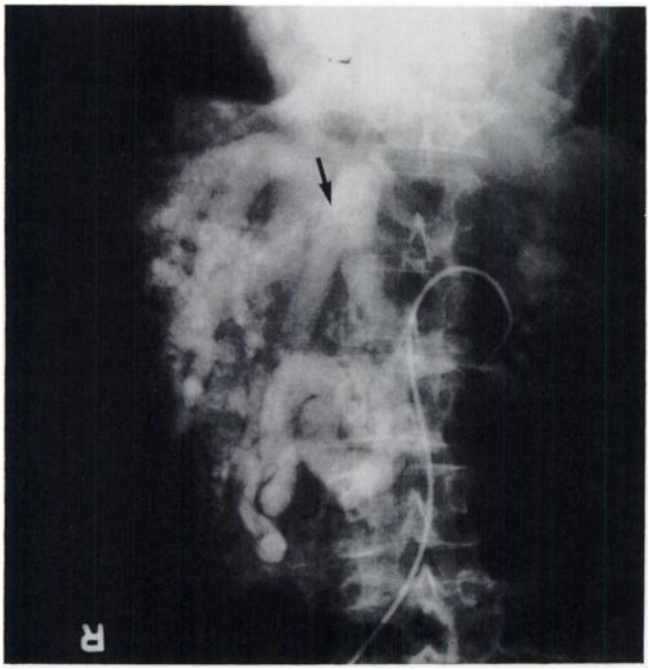

FIGURE 1. Pre-embolization angiographic image of the patient's liver taken 6 sec after contrast injection. Note the massive flow of contrast into the extensive hepatic arteriovenous malformation and the prominent early-draining veins (indicated by arrow).

medicine department where additional images were obtained (Fig. 3). She was then injected with 5 mCi of ^{99m}Tc-SC and additional images were performed. Postembolization images demonstrated that the radiolabeled PVA particles were confined to the right lobe of the liver; no pulmonary activity was seen.

Following the embolization procedure, the patient's cardiac output fell from 10 liter/min to 6 liter/min. She subsequently underwent two additional embolization procedures. At completion of her therapy, the patient's cardiac output was 4.1 liters/min.

DISCUSSION

Hepatic arterial embolization using particulate PVA has been used to treat hereditary hepatic AVMs, hepatic hemangioendotheliomas, benign and malignant hepatic tumors, hemorrhage, and AV fistulae (*2–6,9,14*). The two most common complications are inadvertent pulmonary embolization and reflux migration of embolization particles to distant sites. These usually result from the inability of the angiographer to visualize PVA through conventional radiography. The morbidity of these complications is high (*6,10*); even more disturbing are the recent deaths of two infants due to complications following hepatic AVM embolization (*5*).

PVA particles are radiolucent and therefore not seen with fluoroscopy (*1,12*). Barium-impregnated PVA is essentially radiolucent due to the small size of the PVA particles; they have also contributed to patient morbidity and mortality (*1,12*). PVA particles suspended in contrast and imaged fluoroscopically provide general information about PVA dispersal patterns but cannot predict the appropriate particle size required for embolization, and reflux migration of PVA is not detected (*15,16*). There is evidence that the flow of contrast does not necessarily correlate with the eventual embolization site of simultaneously injected embolization particles (*17*).

Scintigraphic imaging of radiolabeled PVA provides precise localization. Complications can be detected immediately and steps can be taken to correct the problem or terminate the procedure. In addition, selection of the appropriate particle size for embolization is based on an actual physiologic challenge of the vascular integrity of the AVM.

Right-to-left shunting of PVA through anomalous cardiac defects or vascular connections during hepatic embolization probably occurs more frequently than is clinically documented (*5*). Repa et al. reported a patient with a patent foramen ovale who had PVA embolized to the small vessels of the heart, spleen, pancreas, meninges, and the intraparenchymal arterioles of the lungs. Patients at risk for right-to-left embolization complications include infants with patent foramen ovales and individuals with atrial/ventricular septal wall defects, probe-patent foramen ovales, or pulmonary hypertension.

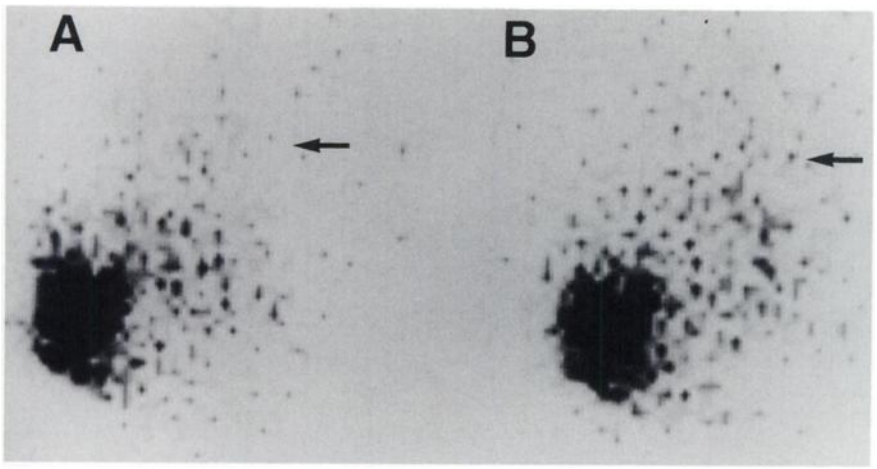

FIGURE 2. Serial portable gamma camera images of ^{99m}Tc-sulfur colloid radiolabeled polyvinyl alcohol particles embolized to the right lobe of the patient's liver. Images were obtained in the angiographic suite during the injection of the radiolabeled polyvinyl alcohol particles. Images of the chest and upper abdomen taken at the beginning (A) and at the end (B) of the procedure demonstrate activity confined to the patient's right upper quadrant. Arrows indicate the approximate level of the xiphoid process.

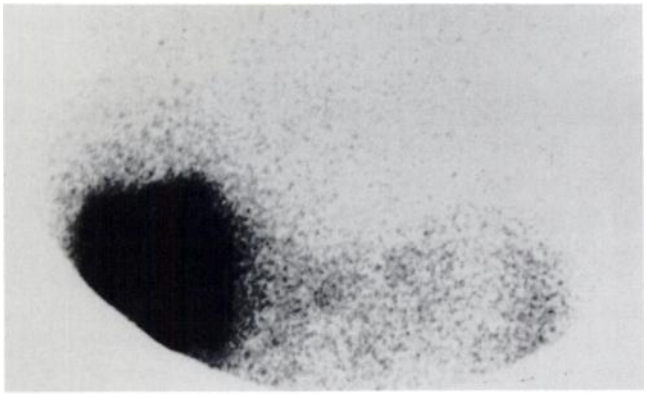

FIGURE 3. Postembolization images confirming the location of the radiolabeled polyvinyl alcohol particles in the hepatic arteriovenous malformation with no activity in the lungs.

Preparation of PVA with homogenous particle size is critical to preventing complications; however, procedures used to ensure this are not foolproof. Rasp preparation of PVA is labor-intensive and dependent on the skill of the preparer (*7,18,19*). Mechanical sieving does not guarantee uniform particle size as particles have a tendency to clump together or fracture (*7,16,18,20*). Repa et al. demonstrated that commercially prepared PVA suspensions are not necessarily homogeneous and felt that the preparations contributed to the deaths of two infants (*5*). Scintigraphic imaging of radiolabeled PVA eliminates these problems. Technetium-99m-SC radiolabels PVA particles of all sizes (*12,13*); smaller than expected particulate PVA contamination that passes through the target AVM is readily detected.

Multi-step embolization procedures decrease morbidity and increase efficacy of AVM embolization therapy (*6, 21*). Recruitment of collateral vessels following the patient's first embolization procedure, or formation of direct arteriovenous fistulae, can complicate subsequent embolizations (*1,21*). A specific PVA particle size that was large enough to lodge within the AVM initially may be too small for subsequent embolizations. Radiolabeled PVA should be used to evaluate AVM vascular integrity prior to and during each therapeutic embolization session, especially in patients with significant pulmonary disease.

Embolization particles should be small enough to flow as far as possible into the AVM vascular bed without traversing it and entering the lungs (*13*). This occludes small vessels while minimizing parenchymal liver damage. A 1.0-mm diameter PVA particle provides adequate occlusion of most small-vessel AVMs (*6*); however, they may be inadequate in AVMs with large fistulae. Since exact vascular size is difficult to determine angiographically, all AVMs should be evaluated with radiolabeled PVA prior to embolization therapy to determine the appropriate particle size for embolization. Jack et al. initially uses small radiolabeled PVA particles (*13*). Progressively larger particles are introduced until no new activity appears in the lungs. Embolization is then performed with this particle size. Repa et al. begin with larger particles (*5*). Smaller particles are introduced until the smallest desired embolization particle is reached or until activity appears in the lungs. Embolization proceeds with the smallest particle size remaining in the AVM. Both options may be viable approaches to different patient populations; however, in patients with diminished pulmonary function, embolization of the patient's lungs by repeat test injection should be avoided.

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