Simultaneous Carotid Angiography*

John Bentson, M.D., Gabriel Wilson, M.D. and William Hanafee, M.D.

（昭和44年6月5日受付）

左右同時注入による頚動脈造影

両側の内頚動脈造影を行なつた 426名の患者のうち，247名には前後像で左右同時注入による内頚動脈造影を行ない，179名には一側ずつ注入して頚動脈造影を実施した．同時注入による内頚動脈造影は，左右の非対称性，腫瘍濃染，無血管野，脳浮腫の発見などに有利であり，また脳循環時間の左右差が診断に役立つことがある．本法は動脈瘤，動静脈奇形，脳血管性病変には適応とならないし，又実施に当つてはカテーテルを用いるべきで動脈針を用いる際には行なうべきでない．Second-order Subtraction を併用すれば診断能を更に高めることが出来る．本法による合併症は一側性内頚動脈造影と比較して高くはなかつた．
（和文抄録は九大，高橋睦正氏による）

Introduction

Obvious advantages are associated with simultaneous injection of both internal carotid arteries for an anterior posterior projection. These include comparison of the two sides for spatial relationships, flow rates, contrast filling of capillaries, and the overall appearance of the brain substance.

Munslow, in 1961, reported on over 100 cases of bilateral simultaneous carotid arteriography without mortality or an increase in complications (1). Others have confirmed the advantages (2, 3, 4), but the possibility of extra-luminal extravasation (3) with needle injections has made the procedure hazardous.

Material

From January 1965 to January 1968, simultaneous bilateral internal carotid injections were done on 247 patients. During this same period, bilateral carotid angiograms with non-simultaneous injections were done on 179 patients. The selection of patients was somewhat arbitrary. Many examinations were done by catheter technique via the femoral artery, and this necessitated separate injections. Some referring physicians were reluctant to accept the simultaneous bilateral injections. Aneurysm and AV malformation suspects were investigated with separate injections in order to evaluate cross filling. In general, the age of the patients, the magnitude of the examinations, and the general conditions of the patients were approximately equal in the two groups. A breakdown of the two groups is listed in Table I. All examinations were performed by the Neuroradiology Division of Diagnostic Radiology. Any complications were carefully recorded and the charts were later reviewed.

Technique

All studies were performed by percutaneous Seldinger technique (5), puncturing either the common carotid artery low in the neck or the femoral artery. The selective technique used in this department since 1962 (6) has been modified by changing to a smaller bore catheter for common carotid entry (.037

*From the Department of Radiology (J. B., NIH Fellow 1 F11 NB 1858-01 NSRA in Neuroradiology, Currently Assistant Professor of Radiology, University of Wisconsin, Madison, Wisconsin; G. W., Assistant Professor and Chief, Neuroradiology; W. H., Professor and Chairman of the Department), UCLA School of Medicine, Los Angeles, California 90024.

inches ID). This catheter is maneuvered selectively into the internal carotid artery, using portable image intensification and horizontal fluoroscopy.

When the needle was first passed into the common carotid artery, a test injection is made under fluoroscopic observation. If there is significant atheromatous disease producing stenosis of the internal carotid artery, the catheter is not introduced and injection is made through the needle. Simultaneous bilateral injections through needles are never made because of the possibility of bilateral extra-luminal extravasation. In this series, the incidence of extra-luminal extravasation was less than one per cent.

If the femoral route is used, a larger bore catheter (.045 inChes ID) is used, and it is maneuvered selectively into each of the internal carotid arteries. The contrast used is Meglumine Iothalamate*. With simultaneous injection, a total of 12 cc of contrast material is used. Injections are preferably made through a Y-connector, but occasionally the tip of one catheter may rest against the vessel wall and nearly all the contrast material would then pass through the other catheter. When this situation exists, injections are made using two syringes simultaneously using 6 cc for each internal carotid artery.

Serial filming was done on all studies, using a Schonander cut-film changer. A base film was obtained before a series, in order that subtraction could be done later. The film sequence is 2 per second for 2 seconds, then 4 films evenly spaced over the next 6 seconds. Second-order subtraction (7) was performed in approximately 25 per cent of the patients, where additional information was desired in order to substantiate pathology or augment anatomic detail (7, 8, 9).

Results

The films in this study were reviewed with attention being given to vascular displacements, changes in circulation time, and the clarity of anatomic detail. If there were questions on the findings, second-order subtraction was performed. Every attempt was made to identify the choroid plexus of the temporal horn.

Displacements and symmetry. The internal carotid arteries are asymmetric in the neck, but are symmetric in the carotid canal of the temporal bone. The intracranial portions of the internal carotid artery show considerable variation. Since subtle changes have played an important role in the management of pituitary tumors (10), care was taken to evaluate minor differences. The asymmetries of the carotid siphon closely simulated the appearance as seen in pituitary tumors. Asymmetries in the configuration

Table 1

Findings of Angiography	Simultaneous Injections	Non-Simultaneous Injections
Tumor	85	38
Aneurysm	10	33
AV malformations	4	15
Atrophy	16	5
Normal	105	58
Arteriosclerosis	11	16
Hydrocephalus	2	5
Abscess	2	1
Hematoma	9	5
Others	3	3
Total	247	179

*Conray 60

of the horizontal portions of the anterior and middle cerebral arteries were the rule. Variations in branches of the middle cerebral artery result in considerable variation in the point in which the last branch exists from beneath the operculum (sylvian point) (11). The lenticulostriate arteries tend to be very symmetrical. The thalamostriate veins are asymmetrical when there is variation in the location of the venous angle.

Circulation time. A simultaneous injection was considered to have occurred when there was less than 3 cm difference in the level of the bolus of contrast material in the carotid arteries on the first film. This is a sensitive index, since blood in the internal carotid artery flows at the rate of at least 15 cm per second (12). If there was variation in appearance of the capillary phase or of the visualization of cortical veins of one second, a significant difference in circulation time was believed present. In the cases of simultaneous bilateral injections, eight patients with tumors demonstrated a significant slowing of circulation time on the side of the tumor (Fig. 1). These included three patients with astrocytoma, two with ependymoma, and one with meningioma. One patient had metastatic disease to the brain and one had a glioblastoma multiforme. Five patients demonstrated an increase in circulation time on the side of the tumor. These tumors were glioblastomas and metastatic tumors, similar to the experience of Leeds and Taveras (13). Accelerated flow was also seen in the cases of AV malformation.

Edema. Bilateral injection helps to demonstrate changes related to edema of one hemisphere. There was a generalized decrease in the caliber of the arteries in six patients with tumors. This was more often noted bilaterally than unilaterally. Encroachment of the sagittal sinus is occasionally observed. In the capillary phase, opacified sulci demonstrated changes related to compression. The sulci in the area involved by an expansive process were often lightly opacified and in a disordered arrangement, while

Fig. 1. Metastatic carcinoma to parietal lobe. Film in early venous phase demonstrates delayed cortical venous filling and hypovascularity on the side of the mass (→). The internal cerebral vein is shifted to the opposite side (⇸).

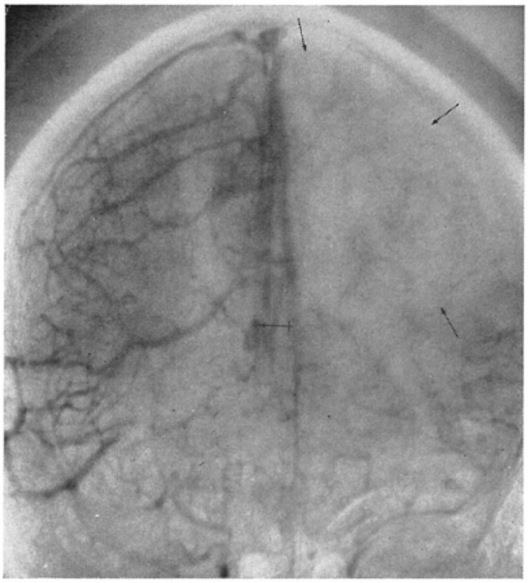
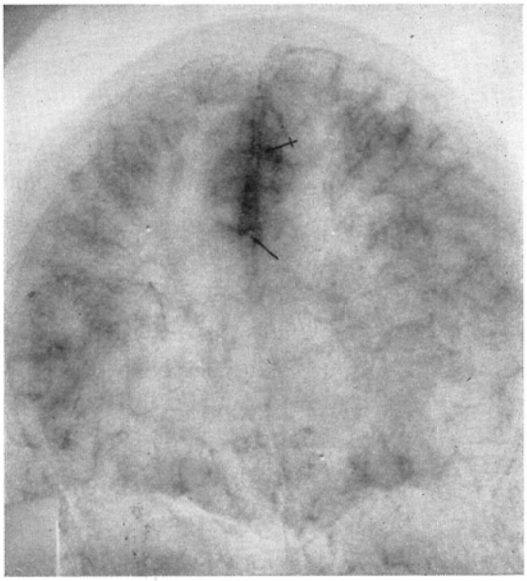


Fig. 2. Cystic ependymoma. This capillary phase film demonstrates shift not only of the callosal sulcus (→) but also the falx (⇸).

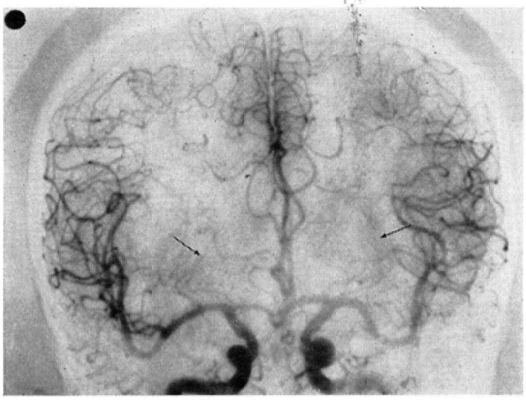


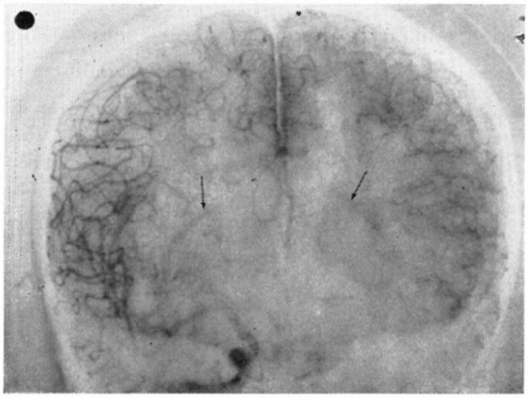
more distal sulci demonstrated concentric ring patterns indicating the direction of expansivity. In four patients in this series, there was actual tilting of the falx away from the side of the edematous hemisphere (Fig. 2). These included two glioblastomas, one ependymoma, and one case of metastatic disease.

Avascular areas. The frequent use of second-order subtraction proved to be very helpful in detecting small avascular areas of the brain. The white matter of the brain appears considerably less vascular than the gray, and some confusion may arise as to whether this represents pathological avascularity. The use of simultaneous carotid injections provide a normal side for comparison, while circumventing the difficulty of attaining identical subtraction technique on two films.

Temporal choroid plexus. In this series, the choroid plexus of the temporal horn was found to be visible in nearly half the cases of simultaneous bilateral injection. In many it was adequately demonstrated to permit detection of small displacements. In 3 cases, displacement of the choroid plexus of one temporal horn was noted in the absence of large displacements of other vascular structures (Fig. 3). The use of second-order subtraction was very helpful in demonstrating the choroid plexus of the temporal horn.

Fig. 3 A and B. Parathalamic astrocytoma. In the arterial phase, there is only slight widening of the space between the right anterior and middle cerebral vessels. The right lenticulostriate arteries are displaced medially (→). In Figure B, the choroid plexus of the temporal horn is seen bilaterally and there is inferior displacement of the posterior choroid of the right temporal born (→).





Complications

In the group of 247 patients on whom simultaneous injections were done, there were six complications (2.4%). In the other group of 179 patients, all of whom had bilateral carotid angiography but without simultaneous injections, there were also six complications (3.5%). Nearly all the complications resulted in temporary disability. A tabulation of the complications follows:

Group with simultaneous injections:

Patient # 1—temporary confusion

Patient # 2—same

Patient # 3—temporary aphasia

Patient # 4—seizure with temporary hemiparesis on the day following the procedure. There was a history of epilepsy.

Patient # 5—permanent hemiparesis resulting from an embolus related to an intimal flap.

Patient ♯ 6—cervical hematoma requiring a tracheostomy. This patient had previously unrecognized clotting deficiencies.

Group of nonsimultaneous injections:

Patient ♯ 1—temporary disorientation

Patient ♯ 2—temporary hemiparesis

Patient ♯ 3—cervical hematoma requiring tracheostomy

Patient ♯ 4—aphasia following an intramural injection

Patient ♯ 5—temporary facial and arm weakness

Patient ♯ 6—temporary aphasia and hemiparesis

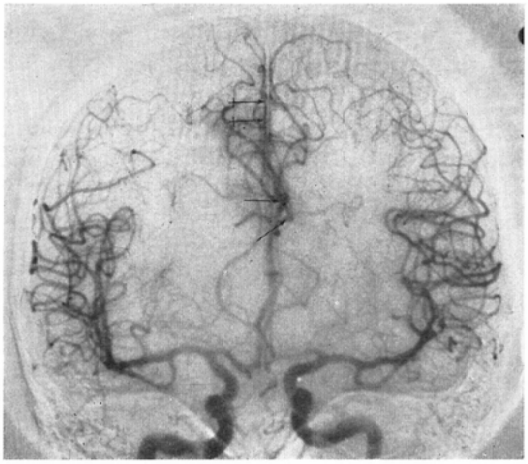
For the total group, the permanent complication rate is 2.8%.

Discussion

It is very helpful to be able to compare the circulation of both sides of the brain on the same film, without having to make allowances for changes in positioning and exposure technique. These comparisons are helpful in all phases—arterial, capillary and venous.

Arterial phase. Minor shifts of the pericallosal arteries are better appreciated when the falx is visible, as it generally is with simultaneous injections, particularly after subtraction (Fig. 4). Repeated observation of bilaterally filled middle cerebral artery groups demonstrate the relatively large variation in position of specific points, including the sylvian point, at which the most posteriorly placed vessel in the sylvian fissure begins its course beneath the operculum. The variations might otherwise be attributed to minor changes in positioning of the X-ray tube or patient. On the other hand, there does appear to be a fairly reliable basic symmetry of the middle cerebral arteries as they course over the insula.

Fig. 4. Astrocytoma centering about the central sulcus. Film in the early arterial phase demonstrates the accentuation of shifts of pericallosal arteries (⟶) by visualization of the negative shadow of the falx (↔).

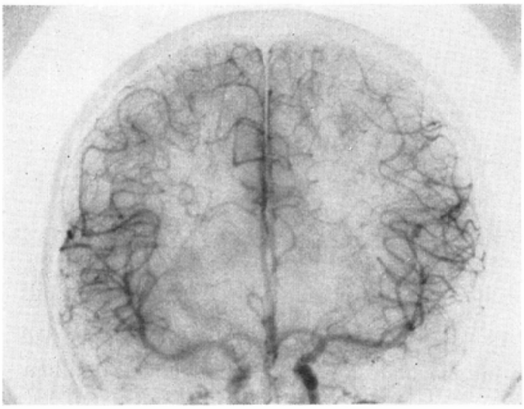


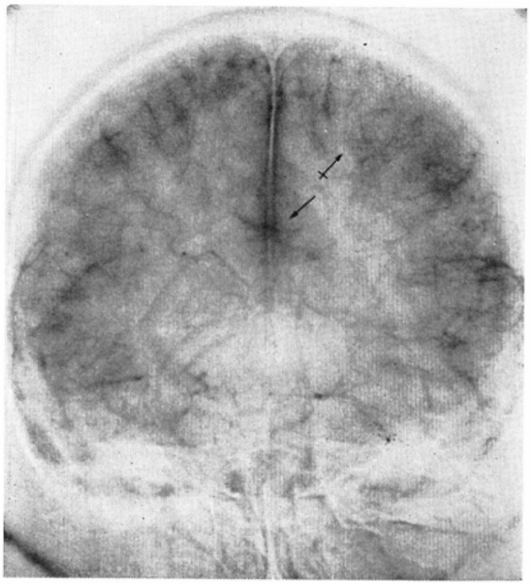
The symmetry of the anterior choroidal arteries is also quite reliable, and evaluation of these is aided by being able to eliminate the positional changes which produce a marked effect on the apparent curves of these vessels on antero-posterior projections. The anterior choroidal artery most commonly originates from the carotid siphon just distal to the posterior communicating artery. The first or cisternal portion courses close to the medial and posterior surfaces of the uncus, then passes across the ambient cistern and through the choroidal fissure of the temporal horn. It enters the choroid plexus in the supracornual cleft of the temporal horn at or just behind its knee. Here the plexal artery divides and its branches extend for a variable distance in the temporal horn, usually ending in the region of the glomus. The significance of displacements of the cisternal portion of the anterior choroidal artery has been appreciated (14, 15). It has, however, been felt that the network of vessels in the plexal portion is rarely visualized roentgenographically. The frequency with which the choroid plexus of the temporal horns could be identified in this series is very interesting. The best opacification is found in the late arterial and early capillary phases. The symmetry of these plexi is apparently reliable. Displacements were noted in expanding lesions of the basal ganglia and of the temporal and parietal lobes.

The lenticulostriate arteries give valuable evidence of thalamic masses versus insular masses. Changes in the size and position of these vessels can better be appreciated when bilateral simultaneous injections are used.

Capillary phase. It is in this phase that second-order subtraction is particularly helpful, allowing visualization of the contrast laden brain. The ability to make comparisons with the normal side on the same film increases the reliability of the detection of small avascular areas. The sulci are visible because of the superimposition of small pial vessels which they contain, and changes in these sulcal pattern may be seen in the presence of masses and/or edema, as described above. The value of detecting slight tilting and shifts of the pericallosal cistern has been described (16). With simultaneous injections, the cistern is routinely well demonstrated in the arterial and capillary phases. Minor displacements across the midline may be detected by comparing its position to that of the falx (Fig. 5).

Fig. 5 A and B. Astrocytoma, posterior frontal lobe. Figure 5A shows no evidence of arterial shift. Figure 5B demonstrates tilting of the pericallosal cistern (⟶). There is slight relative hypovascularity and loss of normal sulcal pattern in the region of the tumor (↛).





Venous phase. With simultaneous injections, the paired internal cerebral veins are well demonstrated, and slight shifts in relation to the falx are detectable. The comparison of the thalamostriate veins is helpful in detection of such lesions as parasagittal and thalamic masses. Asymmetry of these vessels is frequently noted, particularly in the presence of a false venous angle. Subtraction in these instances may sometimes demonstrate small subependymal veins which take the course of the thalamostriate vein and thus complete the symmetry. Comparison of the cortical veins of the two sides is most helpful as a means of detecting changes in circulation time. The compression of these veins against the skull and the presence of mass lesions or cerebral edema or separation of these vessels from the skull in the presence of atrophic processes and extracerebral hematomas may also be noted.

Complications. No statistically significant differences in the rate of complications in the two groups of patients could be detected. Though the numbers involved are small, we believe that the figures support our observation that simultaneous injection does not seem to increase the risks of carotid angiography. It has been pointed out that serious neurologic complications occurring during cerebral angiography have often been associated with traumatic punctures of extravascular injections (17). The use of simultaneous injections through catheters should not increase this risk. The possibility of subintimal injections can not be eliminated by using catheter technique. Two of the complications in this series were due to very small subintimal injections. The incidence is markedly decreased relative to injections through needles (17, 18). Therefore, the risk of bilateral extravascular injections, a definite possibility when simultaneous injections are done through needles, is not believed to be of significance when catheters are used. There is probably no increase in the toxic effect of contrast material with bilateral injections, providing that a given volume of brain substance is not exposed to excessive amounts of contrast material. To prevent this, the volume of contrast material on each side is limited to 6 cc per injection and precautions are taken so that differences in resistance to flow may not result in one side receiving a larger bolus.

Conclusions

A series of 426 patients receiving bilateral carotid angiography was reviewed. In 247 patients, bilateral simultaneous injections were done in the antero-posterior projection. There were six complications in this group (2.4%). In the other group of 179 patients on whom simultaneous injections were done, there were six complications (3.9%). Subintimal deposits occurred in less than 1% of injections. The use of simultaneous injections dose not seem to increase the risks of carotid angiography, and the technique offers definite diagnostic advantages. These include more accurate appraisal of asymmetries, better detection of tumor stains and avascular areas, better appreciation of volume changes, and a means of detecting differences in the circulation times. The technique is recommended in most cases in which bilateral carotid angiography is to be done. It is not advantageous in studying aneurysms, AV malformations, or occlusive cerebrovascular disease. It is not recommended when injections are made through needles rather than catheters. Second-order subtraction is of considerable aid in enhancing the diagnostic advantages of simultaneous injections.

Department of Radiology
UCLA School of Medicine
Los Angeles, California 90024

References

1) Munslow, R.A.: Bilateral Simultaneous Carotid Arteriography. J. Neurosurg. 18: 227–229, March 1961.

2) Campache, R.: Value of Simultaneous Bilateral Carotid Injection for Anterior Cerebral Angiography. Radiologia Clinica 32: 301, 1963.
3) Drobny, M., Polackova, O. and Zuska, K.: Experiences with Simultaneous Bilateral Carotid Angiography. Psychiat. et Neurol. 152: 133–141, 1966.
4) Vetter, K.: Simultaneous Angiography in the Internal Carotid Artery. Nervenarzt 35: 314–317, July 1964.
5) Seldinger, S.I.: Catheter Replacement of Needle in Percutaneous Arteriography: New Technique. Acta Radiol. 39: 368–376, 1953.
6) Hanafee, W. and Weidner, W.: Selective Carotid Angiography: A Preliminary Report. Radiology 81: 589–591, October 1963.
7) Ziedses Des Plantes, B.G.: Subtraktion. Stuttgart, Georg Thieme Verlag, 1961.
8) Ziedses Des Plantes, B.G.: Application of the Subtraktion Method in Neuroradiological Examination. Psychiatria, Neurologia, Neurochirurgia 66: 480, July-Oct. 1963.
9) Hanafee, W. and Shinno, J.: Second-Order Subtraction with Simultaneous Bilateral Carotid, Internal Carotid Injections. Radiology 86: 334–341, February 1966.
10) Udvarhelyi, G.B., Langfitt, T.W. and Cox, A.: Acta Radiol. (Diag.) 1: 485–507, March 1963.
11) Taveras, J.N. and Wood, E.H.: Diagnostic Neuroradiology. Baltimore, the Williams and Wilkins Co., 1964.
12) Bard, P.: Medical Physiology. St. Louis, The C.V. Mosby Co., 1956.
13) Leeds, N.E. and Taveras, J.M.: Circulation Time in Frontal and Parietal Tumors Studied by Rapid Serial Angiography. Acta Radiol. (Diag.) 1: 332–342, March 1963.
14) Sjogren, S.E.: Anterior Choroidal Artery. Acta Radiol. 46: 143–157, 1956.
15) Le May, M.J. and Jackson, D.M.: Changes in the Anterior Choroidal Artery in Intracranial Lesions. Am. J. Roentgenol. 92: 776–785, October 1964.
16) Huang, Y.P. and Wolf, B.S.: Angiographic Features of the Pericallosal Cistern. Radiology 82: 14–23, January 1964.
17) Allen, J.H., Farera, C. and Potts, D.G.: The Relation of Arterial Trauma to Complications of Cerebral Angiography. Am J. Roentgenol. 95: 845–851, December 1965.
18) Saltzman, G.F.: Angiographic Demonstration of the Posterior Communicating and Posterior Cerebral Arteries. Acta Radiol. 52: 1–19, July 1959.