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Clinical Applications of Combined Cerebral Angiograms and Brain CT Scans

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This paper illustrates the clinical value of a computer technique for superimposition of two different kinds of imaging procedures. The initial application was to overlay cerebral angiograms onto computed tomograms of the brain. Case material from three patients with intracerebral abnormalities is presented. The sum of information from the combined studies exceeds that from either study alone and has value for both diagnosis and treatment of head lesions.

Computed tomography (CT) of the brain displays anatomic cross sections showing different soft tissue structures (e.g., white matter, gray matter, and ventricles), as well as bone [1, 2]. Although relatively large vascular structures can sometimes be visualized on postinfusion CT scans, many vessels are beneath the resolution of CT scanners [3–5]. Further, it is difficult to predict if any given vessel will be visualized in a particular patient's scan [4]. Yet, in many cases it would be valuable to visualize the cerebral vasculature on CT scans. A combination cerebral angiogram and CT brain scan would demonstrate the cerebral vasculature as it passes through the intracranial soft tissues, and could provide information about the cerebral vascular anatomy as well as the nature of vascular shifts. This could be a valuable aid in surgical planning for resection or biopsy of lesions.

Methods

We already described a technique for achieving this result [6]. In this paper, we describe its actual application to clinical problems. A summary of the procedure follows. After a standard biplane angiogram, a 10 cm cube is radiographed without changing the orientation of the x-ray tubes and screens. The cube has 13 pieces of lead shot (0.125 cm diameter) embedded in its walls. The position of each shot is precisely known. By digitizing the position of each shot in the two biplanar radiographs, the precise locations of the tubes and screens in that particular angiographic run can be inferred computationally.

During both angiography and CT, three or more pieces of lead shot are taped to the patient's forehead in fixed positions in order to describe a plane that reconciles the angiogram with scan coordinates. The shot pieces are positioned along the patient alignment line projected from the entrance of the tunnel of our EMI 1005 head scanner or along the transverse cross hair projected from the anteroposterior tube in the angiographic suite (fig. 1). The positions of the shot are visible in the images produced by both procedures and are subsequently used to align the images spatially. Since they are used

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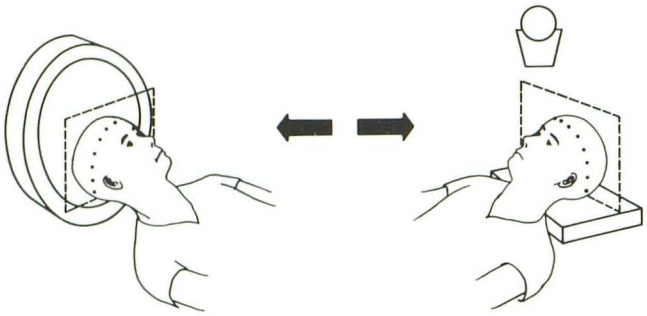

Fig. 1.—Lead shot pieces, attached to patient's head in transverse plane, serve to align and scale angiograms and scans. (Reprinted from [6].)

for scaling and alignment, these shot pieces must be in the same positions during both procedures.

After angiography and CT an analyst (in this study either N. J. P. or E. E. D.) enters vessels of interest into a computer (PDP-11/40) by digitizing a vessel's course in two angiographic views using an interactive image analysis system [6]. By digitizing several vessels in two mathematically known planar projections, it is possible to reconstruct a three-dimensional representation of the patient's angiogram. Using the alignment information provided by the positions of the lead shot, the appropriate sections of the three-dimensional angiogram are then extracted and photographically overlaid onto the appropriate CT cuts.

Further details of the technique are described elsewhere [6–8]. Our procedure now allows the analyst to enter each vessel continuously in one view at a time, rather than selecting corresponding

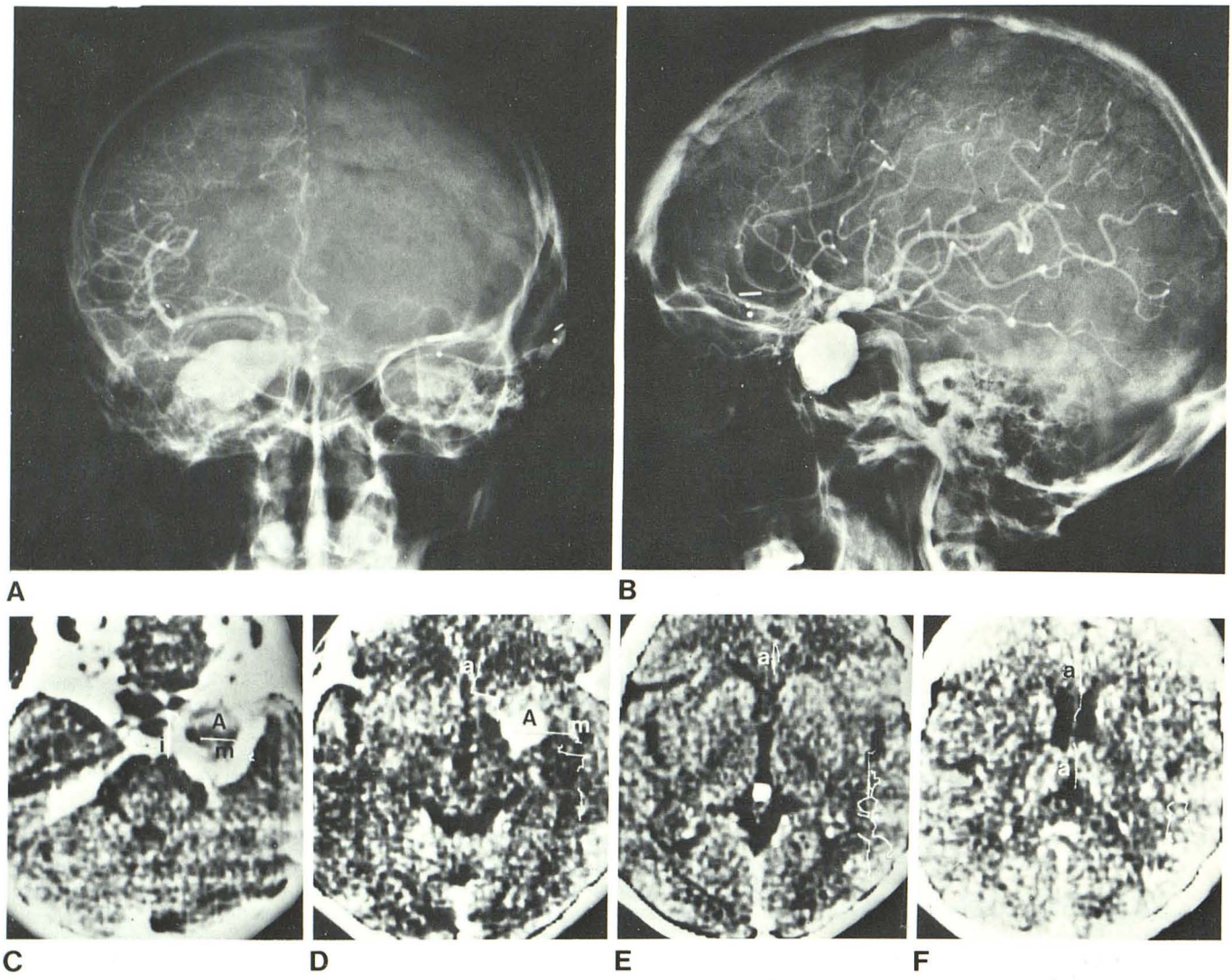

Fig. 2.—53-year-old woman with large internal carotid artery aneurysm. **A** and **B**, Anteroposterior and lateral views. Aneurysm elevates MI segment of middle cerebral artery; only part of aneurysm filled on internal carotid injection. MI segment rests on upper margin of aneurysm. Several shot pieces and two linear pieces of metal are seen; linear pieces of metal help distinguish shot pieces on left side of head from those on right. **C**, Low CT scan. Relation of several vessels to aneurysm. Aneurysm (A) quite large and bounded by carotid artery (i) medially and unlabelled branch of middle cerebral artery at lateral margin of aneurysm. MI segment (m) lies over aneurysm. **D**, Adjacent scan. Upper limit of aneurysm (A) and more MI segment (m) lying over and lateral to it. Part of MI segment included in overlap between this scan and one below. Extension of middle cerebral artery into sylvian fissure plus several branches seen within fissure. Anterior cerebral artery (a) arises from carotid. **E**, Several more branches of middle cerebral artery in sylvian fissure as they extend posteriorly. Anterior cerebral artery (a) curves over anterior margin of corpus callosum. **F**, Final scan. Anterior cerebral artery (a) passes between lateral ventricles. Vessel appears discontinuous since connecting part is in next higher scan (not shown). Some unlabelled branches of middle cerebral artery extend laterally.

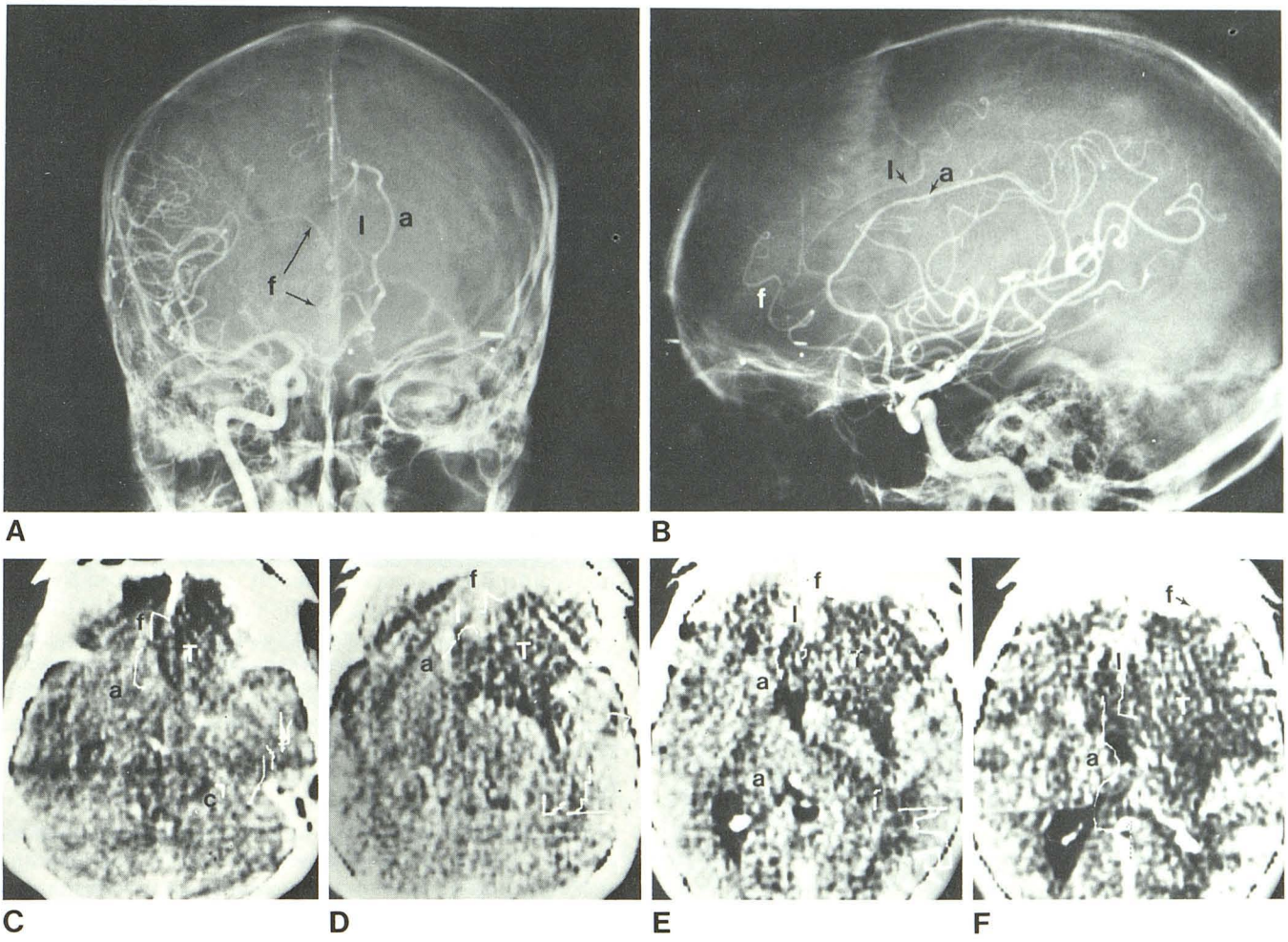

Fig. 3.—51-year-old man with large frontal meningioma. **A**, Anteroposterior view. Large contralateral shift of anterior cerebral artery (a) and its branch, callosomarginal (l). Frontopolar artery (f). **B**, Lateral film. Sylvian triangle flattened and pushed somewhat posteriorly. **C**, Lowest scan in series. Anterior cerebral artery (a) and frontopolar artery (f) near origin from anterior cerebral artery, adjacent to tumor and accompanying edema (T). Anterior choroidal artery (c) approaches atrium of lateral ventricle. Some unlabelled branches of middle cerebral artery. **D**, Adjacent scan. Anterior cerebral (a), callosomarginal (l), and frontopolar (f) arteries, along with meningioma with edema (T). Appearance of most posterior branch of middle cerebral artery "within" bone due to thickness of cut and partial volume averaging of bone [4, 9]. **E**, Higher scan. Anterior cerebral (a) and callosomarginal arteries (l) displaced across midline by tumor. Frontopolar artery (f) anterior to edema (T). Some middle cerebral branches. **F**, Anterior cerebral artery (a) curving abruptly over atrium of left lateral ventricle and crossing under falx cerebri on posterior way to right side of head completes classic round shift described on arteriograms [10]. Part of anterior cerebral artery appears to be running through atrium of left lateral ventricle, again manifesting partial volume effect [4]. Callosomarginal artery (l) and small part of frontopolar (f). Dots trace terminal course of anterior cerebral artery from adjacent superior scan (not shown).

points from two projections, with the matching of positions performed by a least-squares method during the reconstruction phase. This allows the analyst to merely trace along a vessel rather than having to select bifurcation points in the two views. This produces a relatively continuous map of a particular vessel and improves upon the crude connected-line segment representation shown earlier [6].

Application

The applications of this method are illustrated in three patients. The first, a patient with a carotid aneurysm and normal vascular tree above the aneurysm, displays the typical intracranial vascular and soft tissue relation. It may be convenient to study the illustrations before the accompanying commentary.

Internal Carotid Artery Aneurysm

The overlaid vessels provide some interesting new perspectives in the CT scans (fig. 2). The internal carotid artery and the lateral branch of the middle cerebral artery (fig. 2C) clearly define the medial and lateral margins of the aneurysm. Although the lateral margin is well seen, the medial margin that would have been ambiguous without the overlay is now clearly demonstrated. Also, the branches of the middle cerebral artery define the sylvian fissure (figs. 2D

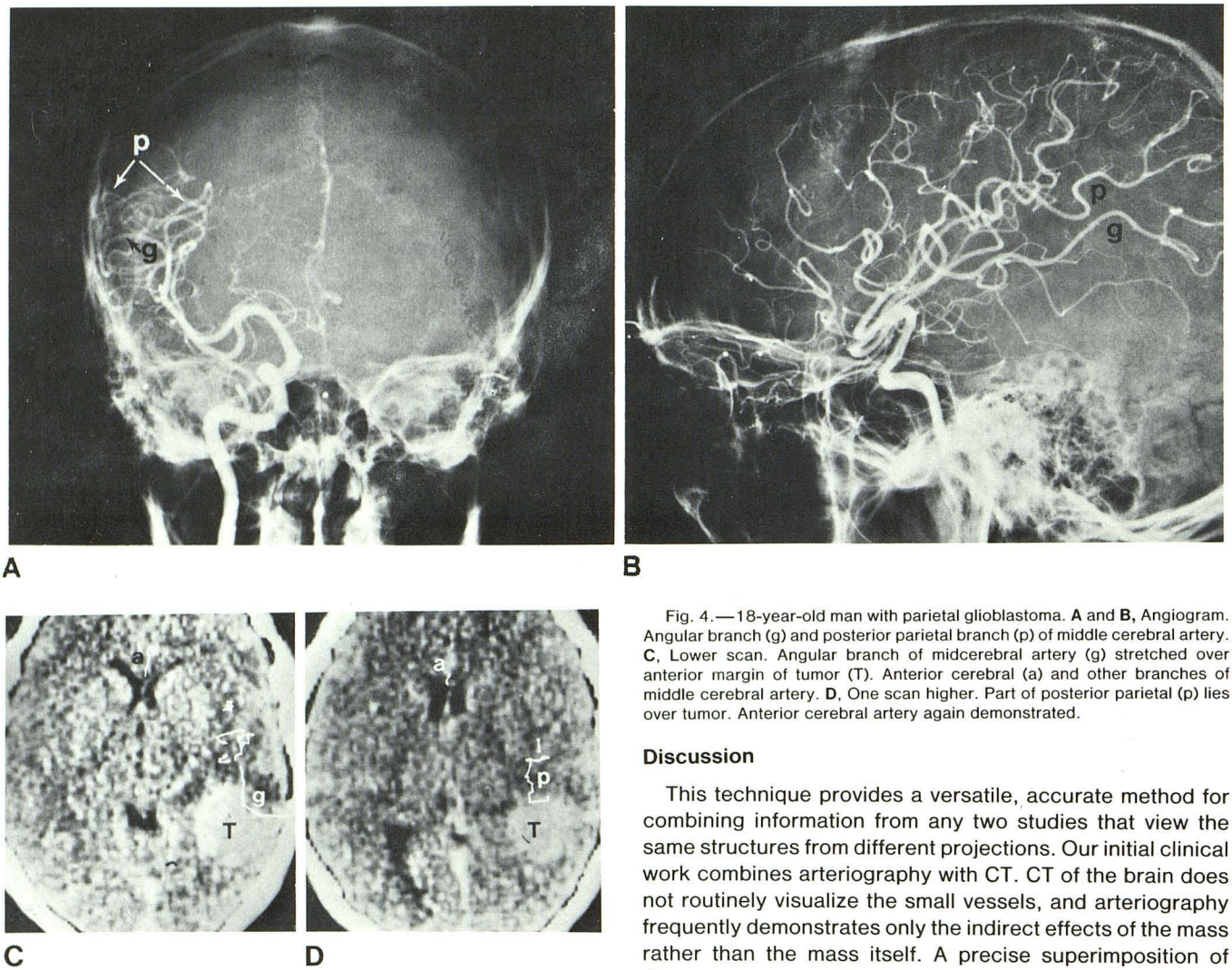

Fig. 4.—18-year-old man with parietal glioblastoma. **A** and **B**, Angiogram. Angular branch (g) and posterior parietal branch (p) of middle cerebral artery. **C**, Lower scan. Angular branch of midcerebral artery (g) stretched over anterior margin of tumor (T). Anterior cerebral (a) and other branches of middle cerebral artery. **D**, One scan higher. Part of posterior parietal (p) lies over tumor. Anterior cerebral artery again demonstrated.

and 2E). This could be important in other cases in determining the location of a mass relative to the fissure.

Frontal Meningioma

The shifted anterocerebral, callosomarginal, and frontopolar arteries show the medial margins of the meningioma on the overlay (fig. 3). Since the positions of these vessels are demonstrated on the scan, this information could be used to determine the best approach for resection or biopsy.

Parietal Glioblastoma

These overlays (fig. 4) show the relations of the angular and posterior parietal branches of the middle cerebral artery to a glioblastoma. It is interesting that the elevations seen on the angiogram are caused by the draping of the vessels over only the anterosuperior parts of the mass. Thus, these vascular structures could be avoided by a more posterior approach to the tumor.

Discussion

This technique provides a versatile, accurate method for combining information from any two studies that view the same structures from different projections. Our initial clinical work combines arteriography with CT. CT of the brain does not routinely visualize the small vessels, and arteriography frequently demonstrates only the indirect effects of the mass rather than the mass itself. A precise superimposition of these two types of information has obvious value to the surgeon or radiation therapist who wishes to know the relations of important vessels to a mass. This technique can be applied to other parts of the body, and it is possible to overlay CT scans of other organs, such as the liver or pancreas, with arteriograms. In addition, this method is not limited to CT imaging and arteriography but in theory can be applied to any two imaging procedures that can show the same structures in two different projections and in which arbitrary common points can be identified in both.

The partial volume effect, which can cause apparent errors in the localization of objects in CT scans, is the first principal limitation [4, 11]. Because of the averaging of densities within a volume element, extreme densities (e.g., bone) tend to dominate so that structures like the skull tend to appear larger or thicker than they actually are [8]. Hence, an overlaid vessel on a CT cut can appear to follow an aberrant course when it actually does not [4]. For example, we display a vessel that appears to be entering the calvarium when it is actually running under the skull (fig. 3D). The partial volume effect only creates a problem when the observer does not recognize that the phenomenon has occurred in a particular instance.

The other major problem is overlapping vessels on the angiographic images. This can make tracking a vessel difficult in a particular view. These problems can often be alleviated by using additional views or allowing the computer to detect erroneous entries. Also, well designed interactive computer systems can be of great value in increasing the accuracy and facility of human-mediated data entry [7, 8]. For example, by knowing the projection of a three-dimensional point in one image, it is possible to constrain the position of that particular point in the second image to a ray. This then defines a particular locus of points within which the point in question must lie. If the computer projects this ray across the second image, the interactive facility, in a sense, guides the user in selecting the correct location of the point in the second projection. We are trying to refine the procedure so that the biplanar data entry, three-dimensional reconstructions, and image combinations can all be performed on a standard EMI independent viewing station.

With improved, faster scanners, thinner slice thicknesses, and bolus injections, more vessels will be demonstrated on CT scans. However, vessels with diameters smaller than 1.5 mm will probably never be seen on pre- or postinfusion CT cuts [3, 5]. Thus, vessels of this size or less would always require an overlay to be visualized on CT.

Our three cases demonstrate some of the clinical applicability of overlays. Combined angiography and CT can be used to define the precise margins of masses in the head when these margins would be ambiguous on individual studies alone. As shown in figures 2–4, overlays also show the relations of surrounding vessels to a mass. As of now, however, an overlay can only display the positions of these vessels and not their diameters. In a case of an arteriovenous malformation (not illustrated), the combined studies provided little additional information. The lesion itself was entirely vascular, and the vasculature was well defined on the arteriogram alone. However, if the arteriovenous malformation had bled, the relations of the vessels to the subsequent hematoma might be valuable information that only an overlay could provide.

REFERENCES

1. Alfidi RJ, MacIntyre WJ, Meaney TF, et al. Experimental studies to determine application of CAT scanning to the human body. *AJR* **1975**; 124:199–207
2. Phelps ME, Hoffman EJ, Ter-Pogossian MM. Attenuation coefficients of various body tissues, fluids and lesions at photon energies of 18 to 136 kev. *Radiology* **1975**; 117:573–583
3. Bergström M, Riding M, Greitz T. The limitations of definition of blood vessels with computer intravenous angiography. *Neuroradiology* **1976**; 11:35–40
4. Naidich JP, Pudlowski RM, Leeds NE, Naidich JB, Chisholm AJ, Rifkin MD. The normal contrast-enhanced computed axial tomogram of the brain. *J Comput Assist Tomogr* **1977**; 1:16–29
5. Weinstein MA, Duchesneau PM, Weinstein C. Computed angiotomography. *AJR* **1977**; 129:699–701
6. Potel MJ, Sayre RE, Robertson A. A system for interactive film analysis. *Comput Biol Med* **1979**; 9:237–256
7. Rubin JM, Sayre RE. A computer aided technique for overlaying cerebral angiograms onto computed tomograms. *Invest Radiol* **1978**; 13:362–367
8. Sayre RE, Rubin JM, Duda EE, Patronas NJ: Quantitative three-dimensional angiograms: applications, including augmentation of computed tomograms. In: *Proceedings of American College of Radiology and IEEE Computer Society 6th Conference of Computer Applications in Radiology and Computer-Aided Analysis of Radiological Images, Newport Beach, Ca, June 18–21, 1979. IEEE Catalog 79CHI404–3C*, **1979**: 95–102
9. Koehler PR, Anderson RE, Baxter BB. The effect of computed tomography viewer controls on anatomical measurements. *Radiology* **1979**; 130:189–194
10. Taveras JM, Wood EA. *Diagnostic neuroradiology*, vol. 2, Baltimore: Williams & Wilkins, **1976**:654
11. Ambrose J. Computerized transverse axial scanning (tomography): part 2: clinical application. *Br J Radiol* **1973**; 46:1023–1047