Splenic Sequestration of Red Blood Cells: A Computerized Approach Using Two Radionuclides

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The current method for measurement of red blood cell sequestration by the spleen is subject to many inaccuracies. Because of the poor imaging properties of ⁵¹Cr, the exact size and location of the areas of interest, the spleen, liver, and precordium, cannot be identified. Similarly, total organ information cannot be obtained using the currently used scintillation probe because of its limited crystal size. We have developed a simple, rapid, and accurate method which overcomes these obstacles by utilizing a second radiopharmaceutical, ^{99m}Tc sulfur colloid for organ/site localization and the use of a dedicated clinical camera/computer system for data collection and analysis from regions of interest.

A splenic sequestration study utilizing body surface counting of chromium-51- (${}^{51}Cr$) labeled red blood cells with a scintillation probe was described by Jandl (1) and others (2, 3). This is a useful procedure for determining the sites of hemolytic dyscrasias as well as a means of predicting the result which might be expected from splenectomy.

Sequential external counting over the liver, spleen, and precordium after administration of ⁵¹Cr-labeled red blood cells, allows spleen/liver, spleen/precordium, and liver/precordium ratios to be generated. These then are used to assess organ hemodynamics.

This study is traditionally performed with a scintillation probe because ⁵¹Cr is unsuitable for direct visualization of the spleen and liver using a scintillation camera since it has only \sim 8% of its emission characteristics in the 320 keV range.

There is considerable disagreement in the literature as to the proper sampling locations on the body surface. In addition, due to the size and shape limitations of the scintillation probe crystal and the varying sizes and shapes of the organs of interest, only partial information of total organ hemodynamics can be obtained.

In an attempt to overcome these shortcomings we undertook the present study. Two innovations were employed. First, in order to more precisely monitor the entire organs of interest, we utilized the region of interest (ROI) capabilities of a dedicated imaging computer. Second, in order to precisely define the ROIs, a second radiopharmaceutical, ^{99m}Tc sulfur colloid (SC), was first employed to locate the spleen and liver before data at the 320 keV ⁵¹Cr energy level was obtained.

MATERIALS AND METHODS

To date, 15 patients diagnosed as having hemolytic anemia were referred to our department for this study. Red blood cells from each patient were labeled with 200 μ Ci of ⁵¹Cr in accordance with the procedure in the standard red blood cell survival technique (4). Twenty-four hours after the administration of the ⁵¹Cr-labeled red blood cells, each patient was injected with 0.5–0.8 mCi ^{99m}Tc SC. Reinjection of ^{99m}Tc SC was made every alternate day thereafter if found to be necessary for organ visualization, until the termination of the study.

Image Acquisition

Using posterior positioning, an acquisition of \sim 50,000 counts was collected by the computer from a large field of view camera with a medium-energy, high-sensitivity collimator at the 140 keV setting and a 20% window setting (Fig. 1).

Without patient repositioning, a 30,000-count acquisition was collected in the computer at the 320 keV setting with a 20% window. This technique was repeated for an eight consecutive day period with reinjection of ^{99m}Tc SC every other day.

Analysis

The ^{99m}Tc SC computer image for each day was spatially filtered using a nine-point filter and was used for the determination of the exact location of the spleen and liver. Regions of interest were created around the spleen, liver, and an area representative of the precordium on this positioning acquisition and saved for use on the ⁵¹Cr 320 keV image.

These three regions (spleen, liver, precordium), were then superimposed over that day's ⁵¹Cr data acquisition, and the respective pixel areas and total counts were recorded. This sequence was repeated for each days' two acquisitions, with the ^{99m}Tc SC acquisition serving as that day's guide to region selection for that day's ⁵¹Cr analysis (Fig. 1).

Calculation

The total counts from each ROI was divided by the total pixel area to yield the total counts/pixel for the spleen, liver, and precordium. This count/pixel determination for each region was used to establish the spleen/liver, spleen/precordium and liver/precordium ratios, which was then graphically plotted for each day of the study.

RESULTS

Of the fifteen patients studied, four underwent splenectomy with improvement of their condition. Prior to surgery, these

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four patients by our method achieved spleen/liver count ratios of >2.1 with the highest being 2.6. Spleen/precordium count ratios were all <2.0.

Total counting times were ~ 20 min.

DISCUSSION

Despite the limited number of patients tested, our procedure was able to correctly identify the need for surgery in four of the fifteen patients studied who had unusually elevated spleen/liver ratios. Splenectomy in all four patients improved their medical condition.

Just what constitutes a significant spleen/liver ratio, by the traditional scintillation probe technique, varies according to the specific investigator and the individual counting technique used. It may be that with the present technique, which offers a more standardized and "exact" sampling system, a universally agreeable level of significance can now be decided. It is **FIG. 1.** Graphic depiction of the use of the 140 keV, ^{99m}Tc SC computer acquisition for generating ROIs to be used on the 320 keV, ⁵¹Cr-labeled RBC acquisition. Data obtained from the superimposition of these ROIs onto the ⁵¹Cr acquisition are used to calculate the spleen/liver, spleen/precordium, and liver/precordium ratios.

possible, that with this further refinement in the counting technique, a significant spleen/liver level might be arrived at which is somewhat lower than the traditionally reported levels.

It is also probable that total counting times could be shortened without seriously compromising diagnostic accuracy.

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