TECHNICAL NOTE

Compton Scatter Image Simulating Jugular Venous Reflux

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In a radionuclide cerebral angiographic study, Tc-99m photons from the subclavian vein may scatter in the superficial tissues of the neck and head, resulting in an image simulating the jugular venous reflux. In a scintillation camera peaked at 140 keV with a 20% window, any scattered photons with a scatter angle of less than 53.5° may be counted in the Tc-99m window. This scatter angle is large enough to allow counting of many secondary photons from Compton collisions in an area quite distant from the radioactive source to be counted, provided the scatter area and source are separated by air.

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Jugular venous reflux during a cerebral radionuclide angiographic study may be due to superior vena cava syndrome, a Valsalva maneuver, or simply a certain arm positioning (*1*). However, a similar finding may be seen in the absence of jugular venous reflux. It is most likely due to Compton scattering of the Tc-99m photons in the superficial tissues of the neck and head on the side of injection when the Tc-99m bolus is held up in the subclavian vein. One such case is shown in Fig. 1. In order to explain the phenomenon, an experiment was carried out as follows.

EXPERIMENT AND RESULTS

A round plastic container of about the size of a head is filled with water and placed in the middle of the field of view of a scintillation camera. Two millicuries of pertechnetate (Tc-99m) in a syringe is placed at the edge of the camera field as shown in Fig. 2 (left). The scintillation camera is peaked at 140 keV with a 20% window, a setting routinely used in brain imaging. Figure 2 (right) shows activity in the water-filled container even though there was no radionuclide in the water.

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DISCUSSION

The experiment obviously showed that Tc-99m photons were scattered in the plastic container and water, and also that the scattered photons were detected by the scintillation camera. The image of the scattered photons erroneously gave an impression of the presence of radionuclide in the water. In a window setting of 20% with a peak at 140 keV, the window range is 126–154 keV. The angle of a Compton collision that will reduce the energy of a photon from 140 keV to 126 keV can be calculated from the following equation:

$$E' = \frac{E}{1 + (E/511)(1 - \cos \phi)},$$

where ϕ is the angle of deflection of the photon, E the energy of the incident photon (in keV), and E′ the energy of the scattered photon (in keV).

If E = 140 keV and E′ = 126 keV, the angle is calculated to be 53.5°. This means that any scattered photon from a Tc-99m source with a scatter angle of less than 53.5° will have energy greater than 126 keV and may be counted in the Tc-99m window. The angle of 53.5° is surprisingly large, allowing many scattered photons to be counted in Tc-99m imaging. Figure 3 illustrates how Compton scatter actually produces images like those in Fig. 1. The Tc-99m radioactivity in the venous bolus in the subclavian vein has to be quite high and the vein must be quite superficial, so that a suffi-

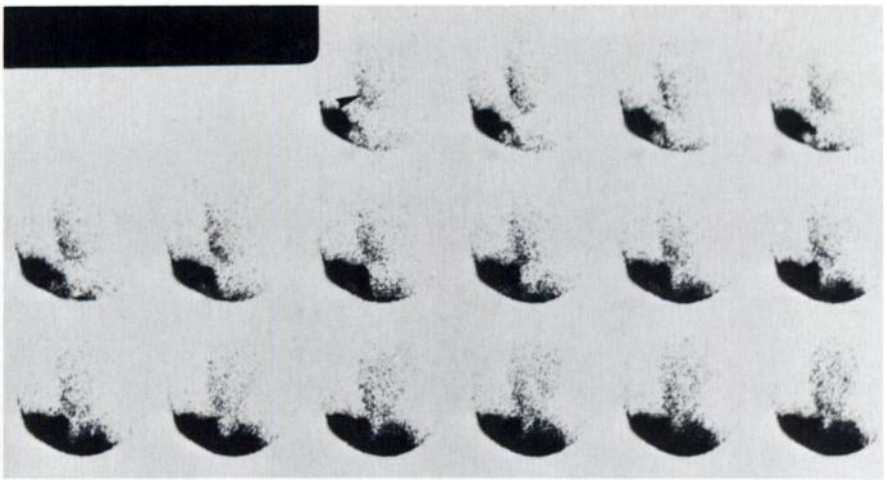

FIG. 1. Radionuclide cerebral angiogram showing Compton scatter image (arrow) simulating jugular venous reflux.

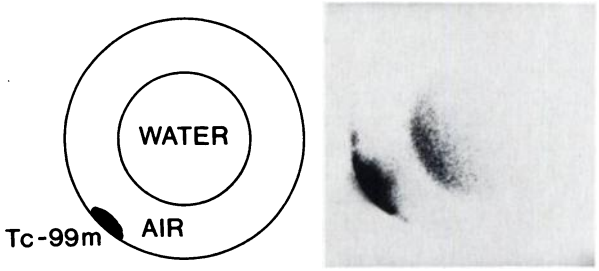

FIG. 2. Experiment with container filled with nonradioactive water; Tc-99m source is nearby, with air in between. Because of Compton scattering, scintigram at right falsely suggests radioactivity in water.

ciently large number of the Tc-99m photons can pass through the air toward the head and neck. Attenuation of the photons through the air is negligible. The scatter, therefore, occurs most frequently in the superficial tissues of the neck and skull. Because of this, the image shows the outline of the neck and head at the injection side, and mimics the image of jugular venous reflux.

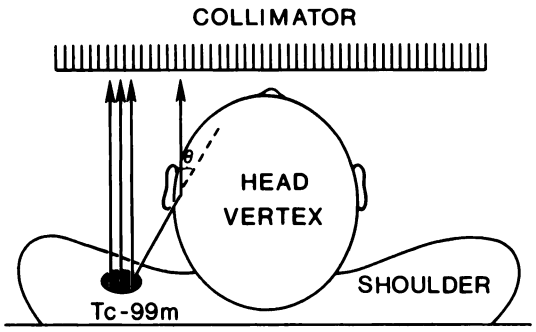

FIG. 3. Diagram to show how Compton scattering occurs in superficial tissues of neck and head when Tc-99m bolus passes through subclavian vein.

REFERENCE

1. YEH EL, POHLMANN GP, RUETZ PP, et al: Jugular venous reflux in cerebral radionuclide angiography. *Radiology:* 118:730–732, 1976