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VISUALIZATION OF SCATTERED RADIATION ORIGINATING FROM THE HEAD

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A peripheral rim of activity seen on the prone vertex view of cerebral flow studies is demonstrated to be an artifact caused by secondary radiation arising from the skull.

Our routine brain-imaging protocol includes a dynamic cerebral perfusion study in the vertex view. With the patient in the prone position, the head is extended and the chin supported on a sponge block so that the orbitomeatal line is as parallel with the stretcher as possible and parallel to the crystal of the gamma camera. The thorax and shoulders of the patient are shielded by a cape made from a lead rubber apron, 0.5 mm lead equivalent, with a hole for close fit around the neck. The patient's arms are extended in front to support himself on the dorsum of his arms exposing the antecubital vein for injection of the bolus of 15 mCi ^{99m}Tc-pertechnetate.

The Pho/Gamma HP III camera is peaked at 140 keV with a 15% window, and images are recorded by "rapid Polaroid pull," and are stored on videotape.

This approach to cerebral radionuclide angiography was selected because the vertex view displays the distribution of the entire cerebral blood pool to greater advantage than the anterior view (*1*). We have used the prone position more frequently than the supine position as we found it to be more comfortable for older patients, less anxiety provoking than extreme extension of the neck with the head hanging over the table, and there is no need to lower and rotate the detector 180 deg from its usual position.

In the majority of patients studied by this method, we noted a peripheral rim of radioactivity in the head on the ipsilateral side of the injection (Fig. 1). This occurred early—simultaneous with the bolus of activity in the arm and great veins of the thorax. This peripheral "crescent" was present in 81% of 69 patients. In 50% of the patients it was faintly perceptible but in 12% it was conspicuous. It may be transient or may persist until it is obscured by the arterial inflow of the radionuclide.

Our initial interpretation was that the "crescent" was caused by reflux in the jugular vein as the timing of the crescent and jugular activity coincided when a good bolus was injected. However, in a case of unsuccessful interstitial injection, a distinct crescent was noted as long as the arm with the localized radionuclide remained near the head although be-

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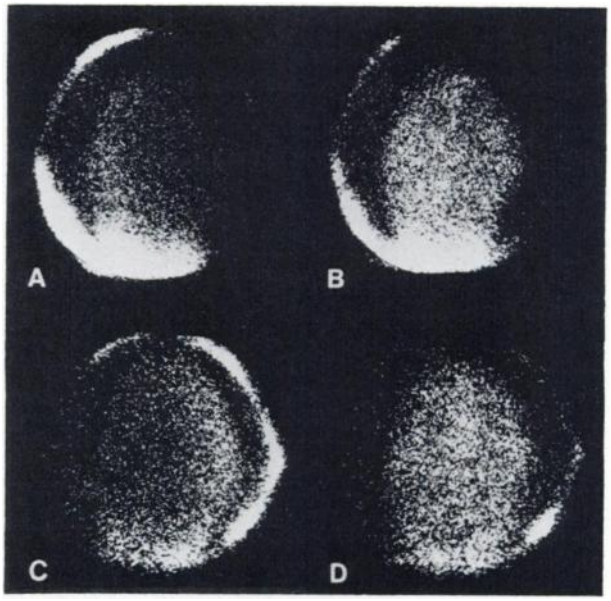

FIG. 1. Peripheral crescents noted during prone vertex cerebral "flow" study. (A) shows left crescent at 0–5 sec and (C) shows right-sided crescent. These are obscured in (B) and (D) during arterial phase. Crescents are ipsilateral to side of injection.

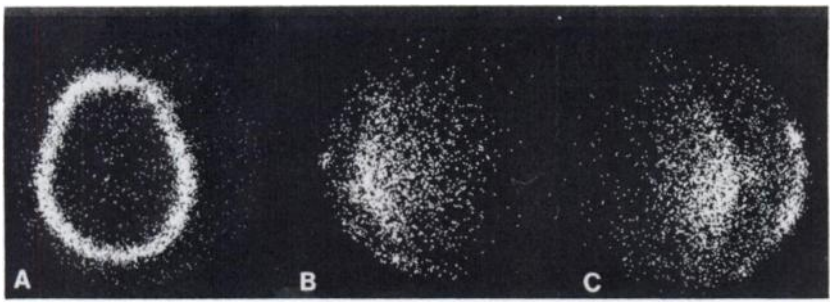

FIG. 2. Peripheral crescents produced by bringing bolus of activity near head but without injection into patient. (A) shows position of head outlined with ^{57}Co marker. (B) and (C) show left and right crescents.

yond the collimator field of view. When the arm was moved, the crescent faded. This led us to postulate that the crescent may be caused by secondary radiation scattered from the skull.

For confirmation of this suspicion, a subject was positioned as for injection and shielded appropriately. No injection was made but a syringe containing 15 mCi of ^{99m}Tc-pertechnetate was passed along his arm under the shoulder and thorax, simulating a bolus of activity passing from the antecubital region to the heart. When the syringe approached the shoulder, the crescent appeared, ipsilateral to the syringe, and a scintiphoto showed that the activity appeared to arise from within the skull (Fig. 2). The position of the head is shown by moving a point source of ^{57}Co around the periphery of the head.

Pulse-energy spectra of the activity were generated on the oscilloscope screen (Fig. 3). Distinct patterns were noted from a syringe of ^{99m}Tc, activity originating from within the patient after injection and the "crescent" produced from an extrinsic source.

The lower photon energies are in the lower part of the photograph. Besides the peak of ^{99m}Tc shown in Fig. 3A, some secondary lower-energy pulses are seen. In Fig. 3B, downward displacement of the spectrum is observed, caused by scattered radiation from within the body. Figure 3C shows the photon spectrum emitted when the "crescent" is produced by the method described. There is a distinct band of lower-energy radiation visible below the usual peak of ^{99m}Tc. This band is interpreted as scattered radiation arising from the skull, originating from a source outside the skull.

Narrowing the energy-discriminator window and a more vigorous shielding with lead aprons have helped to reduce the amount of detected scattered radiation but have not totally eliminated this artifact.

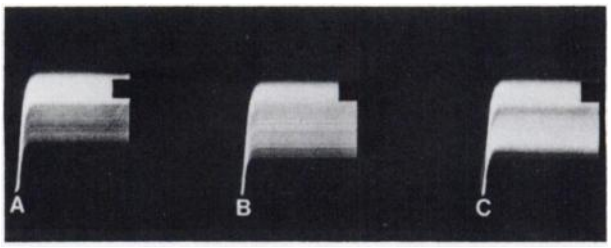

FIG. 3. Spectra of ^{99m}Tc recorded by gamma camera (collimator on). Higher keV photons in upper part of spectra. Dark square is 15% window around 140 keV. (A) Spectrum from unshielded vial of radionuclide, (B) spectrum of injected ^{99m}Tc arising from within patient's head (as in Fig. 1), and (C) spectrum of ^{99m}Tc scattered from head (as in Fig. 2).

Knowing that the "crescent" is an easily identifiable artifact, we ignore any apparent asymmetry if it occurs synchronous with the flow of activity through the axillary and thoracic veins. We have, however, observed bona fide jugular venous reflux. An asymmetry occurring later on in the arterial phase is significant and could mean vascular insufficiency.

Although we have observed secondary scattered radiation on a scan only in the prone vertex "flow study," its unrecognized occurrence under other circumstances is suspected. Perhaps some ill-defined areas of activity observed at a remote point from a focal source of radioactivity may be caused by scattered radiation.

REFERENCE

1. DeLand FH: Scanning in cerebral vascular disease. *Semin Nucl Med* 1: 31–40, 1971