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Intravenous Serial Xerographic Carotid Arteriography

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The rapid, recent development of intravenous digital subtraction angiography has changed the general philosophy of screening for extracranial carotid artery occlusive disease. However, digital subtraction angiography equipment is currently very expensive and may remain so. If a lower cost system for good visualization of the carotid artery bifurcations by intravenous injection of contrast material were available, its benefit would be obvious in this inflationary era. Indeed, a prototype serial xeroradiographic cassette changer has been produced by Xerox Corporation which can be used in conjunction with conventional angiographic equipment to demonstrate peripheral vasculature by injecting the contrast material intravenously. We have made preliminary tests of this method of visualizing the carotid artery bifurcation in 15 patients and present our experience.

Material and Methods

Dr. R. Gärtner Apparatebau (4,000 Düsseldorf, West Germany) has developed a serial changer for eight standard xeroradiographic cassettes or alternatively for eight conventional 24 × 30 cm film cassettes (fig. 1). The changer is programmable for varying sequences with a maximum xerographic rate of one cassette/sec or with a maximum conventional film rate of two cassettes/sec. We employed this changer with xerography only. The commercially available Xerox system 125 processing system was used to process the xeroradiograms.

Exposure values of 120 kv at 80–120 mAs were generally required. An aluminum wedge filter was placed on the x-ray tube collimator to decrease the skin and thyroid radiation dose. This reduced the dose to the skin by about 50%. The filming sequence was 1 frame/sec for the entire eight cassette load.

Typical injections were made using either 0.5 ml Isopaque-440 or 0.5 ml Renografin 76/0.45 kg body weight at a rate of 20 ml/sec via a pigtail polyethylene no. 6 French catheter placed through a femoral vein puncture above the hepatic veins in the inferior vena cava. To time the circulation to the patient's tongue, 1 ml of 50% $MgSO_4$ diluted to 3 ml with normal saline was injected through the inferior vena cava catheter. A very sharp end point can be determined in a cooperative patient by a sudden hot sensation in the tongue following the magnesium sulfate injection. The typical circulation time from the inferior vena cava to the tongue was 8–12 sec. Imaging was quite good with this time sequence (fig. 2).

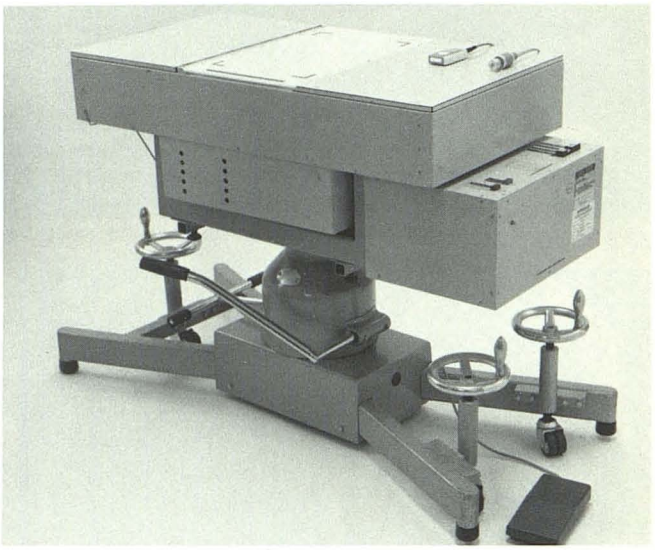

Fig. 1.—Rapid sequence programmable Xerox cassette changer.

Because subtraction of the images was generally found to be desirable, the first film of the series was processed using the negative mode and the remaining films were processed with the positive mode. Photographic subtraction was then performed by making photographic transparencies of the first film and the film of choice in the series (figs. 3 and 4). We are currently developing a simplified Polaroid subtraction system.

All 15 patients having transvenous xerographic carotid arteriography also had selective femorocerebral carotid arteriography as a control on the same day. To limit contrast material, only one intravenous arch-carotid study was made at each examination. The right posterooblique projection was used in all 15 patients.

Results

In contrast to digital fluorography with limited field size (usually 15.2 or 22.9 cm), we visualized the aortic arch, the

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brachiocephalic branches, and the carotid bifurcations with xeroradiography. However, the quality of visualization of the aortic arch and proximal brachiocephalic branches was variable because of differing patient thicknesses.

Of the 15 patients examined, 29 carotid bifurcations could be evaluated. One patient had a common carotid artery occlusion (fig. 5). The image quality was graded on an arbitrary scale of 1+ to 3+. Excellent image quality was graded 3+. The 2+ category was reserved for those cases where the images were not of exceptional clarity but enough information was available to decide whether further diagnostic testing was required. The grade 1+ represented nondiagnostic quality. Thus, images of 2+ or 3+ were placed in the diagnostic quality (or good to excellent) classification. Before subtraction, 22 of the 29 visualized bifurcations were considered of diagnostic quality (table 1). When the seven nondiagnostic images were subtracted, four were elevated to 2+ or 3+ image quality. Subtraction, increased the number of diagnostic carotid studies to 26 of 29 bifurcations: a rate of 89% good or excellent visualization.

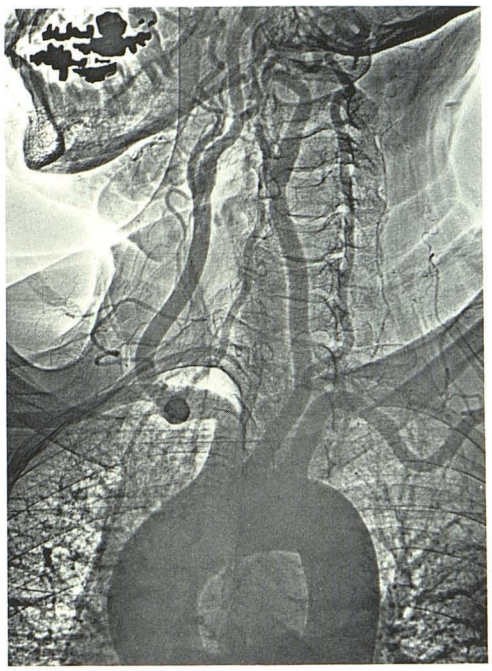
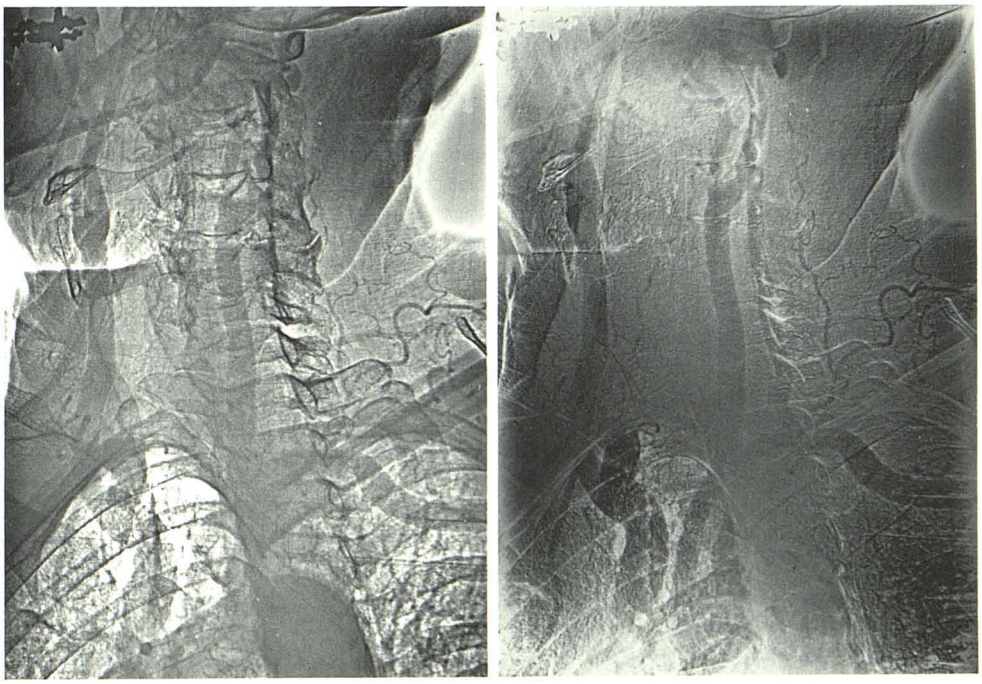


Fig. 2.—Excellent visualization of aortic arch, brachiocephalic branches, and carotid artery bifurcations.

Discussion

Transvenous arteriography is a well-known technique [1–4]. Most recently, de Lahitte et al. [5] showed 80.6% good or excellent results in visualizing the carotid arteries via transvenous peripheral vein injection techniques. Good subtraction technique was essential to their results.

Kramann and Christen [6–8] described the initial use of the Gärtner xeroradiographic cassette changer for intravenously injected serial angiography of the extremities, however, we found no reports of use this technique for carotid occlusive disease. While a major problem in visualizing the carotid vessles is superimposition of the bony structures in the neck, In most cases, we have found that subtraction of the bone in the neck is not necessary. As noted, a few cases required subtraction, usually because of superimposition of the left carotid artery upon the facet joints of the spine in the right posterooblique position. Those few cases



A B

Fig. 3.—When contrast bolus produces unsatisfactorily dilute images (**A**), subtraction (**B**) can be very helpful.

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Fig. 4.—Subtraction view. Patent right and occluded left proximal internal carotid arteries are clearly visualized.

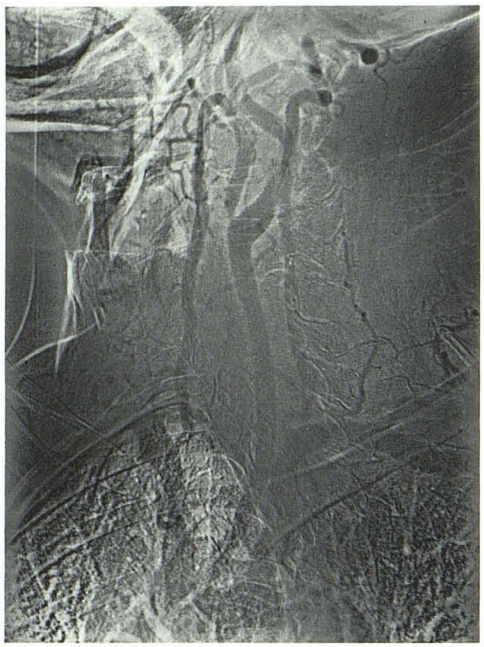

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Fig. 5.—Subtraction study. Occlusion of right common carotid artery. Left external carotid artery is stenotic at origin.

TABLE 1: **Carotid Bifurcation Image Quality by Xeroradiography**

Bifurcation	Images	
	Without Subtraction	All
Right	13/14*	14/14
Left	9/15	12/15
Total	22/29	26/29

* One right common carotid artery was occluded. This was correctly diagnosed.

in which there was inadequate visualization of the carotid arteries with or without subtraction were usually nondiagnostic because of patient motion during the filming sequence which made subtraction unsuccessful. Undoubtedly, the carotid artery visualization could be improved by doing two projections. In a screening situation, where an associated selective arteriogram was not contemplated, two intravenous injections could be made if needed.

The major advantages of the xeroradiographic system include significantly lower cost, a wider field of view, excellent soft tissue contrast, wide density latitude, and edge enhancement. The soft tissue contrast, density latitude, and edge enhancement were very helpful in accentuating vessels with low iodine content. The major disadvantage of this system is the lower photon sensitivity of the selenium coated semiconductor plates when compared with conventional film radiography. Image production, therefore, requires a higher radiation dosage. Having concern for exposure of the thyroid gland, we employed an aluminum wedge filter which decreased skin dosage by 50%. The filtered skin dosage at the thyroid gland was about 0.9 rad/image (0.009 Gy).

We find placement of a catheter in the inferior vena cava via a femoral vein puncture to be a desirable procedure. This can be accomplished quickly and easily with no danger of peripheral vein rupture and extravasation. There has been no reflux of contrast material into the jugular veins which can cause confusing images. This problem has been encountered in many of the digital imaging series using arm vein injection techniques.

We consider rapid sequence intravenous xerographic carotid arteriography to be a feasible and accurate screening examination for occlusive disease of the carotid artery bifurcations. The cost of the xerographic changer and developer is much lower than the currently available digital fluorographic subtraction angiography units. Xerographic arteriography is limited, to some extent, by body part thickness so that it is not as versatile in examining the trunk as the digital systems may be. Also, the skin dose is higher than conventional radiography and digital subtraction angiography.

ACKNOWLEDGMENTS

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