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# Sequential Subtraction for Improved Display of Cerebrovascular Occlusions

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The subtraction method, first developed by Ziedses des Plantes [1] in 1953, eliminates overlying bone shadows from angiographic films, enhancing the display of vascular anatomy. To completely eliminate all bone details, however, a second order subtraction is sometimes necessary; this requires the superimposition of two mask films over the angiographic film to make the final subtraction print [2].

One modified subtraction technique, called sequential subtraction, involves making a mask film of each film in an angiographic sequence and superimposing that mask film onto the next film in the series. This process allows analysis of the filling and clearance phases of different vascular territories and demonstrates an anatomic relation between arteries and veins [3].

We have modified slightly the sequential subtraction technique developed by Rivoir and Huber [3]. With cerebrovascular occlusion, the early arterial phase of the cerebral angiogram usually shows the proximal end of the occlusion, while the distal part is defined during a late phase. In our modified technique, a mask film is made of the early arterial phase to show the proximal part of the occlusion (fig. 1A). By superimposing and then subtracting this image from a film of either the early or late venous phase, we are able to demonstrate the proximal and distal ends of the occlusion on a single film, which thus shows the length of the occlusion and collateral pathways (fig. 1B). In this subtraction film, vessels opacified during arterial phase show up as white shadows, while both the vessels that are opacified later and the distal part of the occlusion show up as gray density.

We have used this method frequently to evaluate embolic episodes in the carotid arteries and to assess arteriovenous shunting and space-occupying lesions of the brain. The technique particularly lends itself to digital subtraction and will likely find instant widespread application with digital fluoroscopy.

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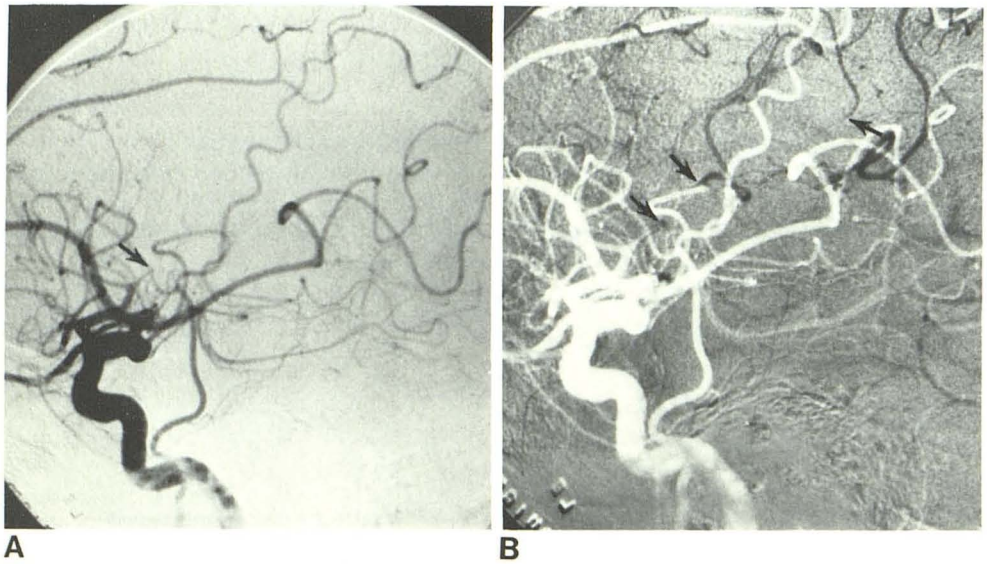


Fig. 1.—Sudden onset of expressive aphasia and right arm numbness in 57-year-old man. **A,** Lateral film, early arterial phase, 3× magnification. Proximal occlusion of one of the anterior branches of left middle cerebral artery (*arrow*). **B,** Final sequential subtraction of late arterial phase. Retrograde opacification of middle cerebral artery branches through anterior cerebral artery collaterals. Distal end of occluded anterior branch of left middle cerebral artery is seen (*arrows*).

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