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Positive Technetium-99m-Red Blood Cell Gastrointestinal Bleeding Scan after Barium Small-Bowel Study

Patrice K. Rehm, Frank B. Atkins and Harvey A. Ziessman
Division of Nuclear Medicine, Department of Radiology, Georgetown University Hospital, Washington, D.C.

A 53-yr-old man with hepatic insufficiency and portal hypertension was hospitalized and underwent a work-up for gastrointestinal bleeding requiring multiple transfusions. The initial evaluation included a negative upper and lower endoscopy and a barium exam of the small bowel. Both studies failed to demonstrate any pathology to explain the bleeding. Immediately following the barium study, the patient had active bleeding. Because of the significant amount of intestinal barium, angiography was deferred. Technetium-99m-red blood cell (RBC) scintigraphy was undertaken to identify the site of bleeding. Despite intestinal barium, the ^{99m}Tc-RBC scan demonstrated an active bleeding site in the small bowel in the left abdomen. Therefore, ^{99m}Tc-RBC scintigraphy can be of clinical utility for identification of gastrointestinal bleeding, despite the presence of intestinal barium.

Key Words: technetium-99m; gastrointestinal tract hemorrhage; barium; attenuation

J Nucl Med 1996; 37:643–645

Technetium-99m-red blood cell (RBC) scintigraphy is an established technique for identification and localization of gastrointestinal bleeding. We report a case in which scintigraphy performed 2 hr after a barium small bowel examination demonstrated active bleeding. Concern about the effects of retained barium led us to explore the factors affecting photon attenuation. We describe a phantom experiment performed to investigate the attenuation of different barium solutions and discuss the underlying physics principles.

CASE REPORT

A 53-yr-old man with a history of cirrhosis and portal hypertension secondary to ethanol abuse presented for weakness. Because of a hematocrit of 25, which was significantly lower than his baseline, and guiac-positive stools, the patient was hospitalized and a work-up for gastrointestinal bleeding was undertaken. He was transfused 7 units of packed RBCs and 2 units of fresh-frozen plasma during the 48 hr after admission, and no further bleeding was noted for 4 days. Upper and lower endoscopy was negative. Prior to anticipated discharge, the patient underwent a small bowel follow-through radiographic exam, which involved the ingestion of 900 cc barium sulfate solution [45% weight-to-weight (w/w)]. Immediately following the normal small bowel exam, there was evidence of rebleeding when the patient passed a maroon stool mixed with bright red blood and barium. The radiology department was consulted about obtaining an angiogram. After discussion, however, it was concluded that angiography was inappropriate at that time and was deferred to await clearance of the barium (Fig. 1A). Scintigraphy instead was suggested.

Within 2 hr, a tagged red blood cell study was initiated to identify the site of bleeding. The patient's blood was labeled with 30.0 mCi (1110 MBq) ^{99m}Tc using the in vitro kit technique; analog images containing 500,000 counts were obtained at 5-min intervals with simultaneous computer acquisition using 1-min frames for 90 min. A changing pattern of abnormal activity was noted in the lower abdomen. Review of the cine and analog images allowed identification of intestinal bleeding and localization to the mid to distal small bowel (Fig. 1B-D). In addition, there was scintigraphic evidence of ascites with a pattern of decreased peripheral activity and relatively increased central abdominal activity (*1*).

During the 24 hr after the RBC scan, the patient intermittently passed stools variably maroon or mixed with bright red blood. The patient received 2 units of packed red cells during that period, and an additional 2 units during the subsequent 24 hr, during which time he remained clinically stable. The patient's total transfusion requirement during the hospitalization was 11 units of packed red cells and 2 units of fresh-frozen plasma.

Three days after the small bowel exam and bleeding episode, the patient underwent angiography of the superior mesenteric, inferior mesenteric and gastroduodenal arteries. Angiography demonstrated hepatofugal blood flow with porto-systemic collaterals (*2,3*) compatible with portal hypertension secondary to cirrhosis, but did not demonstrate any active bleeding or pathology to explain prior bleeding episodes.

In the absence of further bleeding and a stable hematocrit, the patient was discharged without further intervention, leaving the pathological diagnosis unresolved.

Phantom Study

A simple phantom experiment was performed to investigate the relative attenuation of different barium solutions compared to water (as an approximation to soft tissue). [Typically, barium preparations are described in terms of percent w/w, which indicates the number of grams of barium sulfate per gram of final prepared

Received Mar. 16, 1995; revision accepted Jul. 14, 1995.
For correspondence or reprints contact: Patrice Rehm, MD, Nuclear Medicine, Gorman 2005, Georgetown University Hospital, 3800 Reservoir Road, NW, Washington, D.C. 20007.

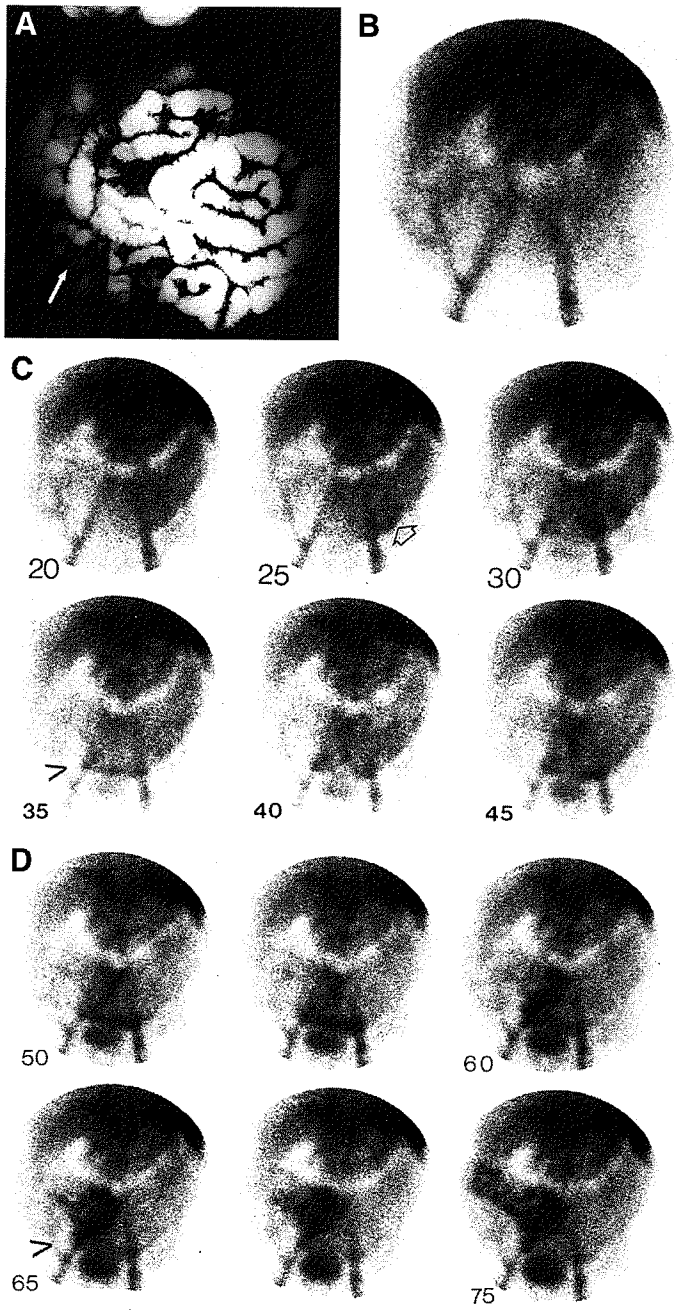

FIGURE 1. (A) Late image in the small bowel study demonstrates barium in multiple small bowel loops, including the terminal ileum (arrow). (B) Immediate image of ^{99m}Tc-RBC scan shows tubular photopenia due to barium in the hepatic flexure, transverse colon and distal ileum and a subtle pattern of lower activity peripherally and increased activity centrally, representing ascites. Serial delayed images at (C) 20–45 min and (D) 50–75 min show evidence of active gastrointestinal bleeding. Photopenia becomes more obvious in C and D (open arrowheads), probably resulting from increased contrast due to intraluminal labeled red cells and possibly barium transit during scintigraphy.

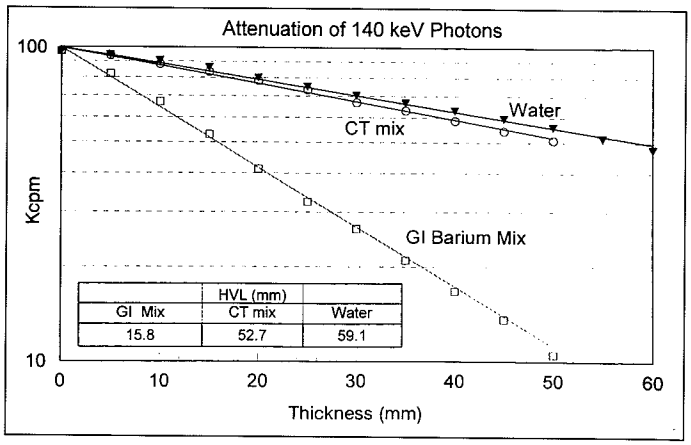

FIGURE 2. Broad-beam geometry attenuation data for 140-keV photons through solutions containing $BaSO_4$ [45% w/w], $BaSO_4$ [1.2% w/w] and 0% $BaSO_4$. The solid lines are the least squares exponential fits to each dataset. The half-value layers shown in the table were obtained from the slopes of the fitted curves.

product expressed as a percentage. For example, 50% w/w indicates 50 g of barium sulfate mixed with 50 g of water]. Three solutions, two containing $BaSO_4$, were used: (a) the standard concentration for small-bowel follow-through at our institution [45% w/w], Sol-O-Pake, E-Z-EM, Westbury, NY; (b) the premixed product for abdominal CT [1.2% w/w], Readi-CAT, E-Z-EM, Westbury, NY and; (c) water. A small source of ^{99m}Tc (approximately 5 mm diameter) was counted with a gamma camera and a low-energy, general-purpose collimator. Solutions of various compositions and depths were placed in a container (5 × 6 mm) directly over the source. The decay-corrected transmission data is shown in Figure 2. The half-value layer for water (5.9 cm) is consistent with other reported values (*4*) for the broad-beam geometry involved in this study.

DISCUSSION

There is scant reference in major textbooks to the issue of scintigraphy in patients with recent barium administration. Generally, conventional wisdom would suggest that intestinal barium is a relative contraindication, and that abdominal scintigraphy should be postponed until intestinal barium has cleared. At times, however, clinical factors weigh against postponement, as in this patient. It was the lack of specific data to guide our actions (to perform or not perform the exam) that led to this case report.

In many radiographic procedures, barium in the form of barium sulfate ($BaSO_4$) solution is used to enhance contrast between the organ of interest and its surrounding tissues. While the attenuation of the x-rays used in these radiographic studies is the result of both photoelectric and Compton interactions, it is the photoelectric component which dominates in the barium solutions because of the photon energy range in which barium radiography is performed. Because an x-ray beam has a broad dispersion of photon energies, in contrast to the monoenergetic photons from ^{99m}Tc, the actual distribution of photon energies in the beam impinging on the patient will depend on the total filtration that has been used. The net result on the x-ray beam can be collectively characterized by an equivalent energy which is much lower than the kVp. For a reasonably filtered beam, this equivalent energy is approximately 40% of the applied kV (*5*). At our institution, the standard small-bowel follow-through study uses a 110 kVp x-ray beam; by using a logarithmic regression to extrapolate from published values, this results in an effective photon energy of approximately 50 keV (*6*). At a higher energy, namely the 140-keV photons of ^{99m}Tc, the photoelectric interaction probability is significantly less. Consequently, the relative absorption of the ^{99m}Tc gamma rays by a barium solution [45% w/w] compared to an equal thickness of soft tissue is less than a factor of about 3.5. It can be seen from Figure 2 that a 2-cm thickness of the barium solution [45% w/w] in the bowel would result in only an additional factor of about 2 reduction in the photons originating from behind the bowel. There would be minimal additional attenuation beyond water alone for the CT barium mixture [1.2% w/w]. Therefore,

although the presence of barium may compromise scintigraphic imaging (*7*), the magnitude of this effect is much less than one might expect if simply based on the radiographic study without further consideration of the appropriate physics (*8*).

Different exam protocols and different barium compositions would result in varying attenuation effects. A variety of barium products are commercially available, and procedures will vary with the institution. In addition, performance of double-contrast exams of the upper and lower gastrointestinal tract using air and a thin coating of higher density barium solution as well as enteroclysis for evaluation of the small bowel have gained widespread use. Double-contrast techniques would result in less attenuation than full column studies because the bowel is distended with air rather than barium solution.

The usefulness of ^{99m}Tc-RBC scanning for the scintigraphic detection of gastrointestinal bleeding is well established (*9–11*). It requires the detection of extravasated intraluminal labeled red cells. Factors that influence successful scintigraphic identification include the rate of bleeding and amount of background activity (*12*), as well as the degree of bowel motility. Previously, a correlation between transfusion requirements and the demonstration of bleeding on scintigraphy has been reported (*10,13*). The patient's transfusion requirements, particularly following the bleeding episode after the barium study, would place him in a subgroup in which scintigraphy is likely to identify a bleeding site, in contrast to patients whose bleeding does not necessitate transfusion. It could, however, not be determined in advance whether the amount and location of the intestinal barium would obscure angiographic or scintigraphic findings of ongoing bleeding. Because of the lack of other nonimaging diagnostic alternatives and the noninvasive advantage of scintigraphy compared to angiography, the tagged RBC study was undertaken.

CONCLUSION

This report demonstrates that a ^{99m}Tc-RBC scan may be of clinical utility for identification of gastrointestinal bleeding, despite the presence of significant intestinal barium. The amount and concentration of intestinal barium as well as its location relative to the site of bleeding may affect the successful identification of the bleeding site. Additional investigations in a larger series of patients would be necessary to address the question of how the presence of barium will affect overall accuracy for detection and localization of the bleeding site. As demonstrated in this patient, intestinal barium should not be a contraindication to performing the exam.

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