# Radionuclide Circulation Studies to Determine Cerebral Death

Today's life-support systems have challenged our traditional concept of death. Cardiac and respiratory arrest can be reversed. A dead brain, however, cannot be brought back to a functional state.

The criteria of death has been established in individual states by either the legislative or judicial branches of government. Approximately one-half of the states use cardiopulmonary function as differentiating life from death while the other states use brain function (*1*).

The Federal government has attempted to modernize and standardize the determination of death. The President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, for example, in concert with legal and medical associations, have proposed as a model statute the "Uniform Determination of Death Act" (*2*). This Act states that an individual is legally dead if he has sustained "irreversible cessation of all functions of the entire brain. . . ."

Several states have already adopted the "Uniform Determination of Death Act" as their legal definition of death (*3*). In any state where brain death is the legally accepted criterion of death, a radionuclide cerebral angiogram (RCA) may be of value in confirming the clinical diagnosis.

The RCA, which includes flow and static images, can aid in the diagnosis of brain death because it allows evaluation of blood flow to the brain. It is relatively simple to perform, and is a valuable tool in the determination of cerebral death.

## Performing the Radionuclide Cerebral Angiogram

The use of a portable scintillation camera and bedside imaging are recommended because the patient's condition in this situation is always serious, and complex support equipment precludes unnecessary transportation. (In those hospitals lacking a portable scintillation camera, the RCA study can be performed in the nuclear medicine department provided that the patient can be accompanied by portable life-support equipment and personnel). We use a high sensitivity, parallel hole collimator on a small-field-of-view mobile camera with a ¼ in. thick crystal. Technetium-99m glucoheptonate (20 mCi) is most often used, although [$^{99m}$Tc] sodium pertechnetate is equally effective and sometimes more available. The patient's head is positioned for an anterior cerebral blood flow study.

A good, compact ($<$ 1 ml) bolus is especially important for these flow studies. Therefore, we recommend using a 20-cc saline flush coupled with a 3-way stopcock and 20-gauge needle for injecting the bolus. The flow study is acquired on the camera imaging system for 2 sec/image and optionally recorded on a video tape unit or a computer. Using the tape unit or computer provides a good backup system because either can be replayed dynamically in the nuclear medicine department or recorded on film. Immediately after the flow study, at least three static brain views (anterior, right lateral, and left lateral) should be obtained for 400k each. The entire procedure takes less than 30 min and can be easily performed on an on-call basis.

For those departments with computer capabilities, the following information may be useful for data processing. We use a mobile computer that can be brought to the patient's bedside. The flow study is acquired in a dynamic mode using a 128 $\times$ 128 matrix for 60 frames at the rate of 1 sec/frame beginning at time of injection. The immediate static images are also acquired on the computer for a preset count of 400k.

## How Best to Determine Brain Death?

There is considerable discussion in the medical community about the criteria for brain death (*4,5*). Several groups and committees have published suggested criteria, and the radionuclide cerebral angiogram is often recommended as a confirmatory test. The Minnesota Medical Association has suggested that a technique that demonstrates absence of cerebral blood flow can be used to confirm a diagnosis of brain death (*6*). A collaborative study on the criteria for brain death, which followed 503 comatose and apneic patients, recommended that a confirmatory test be performed to determine absence of cerebral blood flow (*7*). Of course, cerebral angiography can be utilized to evaluate blood flow, but it is an invasive procedure and cannot be performed at the patient's bedside.

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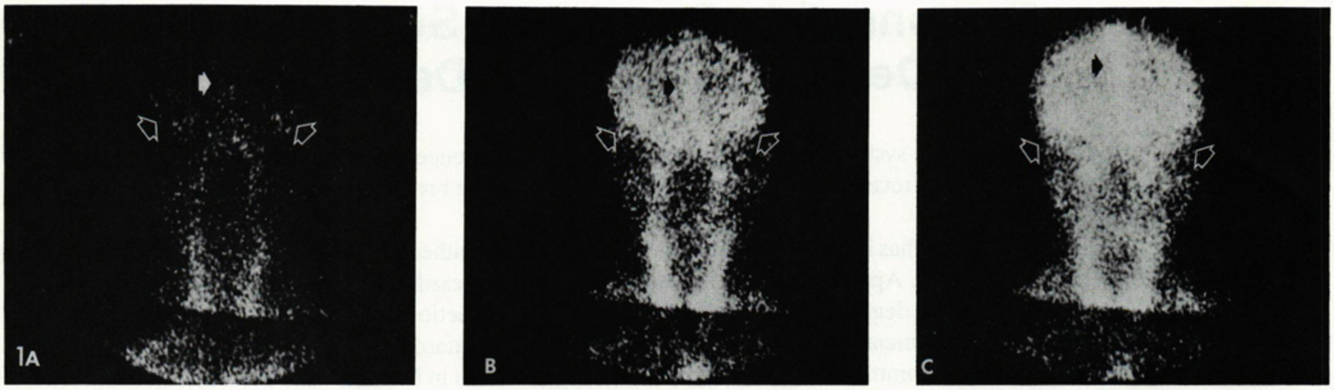


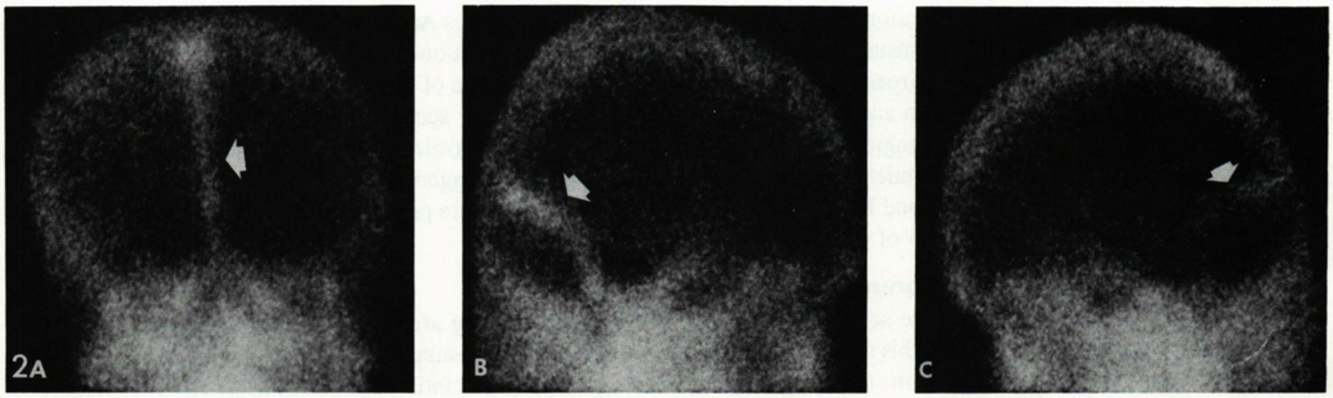


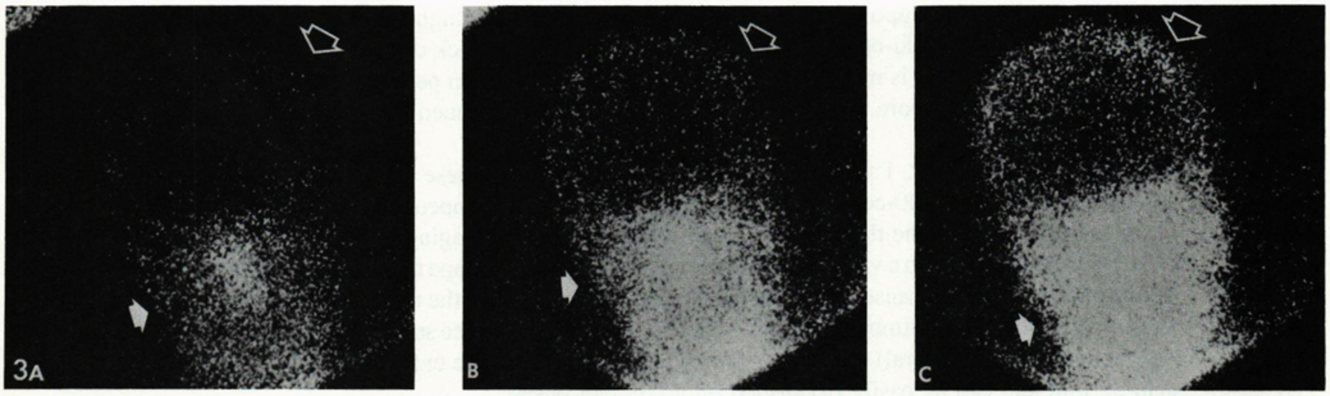


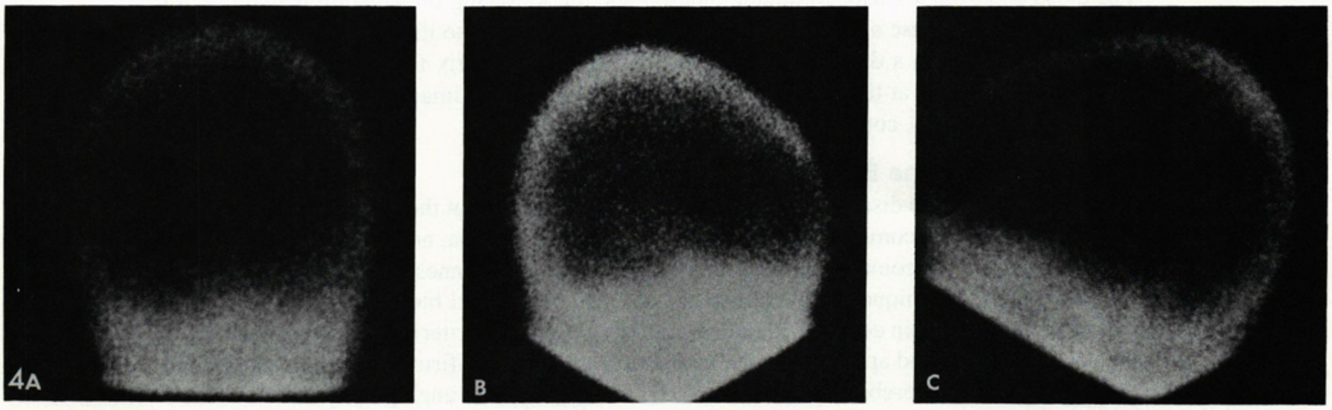


**FIG. 1.** (A–C) Normal anterior cerebral angiogram with normal uptake in anterior (solid arrow) and middle (outline arrow) cerebral arteries. **FIG. 2.** (A) Normal anterior static image demonstrates midsaggital sinus uptake (arrow); (B) normal right lateral; and (C) normal left lateral immediate static images demonstrate normal transverse sinus uptake (arrows). **FIG. 3.** (A–C) Anterior cerebral blood flow images at 2 sec intervals demonstrate uptake in the scalp (outline arrow) and no uptake in the middle or anterior cerebral arteries. Increased flow is seen in the nasal area (solid arrow). **FIG. 4.** (A) Anterior immediate static image demonstrates no midsaggital sinus uptake; (B) right lateral; and (C) left lateral immediate static images demonstrate no transverse sinus uptake.

Recently, Schwartz et al. (*8*) evaluated 15 clinically brain dead patients using the RCA followed immediately by four-vessel contrast angiography. There was complete correlation between the two studies in all patients. Although the number of patients undergoing both tests in this study was small and more studies will be necessary to confirm these findings, the RCA appears to be as accurate as four-vessel contrast angiography in demonstrating cerebral blood flow. Both studies demonstrate brain death by the absence of blood flow. Espinola et al. (*9*) also demonstrated the value of RCA in the diagnosis of brain death in patients being treated therapeutically with hypothermic barbiturate coma.

Most technologists are familiar with the flow pattern characteristic of a normal patient. There are typically five arteries that are visualized in the arterial phase of a radionuclide flow study (Fig. 1): two common carotid arteries, right and left middle cerebral arteries, and two anterior cerebral arteries that appear as one. Because the intracerebral circulation drains into the major venous sinuses, normal delayed static images will visualize these sinuses (Fig. 2).

The RCA of a brain-dead patient will show a very distinctive image: no uptake in the anterior or middle cerebral arteries or in the cerebral hemispheres; however, there will be uptake in the scalp (*10*). Previous work (*11*) had suggested the value of sinus uptake on static images as an indirect indication of cerebral flow. More recent information has shown that this is not true. Sinus uptake can occur in brain death in the absence of cerebral flow (*8*). It is speculated that sinus activity in brain death reflects drainage of extradural, perforating arteries from the external carotid system.

## Brain Death Patient

A 19-year-old white woman was found unresponsive in a closed garage in a car with the engine running. The patient was resuscitated in the emergency room; however, there was no neurologic response at that time. The EEG was flat, and blood tests showed evidence of alcohol and cocaine. An anterior RCA using 20 mCi of Tc-99m glucoheptonate showed no tracer in the anterior and middle cerebral arteries (Fig. 3). This finding is compatible with brain death. Immediate static images performed in anterior, posterior, right lateral, and left lateral positions failed to visualize activity in the saggital or transverse venous sinuses (Fig. 4). This contrasts with an RCA in a normal individual (Figs. 1 and 2).

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