Technical Considerations of Tc-99m Labeled Red Blood Cell Scans in the Detection and Localization of Gastrointestinal Bleeding Sites

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Arteriography to detect gastrointestinal bleeding, which is often intermittent, is only likely to yield diagnostically useful information if the patient is actively bleeding at a rate of greater than 1.0 cc/min at the time of the procedure. To avoid the unnecessary morbidity of a negative arteriogram we studied Tc-99m in vitro labeled red blood cell (RBC) scintigraphy as a screening test for arteriography on 111 patients. Fifty-seven of 111 patients (51%) had RBC scans consistent with active gastrointestinal bleeding. Twenty-three of these patients (40%) with positive scans had arteriography. Twelve of these 23 arteriograms (52%) were positive. Arteriograms were performed in 12 of the 54 patients with a negative scan. One of the 12 arteriograms was positive for active bleeding in the rectum. In retrospect, the scan was also positive but rectal activity was initially confused with bladder activity. Red blood cell scans are a reliable screening test for arteriography and they provide useful localizing information in patients with negative arteriograms. Technical factors that will affect the results include (1) obtaining high labeling efficiency by using in vitro labeled red blood cells; (2) frequent acquisition of images over a 24-hr time period; (3) acquisition of dynamic images to localize confusing patterns of activity; and (4) acquisition of images to separate rectal and bladder activity.

Technetium-99m-labeled RBCs have proven to be useful in the detection and localization of occult gastrointestinal bleeding sites (1-5). Our experience has shown that RBC scintigraphy provides a reliable noninvasive test to screen patients for arteriography, a sometimes dangerous procedure, particularly in the elderly. Red blood cell scans can also provide useful localizing information in patients with negative arteriograms. The prolonged imaging time (in excess of 24 hr following a single injection) possible with RBC scanning is desirable for the detection of gastrointestinal bleeding, which is often an intermittent phenomenon. During the last four years, our experience with gastrointestinal bleeding detection and localization made us aware of several important technical factors necessary to optimize the results from this study.

Materials and Methods

One hundred and eleven patients suspected of having acute gastrointestinal bleeding from an unknown source underwent Tc-99m labeled RBC scanning procedures. Patients ranged in age from 27 to 94 years with mean age of 68.8. Autologous RBCs were labeled with Tc-99m in vitro using the Brookhaven

kit (6). An anterior abdominal flow study (32 1.5 sec 64×64 computer images) was obtained immediately after injection of 15 mCi of labeled RBCs using a large field of view scintillation camera with a general purpose, parallel hole collimator or a small field of view camera with a diverging collimator. Static anterior views of 500,000 counts per 128×128 frame were taken of the entire abdomen at 5-10 min intervals for 90 min. Lateral, oblique, and posterior images were obtained when necessary to aid in the visualization and localization of developing bleeding sites. Shorter interval images, i.e., 15-30 one-min images, were sometimes taken in order to help distinguish patterns of bleeding. If no bleeding site was detected within 90 min, additional delayed images were obtained, generally at 3, 6-8, and 24 hr postinjection.

Arteriography was usually performed within 24 hr of obtaining positive results from the RBC scan. The first selective injection was directed by scintigraphic findings. If the first selective injection was unremarkable, other arteries supplying the gastrointestinal tract were examined. The charts of all 111 patients were reviewed and clinical courses of each were correlated for other diagnostic procedures, transfusions, therapy, and deaths.

Results and Discussion

Fifty-seven of the 111 patients (51%) had positive RBC studies for active gastrointestinal bleeding. Twenty-three of the 57 patients (40%) with positive scans had arteriography. Twelve of these 23 arteriograms (52%) were positive. Of the 54 patients with negative RBC scans, 12 had arteriograms. One of the arteriograms was positive for active bleeding in the rectum. In the nuclear medicine study on this patient, rectal activity had been confused with bladder activity.

We have found that certain technical considerations optimize the gastrointestinal bleeding study. Patient selection is the initial consideration. Patients who undergo scintigraphy should have acute gastrointestinal bleeding great enough to require blood transfusions. In addition, nasogastric aspiration or endoscopy or both should be performed prior to scanning to rule out easily diagnosable causes of upper gastrointestinal bleeding. Likewise, sigmoidoscopy should be performed before scintigraphy in order to rule out obvious causes of lower gastrointestinal bleeding.

The next issue is timing. Whenever possible, gastrointestinal bleeding studies should be performed semielectively, beginning as early as reasonable in the working day. Beginning the

study early in the day facilitates the acquisition of frequent images, which are necessary if accurate localization is to be obtained. In some clinical settings, such as when the patient is bleeding profusely, the gastrointestinal bleeding study may have to be performed urgently at any hour of the day or night.

The RBC labeling procedure is crucial; poor labeling efficiency will result in a false-positive bleeding study because some of the free pertechnetate will be secreted into the gastrointestinal tract via the stomach. We use the Brookhaven kit (6) to label RBCs in vitro. In vitro labeling results in a higher labeling efficiency than does in vivo (7) or modified in vivo (8) labeling. We do not recommend in vivo labeling for gastrointestinal bleeding studies.

Many poorly understood factors affect labeling efficiency. A poor label may occur even when the best techniques are used. If free pertechnetate is suspected, images of the thyroid gland are helpful (Fig. 1). The presence or absence of thyroid activity demonstrates the degree of labeling efficiency. It is important to note that kidney and bladder activity is not a reliable indicator of free pertechnetate because this can be caused by labeling of some small polypeptides of the blood. These polypeptides are easily filterable by the kidneys, but they are not secreted by the stomach

Rarely on the early flow study is the scan positive. However, there is a report in the literature of a hemorrhaged vascular lesion, which was detected only during the first pass of the tagged red cells through the abdomen (9).

Despite the fact that stomach and rectal bleeding should be excluded by pre-scan work-up, these areas should still be imaged during static acquisition. In the past four years, we have had only one case in which a positive arteriogram had a negative RBC scan. Arteriography found active bleeding from the superior hemorrhoidal artery. Scintigraphy was initially read as negative since overlying bladder activity obscured accumulation of rectal activity. Therefore, it is important that lateral views be obtained in order to separate bladder and penile activity from rectal activity (Fig. 2).

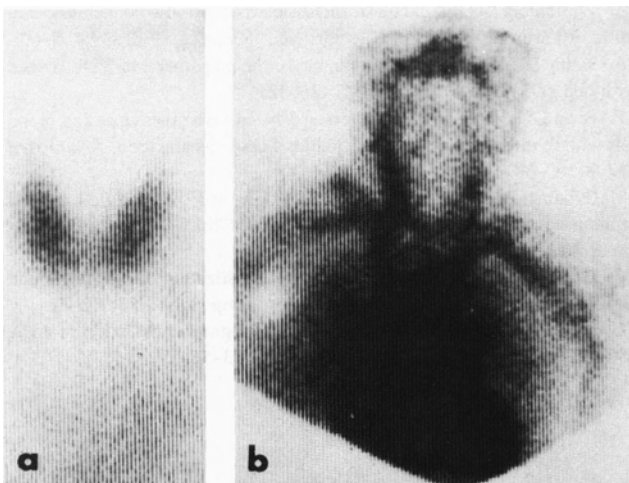Frequent imaging is also an important technical considera-
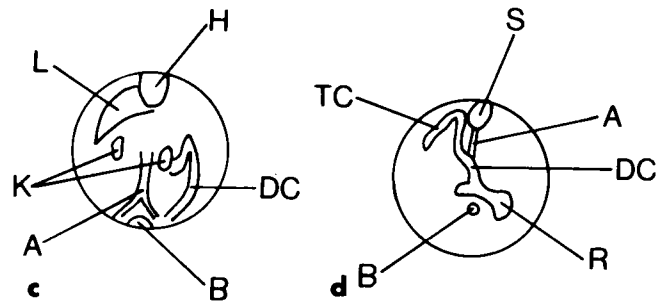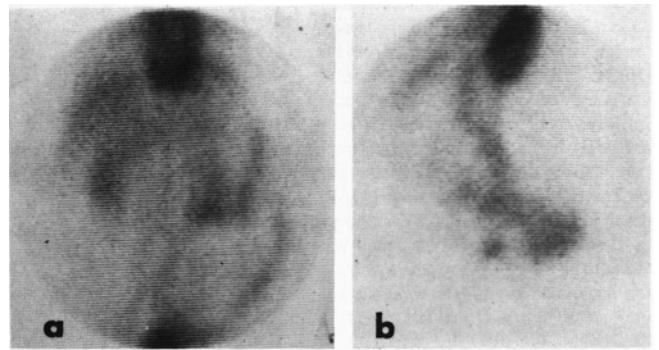

FIG. 2. Lateral view of the abdomen is useful in separating bladder activity from rectal activity. Lateral views should be routinely obtained so that rectal bleeding is not missed because of overlying bladder activity. The structures in the scan are identified by the accompanying line diagram. (A and C) In the anterior view, H=heart, L=liver, K=kidneys, A=aorta, B=bladder, and DC=descending colon. (B and D) In the left lateral view, S=spleen, TC=transverse colon, A=aorta, DC=descending colon, R=rectum, and B=bladder.

tion. The exact source of bleeding can be documented only by frequent acquisition, since activity within the gastrointestinal tract can move forward (propulsive peristalsis) (Fig. 3) or backward (mixing peristalsis). The origin of bleeding cannot be inferred from images that contain considerable extravascular activity. Also, the colon serves as a reservoir for gastrointestinal contents. Therefore activity in this region is significant only if there has been less than a 1-2-hr delay between images.

When the pattern of activity is confusing, the acquisition of 15-30 one-min images may be very helpful. Typically, small bowel activity creates a rapid serpiginous (snakelike) pattern, whereas large bowel bleeding moves much more slowly and remains localized. These dynamic studies are useful not only in identifying the location of bleeding, but also in detecting small amounts of bleeding.

The intermittency of gastrointestinal bleeding has been also documented by frequent imaging. Our experience has shown that some cases, which are negative up to 12 or 24 hr, subsequently become positive 2 hr later (Fig. 4).

The detectability of bleeding using RBCs is somewhat flow independent, since the activity can accumulate in one area over a period of hours. Five to 70 cc of extravasated blood is needed for detection by RBC scintigraphy (1). Technetium-99m-sulfur colloid has been demonstrated to detect bleeding at much lower rates than those needed for positive arteriography and RBC scintigraphy. Unlike the 24-hr monitoring of gastrointestinal bleeding with labeled RBCs, sulfur colloid will only detect bleeding that occurs within the first

FIG. 1. (A) Thyroid is clearly visualized when labeling efficiency is poor. (B) No thyroid activity is seen when labeling efficiency is good.

FIG. 3. Activity, first clearly seen at (B) 55 min (arrow), moves forward and fills entire transverse colon by (C) 6 hr. If only the 6-hr image were obtained, the bleeding site could not have been definitively localized since activity can move both forward and backward in the gastrointestinal tract. In retrospect, a small focus of activity can be identified on the 15-min image (A) confirming that the bleeding site is in the ascending colon. At surgery this patient was found to be bleeding from a diverticula in the ascending colon. [Reproduced with permission from *Gastroenterology (1)*].
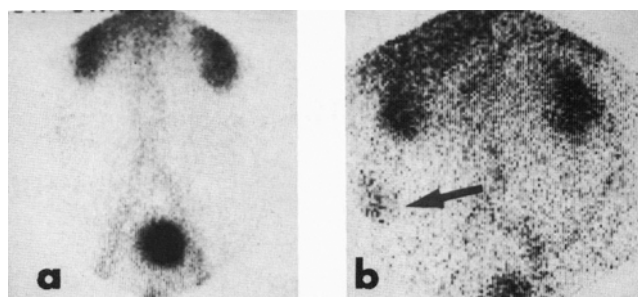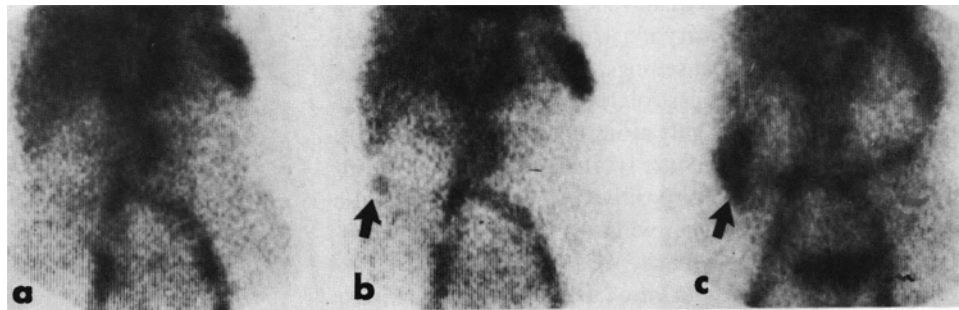

FIG. 4. Despite the fact that this patient's study was negative at (A) 12 hr, bleeding was clearly evident (arrow) at (B) 15 hr. Gastrointestinal bleeding is often intermittent.
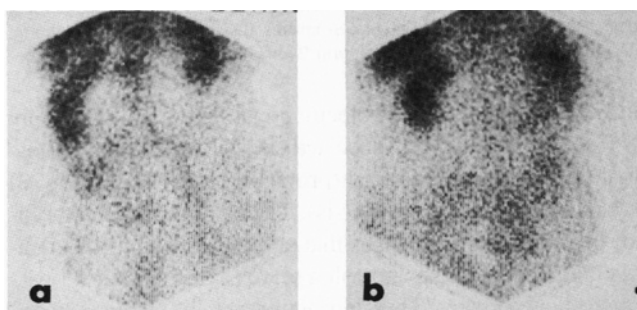

FIG. 5. In the anterior view (A) it is not clear how much of the right sided activity is in the kidney and how much is in the gastrointestinal tract. The posterior view (B) shows that the right kidney is higher than the left kidney; therefore the activity seen on the anterior view is mostly within the gastrointestinal tract. It is normal to see kidney activity, especially on delayed views.

10-15 min of injection. Reasonable estimates of the minimal detectable flow which would be identifiable with sulfur colloid and arteriography are 0.1 cc/min *(10)* and 1 cc/min, respectively.

Another technical consideration is the separation of abdominal from renal activity. Anterior and posterior images should be obtained if there is prominent renal activity, usually seen on delayed views (Fig. 5). If bleeding is questioned in the region of the kidneys, posterior or lateral views may help delineate actual kidney activity from bleeding activity.

In conclusion, the accuracy of gastrointestinal bleeding studies can be improved by following certian protocols. It is important to obtain a high labeling efficiency. Scheduling the patient semielectively facilitates the acquisition of frequent images. Acquisition of dynamic images aids in the identification of small bowel versus large bowel bleeding. The use of lateral and posterior views helps to distinguish abdominal activity from activity in normal structures.

Acknowledgment

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