Pitfalls in the angiographic diagnosis of serious head injury

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The problems in interpretation of emergency cerebral arteriograms are discussed with relation to the apparent displacement of "landmark" vessels that is actually produced by rotation or by the type of anteroposterior projection of the vessels, rather than by mass lesions. Anterior cerebral artery, middle meningeal artery, and pineal displacements are reviewed, along with possible pitfalls of diagnosis and attempts at correction. Utilization of dried skulls afforded depth visualization of middle meningeal artery grooves as well as the radiographic projection. The most reliable region on each different type of anteroposterior projection is discussed with regard to the emergency situation where repeat angiographic detections or special views may not be possible.

Key Words • middle meningeal artery • anterior cerebral artery • angiography • head injury • extracerebral hematoma

The purpose of this paper is to identify potential errors in the radiological diagnosis of serious head injury based upon the positions of the ACA and MMA.

Materials and Methods

Anterior Cerebral Artery

A celluloid sagittal septum was constructed from a lateral angiogram film, corrected for magnification, to fit into the midline plane of a dried skull (Fig. 1). Malleable lead wire was formed to the curvature of the ACA and fastened to this septum. Following the method described by Rayport and Rayport,² we represented the pineal gland by a lead shot. The groove of the major anterior branch of the MMA was also outlined with malleable lead wire. X-ray films of the skull in the standard semiaxial AP (carotid) projection, with the supraorbital ridges superimposed on the petrous ridges, were obtained parallel to the midsagittal plane and at rotations of 5°, 10°, and 15° in the direction of the wire MMA. Apparent displacement of the ACA and pineal gland from midline was measured in each position.

Middle Meningeal Artery

In 34 additional dried skulls, malleable lead wire was used to outline the major anterior branch of the...
MMA. Films were obtained in the modified hyperextended AP projection (resembling a reverse Caldwell position), the AP carotid projection (supraorbital ridges superimposed on petrous ridges), and the modified Towne projection as used in vertebral angiography. Measurements of "apparent deviation" of the "vessel" were made at 9 cm from the vertex, at the point of greatest deviation (maximum error), and at the point of least deviation from the inner table of the skull (minimum error).

Results

Anterior Cerebral Artery

The effect of skull rotation on the apparent displacement of the ACA from the midline is demonstrated in Fig. 2. In the unrotated position (0°), the ACA is in the midline coinciding with the "pineal gland." At 5° rotation, the ACA has "deviated" 9 mm from the midline in the direction of rotation, and the pineal body has shifted 1 mm. At 10°, the ACA has...
deviated 11 mm with a "pineal shift" of 2 mm in the direction of rotation. The 15° rotation resulted in an ACA "deviation" of 16 mm with a "pineal shift" of 2.7 mm.

**Middle Meningeal Artery**

The effect of skull rotation on MMA displacement was studied in the AP carotid projection. As rotation increased from 0° to 15° toward the MMA, the vessel appeared to move closer to the inner table of the skull (Fig. 2). Use of rotation to the affected side in the modified hyperextended AP view was less effective in correcting "apparent deviation" (Fig. 3).

The effects of projection on the "apparent deviation" are illustrated in Fig. 4. Nonrotated radiographs demonstrated a medial convexity, or "pseudoshift" (apparent displacement of the MMA from the inner table accompanied by a medially directed convexity) in 60% of the skulls in both the transocular portion of the modified hyperextended projection and the convexity of the carotid projection. In the temporal region, the least error was seen in the modified Towne projection just superior to the petrous-calvarial junction. The greatest overall error was seen in the area of the convexity "pseudoshift" on the vertebral projection. Examination of the graphs in Fig. 5 reveals that in the modified hyperextended AP view the MMA was least distorted, and most accurately reflected the parietal convexity. The carotid projection showed significant error over the convexity with greatest reliability just above the superior orbital margins. The modified Towne projection was reliable only at the point of minimum error (which was almost

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**FIG. 3.** Modified hyperextended anteroposterior view has been rotated 10° toward the side of the vessel, as done with the carotid position, to try to reduce the pseudoshift in the temporal area. The degree of apparent displacement of wires from the internal table remains, however, and is less effective with the rotation than was the rotated standard carotid projection.

**FIG. 4.** A: Standard carotid projection showing some apparent displacement of the wire from the inner table, which is slightly underpenetrated. B: Vertebral-type projection showing increasing apparent deviation of the wire from the internal table when proceeding from the lower convexity toward the vertex (*small arrow*). Large arrow demonstrates close approximation of the wire to the internal table in the temporal area on this view. C: There is a relatively minimal error over the convexity with regard to the wire and the inner calvarial table (*small arrow*). The transorbital portion (*large arrow*), however, shows continued apparent displacement.
always just superior to the junction of the petrous ridge and inner table).

Discussion

Anterior Cerebral Artery

The influence of skull rotation on apparent displacement of the ACA has been described by Taveras and Wood. The "Taveras rule" is that one-half the sum of the distance from the zygomatic process of the frontal bone to the lateral margin of the calvaria on each side of the skull should exceed the maximum displacement of the ACA in the direction of rotation. Taveras and Wood suggest that the presence of a "step" due to the tendency of an artery to return to the midline at the falx is a more important sign of a midline shift than slight differences in measurement. We have demonstrated that the "Taveras rule" is valid for up to 15° of skull rotation. The pineal gland and the great vein of Galen, two other structures used to determine subfalcial herniations, have been shown to be reliable in 80% of the skulls for up to 8° of rotation. When films of a patient have more than 8° of skull rotation, application of the "Taveras rule" to ACA displacement will still allow evaluation for midline shift.

Middle Meningeal Artery

Sones, et al., described displacement of the anterior branch of the MMA on angiography in epidural subtemporal hematoma using the modified hyperextended AP projection. McGrath and Sondheim, in the standard semiaxial AP projection used in carotid angiography, investigated anatomical variations in projections of the MMA in dry skulls and normal angiograms. They demonstrated that apparent displacement was present in normal subjects, with varying degrees of medial convexity of the curvature. Turning the head 10° toward the injected side was suggested to minimize this effect, which they blamed on anterior tapering of the skull. In our study, the majority of the error in the temporal area in the modified AP projection was produced by the course of the anterior branch of the MMA coursing up the anterior wall of the middle fossa rather than by the anterior tapering of the skull (Fig. 6).

In the carotid projection, displacement of the MMA would require other corroborating signs, such as...
as extravasations, herniations of the MMA into a fracture line, or venous communications, for diagnosis of epidural hematoma. Selective external carotid injections in this projection with 10° rotation toward the side of the expected pathology would be preferred (unless hematoma appears posterior on the initial injection, in which case the modified hyperextended AP view would be preferable). However, as some patients may be deteriorating too rapidly to permit additional injections, whatever projection is obtained may provide diagnostic information, taking into consideration the areas of minimum error.

Conclusion

Difficulties in the interpretation of emergency cerebral angiograms have been discussed with relation to "apparent" deviations of standard angiographic landmarks produced by rotation and positioning of the patient's head in the AP view. While repeat angiographic injections in special positions or selective external carotid injections may be ideal (especially in the temporal and subtemporal regions), the urgency of the patient's condition frequently necessitates making a diagnosis from the single examination in hand. If the appropriate corrections are used, however, and the areas of accuracy and inaccuracy of a substandard or undesired projection are understood and capitalized upon, adequate diagnostic information can be obtained.

References


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