The Hole in the Head: An Artifact of Immediate Brain Imaging

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An artifact occasionally found on posterior brain images, recorded in the supine posterior projection immediately following radionuclide angiography, is described. The artifact appears as an avascular area or areas just above the transverse sinuses, suggesting the possibility of a cystic lesion in the posterior aspect of the cerebrum. Since the initial observation, the artifact has been noted in many additional cases. The artifact was thought to be due to decreased perfusion in that portion of the scalp that presses against the camera collimator. This was proved during two studies of brain death in which there were documented absences of cerebral circulation. The "hole-in-the-head" phenomenon was pronounced, since the only circulation recorded was from external carotid perfusion of the scalp. Images recorded immediately after lifting the head several millimeters from the collimator resulted in disappearance of the artifact as circulation was restored to the compressed area of the scalp. The artifact is related to the patient as well as to technique and an awareness of this may prevent consternation in the interpretation of brain images.

Most artifacts on radionuclide images are easily recognized. Those on Polaroid film are due either to film defects (defective emulsion or developer), equipment defects (light leaks, dirty rollers), or operator error (improper film pulling technique, scratching the emulsion while fixing) (*1*). These types of artifacts generally do not cause problems in the interpretation of the images, since they are fairly characteristic in appearance.

Artifacts related to the patient or imaging technique, or both, are more difficult to recognize. These include abnormalities secondary to malpositioning, patient motion, articles on the patient's body that cause attenuation of photons (*2*), scattered radiation (*3*), saliva or urine contamination, and anatomic variants (*4*). Such artifacts can be recognized and, once identified, prevented. We describe an artifact, which has been observed on a number of occasions, and is related to the patient as well as to technique. We call this artifact "the hole in the head," since it reminds us of the "artifact" created by Fearless Fosdick's bullets (Fig. 1).

Technique

Radionuclide brain imaging at our institution includes radionuclide cerebral angiography in the posterior supine position, using Tc-99m pertechnetate followed by immediate static or blood pool (*5*) images on the gamma camera. Delayed images are obtained at 2–4 hr, with either a rectilinear scanner or a gamma camera, depending upon patient cooperation and size.

The radionuclide cerebral angiogram is recorded with the patient in the posterior supine position for the following reasons:

It is less frightening for a child to lie supine with his head resting upon the inverted gamma camera collimator than to have the instrument over his face (*6*).

Positioning can be accomplished more accurately and immobilization of the child is simpler with the use of a head holder.

Injection sites are more accessible when the camera head does not obscure much of the child's body.

The posterior fossa and the position of the vascu-

FIG. 1. Things are seldom what they seem. [Figure reprinted by permission of Al Capp.]

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lar sinuses are of major importance in detection of neoplastic and congenital abnormalities in children and the posterior projection is more suitable for visualizing these structures (*7*).

The initial gamma camera static images are obtained immediately following the transit of the radionuclide bolus. The posterior image, therefore, is recorded within 3–5 min after injection without moving the patient from the supine position. Of course, anterior projection radionuclide cerebral angiography is recorded when lesions are present clinically in the anterior portion of the brain.

Artifact

A child with a history of occipital headaches was examined with radionuclide brain imaging (Fig. 2). On the immediate static brain image, a photon deficient area appeared just above the left transverse sinus adjacent to the sagittal sinus. On subsequent delayed images at 2 hr, the defect disappeared. Although this was thought to be related to the imaging technique, the question arose whether the abnormality on the brain image could represent a small cystic malformation or porencephaly in the occipital lobe of the brain. Subsequent roentgenographic contrast angiography was normal. Since the initial observation, this artifact has been noted in many (20–30) additional cases. It has been localized on either one or both sides of the sagittal sinus. It is most commonly found in older children with an adult-sized head The defect was considered to be artifactual in those patients who were studied after the initial observation.

Etiology

For the following reasons, we suspected that the artifact was caused by diminished perfusion of that portion of the scalp compressed against the camera collimator.

The defect is not seen during the arteriographic phase of the radionuclide cerebral angiogram when the internal cerebral circulation is the primary com-

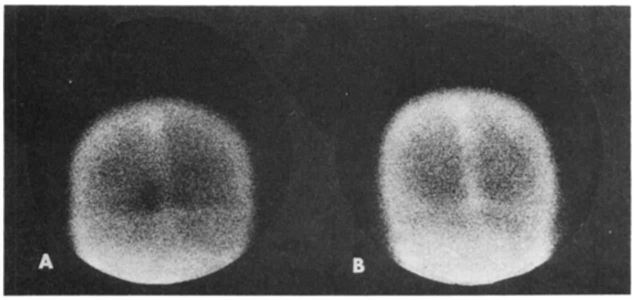

FIG. 2. A photon deficient area is noted above the left transverse sinus on the immediate static brain image (A). At a delayed interval, the abnormality disappeared (B).

ponent visualized. This would suggest that the defect is a result of an abnormal external carotid artery circulation.

The artifact occurs only on the immediate static images, never on delayed imaging, and rapidly disappears if the patient's head is elevated, relieving pressure on the scalp. As pointed out by Oldendorf (*8*), scalp circulation contributes a significant portion of radioactivity to the overall brain image. Localized interference to scalp circulation could result in creation of a perfusion defect (*9*).

The defect occurs primarily in older children with larger heads, which provide more weight for compression of scalp tissue. In addition, when a greater surface area is compressed, the defect becomes more pronounced.

These postulates were proven during examination of a comatose child with a severe head injury following an automobile accident. The patient's condition required maintenance on a respirator and it was suspected that

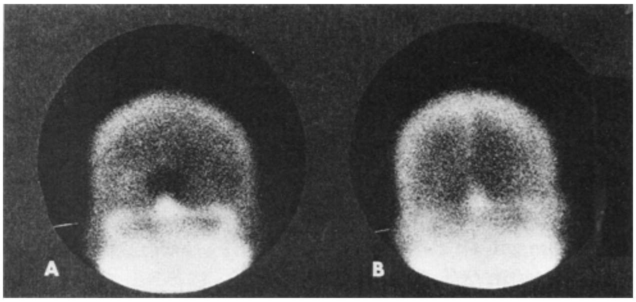

FIG. 3. A prominent photon deficient area is seen above the torcular Herophili in this child with brain death (A). Imaging after slight elevation of the head from the collimator resulted in rapid disappearance of the defect (B).

brain death (*10, 11*) had occurred. The radionuclide cerebral angiogram illustrated absent perfusion to the supratentorial regions of the brain. The sagittal sinus did not visualize on the early images. The torcular Herophili and transverse sinuses appeared because of an intact vertebral and basilar circulation. The immediate brain scan radioactivity in this patient, therefore, represented only cranial and scalp circulation from the external carotid arteries. This was verified with roentgenographic contrast angiography performed immediately after the radionuclide study.

On the immediate static posterior image obtained within 3 min of radionuclide injection, a large defect was noted in the midline just above the level of the torcular Herophili (Fig. 3). This phenomena has been subsequently verified in several patients with brain death and in others having normal internal carotid circulation. The patient's head was then elevated several millimeters off the camera and the posterior image repeated. The defect disappeared after circulation to the compressed scalp tissue was restored.

Discussion

We report an uncommon artifact of brain imaging with an explanation for its origin. This perhaps has not been previously reported since most radionuclide cerebral angiograms are performed in the anterior projection and, indeed, often with the patient erect.

In children, a hole-in-the-head artifact is occasionally observed since the initial static imaging, as well as the angiogram, is done in the posterior supine position. In a retrospective review of cases that demonstrate this artifact, the majority of children were over ten years of age. The weight of the head compresses the scalp in those children with larger heads and prevents the distribution of radionuclide to the scalp tissues.

This is further demonstrated in the case of a child with a thickened cranium and scalp (Fig. 4). The radionuclide angiogram image illustrates separation of scalp radioactivity from intracerebral activity. The thickened cranial vault is further emphasized by the delineation of the sagittal sinus in the lateral view.

Radionuclide brain images of a younger child did not demonstrate the artifact upon an initial examination. However, a repeat examination two months later illustrates the artifact after the patient had a significant increase in head size because of hydrocephalus. The hydrocephalus reduced the intracerebral perfusion, which accents the external carotid circulation contribution to the brain image. An awareness of this defect will decrease consternation in the interpretation of studies when it appears. The hole in the head should not be confused with an anomalous venous channel (Fig. 5), since the latter appears during all phases of the study.

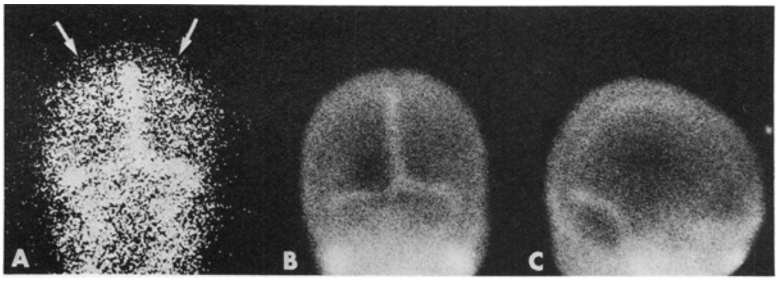

FIG. 4. A thickened cranium and scalp are illustrated on the angio (arrows) (A). A prominent hole in the head is found on the immediate posterior static image (B). The thickened cranial vault is further emphasized by the delineation of the sagittal sinus in the lateral view (C).

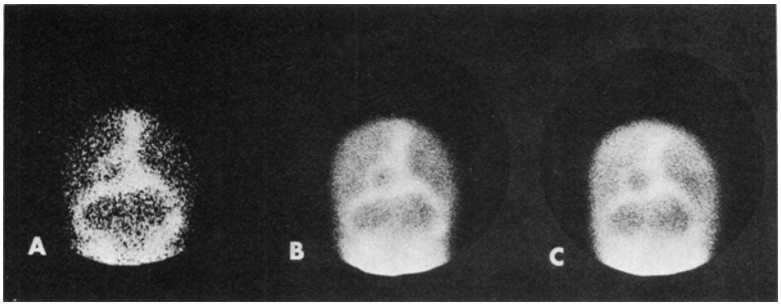

FIG. 5. A pseudo hole in the head is caused by a variant of venous drainage between the sagittal and left transverse sinus. Its presence in all phases of the study differentiates it from the true hole-in-the-head phenomenon (A, B, and C).

Summary

An occipital artifact can be found on posterior brain images recorded in the supine posterior projection immediately following radionuclide angiography. This defect is due to decreased perfusion in that portion of the scalp pressing against the camera collimator. The artifact is best seen in patients with thick scalps, heavier heads, or conditions with diminished intracerebral circulation. This has been termed the hole-in-the-head phenomenon. An awareness of technique artifacts may prevent consternation in the interpretation of brain images.

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References

1. Weiss S, Conway JJ: Polaroid film artifacts. *J Nucl Med Tech* 4: 183-188, 1976

2. Weiss S, Conway JJ: Bone imaging artifacts. *J Nucl Med Tech* 5: 17-22, 1977

3. Greyson ND, LeBlanc J: Visualization of scattered radiation originating from the head. *J Nucl Med* 15: 1035–1036, 1974

4. Burt RW: Brain scan abnormalities produced by electroencephalographic procedures. *J Nucl Med* 15: 369–370, 1974

5. Gilday DL: Various radionuclide patterns of cerebral inflammation in infants and children. *Am J Roentgenol Radium Ther Nucl Med* 120: 247–253, 1974

6. Conway JJ: Sedation, injection, and handling techniques in pediatric nuclear medicine. In *Pediatric Nuclear Medicine,* Philadelphia, W. B. Saunders, James AC, Wagner HN, Cooke RE, eds, 1974, pp 95–102

7. Conway JJ, Yarzagaray L, Welch D: Radionuclide evaluation of the Dandy-Walker malformation and congenital arachnoid cyst of the posterior fossa. *Am J Roentgenol Radium Ther Nucl Med* 112: 306–314, 1971

8. Oldendorf WH, Iisaka Y: Interference of scalp and skull with external measurements of brain isotope content: Part I isotope content of scalp and skull. *J Nucl Med* 10: 177–183, 1969

9. Buhl M, Charles P, Jensen FT: Elimination of scalp blood flow by headband during dynamic brain scintigraphy. *J Nucl Med* 16: 679–681, 1975

10. Goodman JM, Mishkin FS, Dyken M: Determination of brain death by isotope angiography, *JAMA* 209: 1869–1872, 1969

11. Mishkin F: Determination of cerebral death by radionuclide angiography. *Radiology* 115: 135–137, 1975