Spleen Scanning in Humans with Tc-99m-Labeled Erythrocytes: Concise Communication

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Technetium-99m-labeled heat-damaged erythrocytes were evaluated as a spleen imaging agent in 14 patients. Spleen-to-liver deposition ratios were increased to such an extent that the liver was rarely visualized, and interference from the hepatic left lobe of the liver was eliminated. Information obtained was accurate and diagnostically adequate in various splenic involvements. This tracer appears to be one of the better spleen imaging agents presently available.


Splenectomies for various conditions—traumatic, hematologic, or malignant—have resulted in a syndrome of overwhelming postsplenectomy infection in a significant group of patients. Balfanz et al. (1) reported a mortality rate as high as 66% resulting from infections occurring 8 mo to 15 yr after splenectomy for traumatic rupture of the spleen.

Because of this increased risk of serious infection, splenectomy is used less often than formerly as the treatment of choice for splenic trauma, and conservative treatment is becoming more common (2). Imaging of the spleen appears to be a very useful diagnostic tool in these cases.

The correct diagnosis of splenic trauma has, therefore, become increasingly important and challenging to the surgeon. In certain cases the initial injury may be severe enough to cause splenic rupture with massive hemorrhage, warranting splenectomy. On the other hand, the initial insult to the spleen may result in disruption of tissue, followed either by healing or by temporary hemostasis and then delayed hemorrhage (3,4). Proper initial treatment in these cases is conservative, with observation for evidence of shock, signs of left upper quadrant peritoneal irritation, left shoulder pain, or a falling hematocrit.

Spleen scans are most helpful during this initial period when the risk of delayed hemorrhage is greatest. The scans may delineate abnormalities such as irregularity of margins or evidence of fragmentation of the pulp of the organ. Follow-up scans may reveal progression in the size of defects indicating the need for surgery. A stable or improving scan is an indication that conservative treatment be continued. Splenic defects persisting more than 2–3 mo after trauma may remain demonstrable permanently on scans.

Spleen imaging is generally performed with technetium-99m sulfur colloid. Uptake of the colloid by the left lobe of the liver may interfere with imaging of the superior pole of the spleen, particularly in the left lateral projection. At times, this interference may produce inconclusive results.

Selby and Gooneratane (5) reported a case of sub-

FIG. 1. (A) Defect with irregular uptake is noted in spleen inferi-

orly-anteriorly. (B) 1 mo later: Note diminution in size of defect. Two

more scans (not shown) were performed in interim for follow-up.
capsular hematoma that was imaged through the in vivo labeling of red blood cells. With this method, the radionuclide accumulation in the surrounding tissues may make confirmation of certain splenic defects difficult, i.e., the target-to-nontarget count ratio is not optimal.

If the spleen is selectively visualized and if a large fraction of the injected material is localized in the spleen, one obtains much better information. This may be accomplished by imaging the spleen with the help of de-natured red blood cells tagged with technetium-99m (6,7). With this method, very little tracer, if any, is seen in the liver and other surrounding structures (Fig. 1).

MATERIALS AND METHODS

Eighteen spleen scans were performed on six male and eight female patients. The age range was 2–78 yr. Table 1 shows the various reasons for doing these scans, namely, (a) left upper quadrant injury, (b) asplenia, (c) situs inversus, (d) sudden increase in splenic size with a fall in hematocrit in patients with infectious mononucleosis and leukemia, or (e) confirmation of a suprarenal mass (Fig. 2).

For the tagging of red blood cells, we used the kit supplied by Brookhaven National Laboratory, following the method outlined by Smith and Richards (10). The tagged red cells were converted into spleen-seeking agents by damaging them. This was done by incubating and gently mixing them for 15 min at 49°.

With this method, Smith and Richards (10) described labeling yields of 97%. We did not calculate the yield in our laboratory, but we assessed it qualitatively by observing the count rate from the spleen and comparing it with the radioactivity in the surrounding tissues. The completion and adequacy of the damaging process of the tagged blood cells were indicated by the fact that when the damage was adequate, the liver and the surrounding tissues were not seen or were only faintly imaged. Atkins et al. (6) reported that up to 6% of the injected technetium is not firmly attached to the red blood cells and is present in the plasma at 15 min utilizing this technique. Addition of a third saline wash to the procedure did not remove this unwanted activity, however, image quality did not appear to be adversely affected by this plasma activity.

The dose of Tc-99m is 5 mCi for an average 70 kg male adult and 4 mCi for an adult female. Pediatric doses are calculated on the basis of weight. Satisfactory imaging using this material has been obtained with doses as small as 1 mCi. When splenic damage is detected, and

<table>
<thead>
<tr>
<th>No.</th>
<th>Sex</th>
<th>Age (yr)</th>
<th>Diagnosis</th>
<th>Spleen image</th>
<th>No. of scans</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>18</td>
<td>Ruptured spleen inf. mono.</td>
<td>Increase in splenic size; no defects noted</td>
<td>2</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>5</td>
<td>LUQ trauma Hct.</td>
<td>Positive for spleen laceration</td>
<td>3</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>15</td>
<td>Abd. trauma</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>14</td>
<td>LUQ trauma</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>6</td>
<td>LUQ tenderness</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>9</td>
<td>Abd. trauma</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>8</td>
<td>R/O suprarenal mass</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>9</td>
<td>R/O suprarenal mass</td>
<td>Combination spleen-kidney study ruled out a suprarenal mass</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>20</td>
<td>LUQ pain</td>
<td>Defect in the upper pole</td>
<td>1</td>
<td>Arteriogram showed a defect, but it was not typical of either subcapsular hematoma or infarct</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>61</td>
<td>R/O splenic rupture</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>2 1/2</td>
<td>Dextrocardia</td>
<td>Spleen on right side</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>18</td>
<td>Defect on routine liver-spleen scan</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>78</td>
<td>Splenomegaly, AML</td>
<td>Normal</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>2</td>
<td>Polycythemia/huge lb. abdominal mass with irregular uptake</td>
<td>Massive splenic enlargement with irregular uptake</td>
<td>1</td>
<td>Nonsurgical</td>
</tr>
</tbody>
</table>
The images obtained by this method have yielded adequate and, we believe, completely accurate information. There were no false-negative or false-positive results. In four out of the eighteen cases, the liver was faintly visualized. However, the liver shadow did not interfere with the interpretability of the spleen images.

The efficacy of heat damaging techniques was studied by Hamilton et al. (9) who reported that nearly 50% of the injected dose goes to the spleen in rats. Since our study was done in humans, we could do only a qualitative assessment of the scans. With the exception of the above-mentioned four cases where the liver was very faintly visible, none of the other scans showed liver or kidney uptake. Hence, we presume that the deposition of tagged and damaged erythrocytes in the spleen was of a similar magnitude as that obtained by Hamilton et al.

Four typical cases are described below.

**Case 1.** A 5-year-old white male fell on a desk and injured his upper abdomen, causing left hypochondrial pain and vomiting. His private physician found left upper quadrant tenderness and an hematocrit of 29%. His previous known hematocrit was 36%. He was referred to our hospital and was admitted to rule out splenic rupture. On admission, BP was 90/60; pulse, 84/min; and respiration, 20/min. Physical examination revealed left upper quadrant tenderness and no other abnormal finding.

Spleen scan on admission showed an irregular defect inferiorly and anteriorly (Fig. 1A). Vital signs, which were monitored every 2 hr, and the hourly hematocrit, remained stable.

It was decided to treat the patient conservatively. The follow-up period showed no drop in hematocrit or blood pressure. Repeated spleen scans revealed no increase in size of the defect. The last scan performed 1 mo after injury showed diminution in size of the abnormal area (Fig. 1B). The hospital course during his stay was unremarkable; no surgery was performed.

**Case 2.** A 20-year-old female with infectious mononucleosis developed a sudden drop in hematocrit along with left upper quadrant tenderness. She was referred for spleen imaging to rule out splenic bleeding. Images obtained with the use of heated, tagged red blood cells revealed an area of decreased uptake at the superior pole of the spleen. A follow-up splenic angiogram was performed. It revealed a defect in the area corresponding to the scan abnormality, but this area on the angiogram did not have the typical appearance of either a subcapsular hematoma or infarct. Clinically the patient's condition remained stable, and she was thought to have a splenic cyst.

**Case 3.** A 2 1/2-year-old male was admitted to our hospital for the treatment of Hemophillus influenzae meningitis. On physical examination, dextrocardia was an incidental finding. He was referred to rule out asplenia. Spleen imaging revealed the spleen to be situated on the right side, suggesting situs inversus.

**Case 4.** A 9-year-old child was thought to have a left suprarenal mass. A spleen scan was obtained (Fig. 2A) with Tc-99m tagged red cells. This was followed by the administration of a renal scanning agent, and a combined scan of the spleen and kidneys was obtained. The resulting image (Fig. 2B) clearly demonstrated the anatomic relationship of the spleen and the left kidney, and a mass was ruled out.

**CONCLUSION**

The Brookhaven kit is simple to use. The Tc-99m tagging and damaging of red blood cells is very satisfactory. The information obtained from these scans was more accurate than that obtainable by other tracer methods. In each case, the scans assisted in the proper management of the patient. Selective splenic imaging is important in the conservative management of splenic trauma as well as in the evaluation of other conditions affecting the function, size, and anatomic location of the organ. Invasive diagnostic procedures, such as abdominal paracentesis and splenic angiograms, may be unnecessary when the information derived from the radionuclide study is available.

**REFERENCES**

sepsis following splenectomy for trauma. Pediatrics 88: 458–460, 1976

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