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A Clinical Evaluation of Carotid Angiography

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Since carotid angiography has become a routine procedure in the management of intracranial conditions, an evaluation of its use is necessary. Both the indications and hazards of the procedure must be considered in recommending it for diagnostic purposes. It seemed valuable, therefore, to review the angiograms done on the neurological service of a general hospital. During the past 20 months, 117 percutaneous diodrast angiograms were completed by members of the resident house staff. The majority were done directly by the authors.

A variety of neurological conditions including suspected brain tumors, vascular anomalies, subdural hematomas, vascular diseases and diffuse degenerative diseases were selected by the attending staff as suitable candidates for angiography. In each case, a percutaneous carotid angiogram was performed according to the usual descriptions (1). Either local infiltration by novocaine or general anesthesia by pentothal or surital was used. A Cournand-Grino needle was inserted into the carotid artery at the level of the thyroid cartilage. In most instances the common carotid artery was cannulated; in a few instances the internal carotid alone.

Ten to twelve cc. of 35% diodrast solution were used in each injection. A simple manual multiple cassette holder was used. This permitted three consecutive lateral films and a single antero-posterior (A—P) view.

In each case the A—P and lateral films were immediately developed, and, if indicated, the injection was repeated. If no pathology was noted on these films, the procedure was repeated on the other side whenever advisable. Bilateral procedures were carried out in 26 subjects.

Results

Diagnoses of various conditions were made prior to angiography. Of these, "brain tumor suspects" made up the largest group; suspected vascular anomalies and subdural hematoma were the next largest groups (see Table I). The interpretation of the films was based on descriptions by Moniz (2a), Lima (2b), and Green and Arana (1b).

Brain Tumor Suspects

Of 55 patients in whom intracranial masses were suspected, angiographic diagnoses of brain tumor were made in thirty. Of these, 25 were confirmed by subsequent surgery or air studies. Confirmation was not obtained in three patients because further studies were contraindicated by patient's age or family's refusal to give permission. In two cases the angiograms were interpreted incorrectly and these cases are described.

Case I: D.H. a 48 year old woman was admitted to Bellevue Psychiatric Hospital because of headaches and progressive confusion. The examination revealed early papilledema, left central facial palsy, skull tenderness on the right and memory deficits. An electroencephalogram showed a right cerebral focus.

Bilateral carotid angiography under general anesthesia revealed definite elevation (displacement) of the parietal branches of the right middle cerebral artery. Subsequent to this procedure the spinal fluid syndrome was noted to be positive for active syphilis. Anti-luetic treatment was instituted and the patient improved rapidly.

Five weeks later, the right carotid angiogram was repeated.

These films showed the parietal vessels to have a normal configuration.

Case II: O. O., a 64 year old male was admitted because of recent onset of grand mal seizures and left-sided weakness. Examination revealed a mild left hemiparesis, most marked in the lower extremity. There was a positive Babinski response and increased reflexes. The cerebrospinal fluid syndrome was normal.

A right carotid angiogram under local anesthesia was performed and demonstrated good filling of the anterior and middle cerebral arteries. There was straightening and depression of the pericallosal artery on the lateral views; and increased vascularity near the termination of the anterior cerebral artery on the A—P film. These changes were interpreted as evidence of a parasagittal tumor mass displacing blood vessels.

A pneumoencephalogram was done and this did not demonstrate the mass. The patient improved without treatment and was discharged. He was readmitted a few weeks later with evidence of an acute brain stem syndrome. In view of the course of the illness and multiplicity of lesions, it was believed that the patient's symptoms were due to degenerative changes, and not a neoplasm. No further studies were undertaken.

In this group of suspected brain tumors 22 angiograms did not show any pathology. Eleven of these were confirmed by air studies or autopsy. In two patients, however, satisfactory angiograms failed to demonstrate lesions later demonstrated by other studies.

Case III: F. M., a 57 year old man was admitted to the hospital because of left hemiparesis, bladder and bowel incontinence, and grand mal seizures of 4 weeks duration. On examination, there were severe personality changes, and a spastic left hemiparesis with pathological reflexes. Cerebrospinal fluid syndrome was normal.

A right carotid angiogram under pentothal anesthesia was done. Two sets of lateral films and one A—P view were taken. The films showed no evidence of cerebral tumor.

One week later a ventriculogram demonstrated a large right fronto-temporal mass. The presence of a malignant glioma was confirmed by surgery.

Case IV: J. S., a 49 year old man developed left sided seizures and aphasia during hospital treatment for furunculosis. On neurological examination there was evidence of a lesion in the right hemisphere. On skull x-ray the pineal shadow was shifted to the left.

An arteriogram on the right side under general anesthesia was done and no pathology demonstrated. A pneumoencephalogram, however, revealed a deformity of the right frontal horn.

The patient expired one month after angiography and at postmortem, multiple cerebral abscesses were demonstrated bilaterally.

Other erroneous angiographic diagnoses were made in patients who proved to have vascular thromboses. In two patients with signs of a brain tumor, the angiograms revealed an avascular area in the parieto-temporal region with displacement of middle cerebral vessels. Surgical exploration revealed edematous necrotic brain tissue, without evidence of tumor. Each case came to autopsy, and

TABLE I

ANGIOGRAPHIC DIAGNOSES

Group	No. of Patients	Pos.	Neg.	Not Diagnostic (a)	Pos. Diagnosis Confirmed	Neg. Diagnosis Confirmed	Incorrect Diagnosis
Intracranial Mass	55	30	22	3	25	11	4
Vascular Anomaly and Aneurysms	21	9	11	1	2 (b)	1	(c)
Subdural Hematoma	17	9 (d)	8	—	9	7	—
Occlusive Vascular Disease	11	7	4	—	6 (e)	1	—
Other (f)	13	2	10	1	—	5	—

Notes:

(a) Technically unsatisfactory films.

(b) Two cases confirmed by surgery but 7 other patients with anomalies demonstrated on arteriograms were not subjected to further studies.

(c) The 11 patients with negative arteriograms were not subjected to further study.

(d) Includes seven diagnoses of subdural hematoma, one of intracerebral hematoma and one of brain tumor.

(e) Failure of the anterior or middle cerebral, or internal carotid artery to fill on at least two consecutive injections, while the remainder of the circulation filled well.

(f) Includes three "follow-up" angiograms, seven patients with diffuse degenerative disease and three patients with lesions of the skull.

in both, thrombosis of a branch of the middle cerebral artery was found. The angiograms could not be differentiated from those seen in cases of tumors in the same region.

Vascular Anomalies: Twenty-one patients suspected of intracranial vascular anomalies or aneurysms were subjected to angiography. The angiograms were bilateral in only three of these, and unilateral in the other nine. One set of films were not satisfactory and were not repeated.

Seventeen of these patients had manifested spontaneous subarachnoid hemorrhages. In nine cases an anomaly was clearly outlined on the arteriogram. Five of these were aneurysms at the base, and four, vascular malformations of the hemisphere. No anomaly was demonstrated in eleven cases.

Confirmation of findings by other methods of study was most difficult to obtain in this group. In the nine cases where the anomaly was demonstrated, further confirmation was achieved in two cases. In one, an angiomatous malformation was amputated at operation. In the other, an aneurysm of the anterior communicating artery was dissected at post mortem. Air encephalograms were normal in two patients, despite the angiographic evidence of a large angioma of the cerebrum. The specificity of angiography in the diagnosis of vascular malformations is demonstrated by such cases.

Of the eleven patients with negative angiographic findings, two were subjected to air studies. These films were normal. The other nine patients were discharged without further study.

Subdural Hematoma: The diagnosis of subdural hematoma was made angiographically in seven of seventeen patients suspected of traumatic intracranial hematomas. The characteristic separation of the vascular patterns from the internal table of the skull as seen on the A—P projection was the basis for these diagnoses. In each of these cases the diagnosis was confirmed by trephination.

Furthermore, in the eight patients in whom a diagnostic vascular pattern was not seen, diagnosis of no blood in the subdural space was made. These diagnoses were all confirmed by pneumoencephalography.

In two patients angiography demonstrated an intracerebral mass, rather than a subdural process. In one case, this diagnosis made it possible for the surgeon to approach the lesion by a well localized and definitive procedure. The diagnosis was confirmed in the second at autopsy.

Vascular Disease: Angiographic studies were done in 11 patients in whom occlusive vascular disease was believed to be the basis

for their neurological findings. Failure of a portion of the vascular distribution to fill on two consecutive injections was observed in seven of these cases, and normal vascular patterns were seen in the other four. In the first group incomplete filling of the middle cerebral artery was seen in four cases; of the anterior cerebral artery in one case; and of the internal carotid artery in two cases. The vessels which appeared involved on the films were in each instance the same vessels as indicated by the patient's clinical syndrome.

In four of these patients pneumoencephalography demonstrated areas of atrophy in the involved region of the brain. In one case, post mortem studies confirmed the angiographic findings. No confirmation was obtained in the other six cases.

Miscellaneous Group: Of the 13 angiograms in the group, seven were done in patients with diffuse cerebral disease of a degenerative type. These films were not characteristic but in each case air studies demonstrated an enlarged ventricular system without shift or deformity. In three patients with lesions of the skull angiography failed to demonstrate any cerebral involvement. Pneumoencephalograms were done in only two of these patients and were normal.

Complications: In an evaluation of the indications for a diagnostic procedure the incidence and severity of complications must be considered. In this series of 117 angiographic studies, 36 patients suffered a total of 43 complications. There were five cases with severe and permanent complications. In all other instances the complications were mild and transient. Of the transient complications, 22 hematomas of the neck were recorded. This was recorded only when the hematoma was large. In one case, in a child, the hematoma was large enough to cause tracheal shift and respiratory difficulties. It was necessary to intubate the patient and maintain the airway during the evening of the procedure. Transient hemiparesis or transient increase in an existing hemiparesis was seen in 7 cases, and a grand mal seizure was observed in 2 patients. In each instance the phenomena disappeared within 48 hours. In 4 cases urticaria, chills and vomiting followed angiography, and seemed to represent an allergic response to the diodrast. In one patient, in whom a vascular anomaly was demonstrated, fresh blood was manifest in the spinal fluid the morning after the procedure.

Of the severe complications, death occurred within 24 hours of angiography in two patients (cases V, VI). In three other patients

severe complications were directly related to angiography. In a young child an osteomyelitis of the transverse process of the fifth cervical vertebra resulted after a difficult cannulization (case VII). A permanent mixed aphasia (case VIII) and an intensification of a pre-existing hemiparesis (case IX) were also observed.

Case V: G. B. male, 62. Craniotomy, three months before arteriography, had demonstrated a right middle fossa spongioblastoma polare which was spreading along the sphenoid ridge and had crossed the midline. The patient completed a course of x-ray therapy and was alert and ambulant. A vertebral angiogram was suggested to evaluate the intracranial mass. The patient was sedated with demerol, scopolomine and luminal. Three injections of 11 cc. each of 35% diodrast, were made. The record states that: "while attempt was made to enter right common carotid, patient became cyanotic, respirations shallow, and pulsations of the artery, which were strong, became weak." The patient expired within 20 hours after developing hematemesis, melena, and two grand mal seizures. No autopsy was obtained.

Case VI: R. W., a 40 year old male, was admitted because of sudden onset of headache and stiff neck. The spinal fluid was grossly bloody and the diagnosis of a spontaneous subarachnoid hemorrhage made. Patient developed pneumonia and ran a septic course. This responded to antibiotic therapy and patient seemed well one month after admission when he developed a second episode of subarachnoid bleeding. One week later, while patient was comatose, a right carotid angiogram was done. The films were not diagnostic and patient expired within 18 hours of the procedure.

An aneurysm of the anterior communicating artery with hemorrhage extending into the lateral ventricles was seen at post mortem.

Case VII: N. B., a 5 year old girl, was admitted because of petit mal seizures for two months. Examination demonstrated left homonymous hemianopsia and an electroencephalographic focus of abnormal activity on the right parieto-occipital region.

A right percutaneous carotid angiogram was done under general anesthesia, with difficulty, and a normal vascular pattern demonstrated. Patient had a large hematoma of the neck with tracheal shift, necessitating intubation that night. Patient recovered rapidly, but complained of pains in the neck and kept the head fixed with chin turned to the left. Repeated x-ray examinations eventually disclosed an area of rarification in the transverse process of the fifth cervical vertebra. This responded to immobilization and chemotherapy. When seen six months later, the child had recovered completely.

Case VIII: M. C., a 30 year old male, was admitted to the neurological service because of left sided headaches of a few years duration and three episodes of loss of consciousness during the previous six months. On examination there was diminution in perception of tactile stimuli in the right hand. This defect was exaggerated by double simultaneous stimulation. Electroencephalography demonstrated a persistent focus in the left parietal region. The pneumoencephalogram was normal.

A left percutaneous carotid angiogram was done. Four injections of diodrast were made. After the last injection a complete hemiplegia, hemisensory syndrome and hemianopsia was observed on the right. The patient was totally aphasic but responsive. During the ensuing weeks the weakness and sensory changes cleared, so that when seen one year after the episode, only minimal sensory changes in the

right upper extremity were observable. The aphasia, however, after some initial resolution, persisted. The patient expressed himself with difficulty and made many errors, could not carry out complicated commands, and made errors in imitating mouth and hand movements.

The angiographic films were interpreted as within normal limits except that the vessels of the middle cerebral group were few in number and widely separated.

Case IX: E. B., a 64 year old man, was admitted because of headache and "nervousness" of some months duration; and repeated episodes of loss of consciousness without convulsive movements for one month. On examination there were mental changes, hyperreflexia and a positive Babinski on the left, but no manifest weakness or sensory changes.

A right percutaneous angiogram was done with local anesthesia using four injections of diodrast. Immediately after the last injection the patient lapsed into a torpid state, his eye movements became dissociated, and the left upper and lower extremities were flaccid. During the ensuing days, the torper diminished until the patient could respond verbally to command, but the hemiplegia became spastic. It persisted until the patient was transferred to another hospital one month later.

The angiograms were interpreted as normal. A pneumoencephalogram revealed bilaterally dilated ventricles without shift or distortion.

A number of factors such as sensitivity to the contrast medium (3a), the amount of drug and rapidity of injection (3b), and existing hypertension (3c), have been suggested as causes for complications. In the present series, these factors are not outstanding in the patients who developed complications when these are compared to the uncomplicated cases.

Either conjunctival or intradermal diodrast sensitivity tests were carried out in every subject. In one case, the onset of wheezing, sweating, and palpitation after the intradermal test caused us to cancel the studies. In all other subjects, including the patients with complications, the sensitivity tests were negative. This was notably true in the four patients who developed "allergic-like" reactions of urticaria, chills, and vomiting, following the angiography, but who failed to react to the test dose.

There is no apparent relation in the data between complications (excluding hematoma of the neck) and the number of injections of diodrast (see Table 2).

TABLE II

No. of Injections	1	2	3	4	5	6	more than 6	Total*
No. of patients with complications	1	0	6	6	2	1	0	16
No. of patients without complications	3	9	27	22	13	8	3	85

* Excluding 16 uncomplicated cases in whom total dosage was not recorded.

Similar analyses of the factors of anesthesia and the number of carotid punctures at one session (unilateral or bilateral angio-

graphy), reveal no significant correlation between these factors, taken singly, and the incidence of complications.

Arterial hypertension was not a contraindication in the selection of patients for angiography. Ten hypertensives (all with diastolic pressures of 100 mm. Hg. or more, and systolic pressures of more than 160 mm. Hg.) were subjected to angiography, and in none of these were there any complications. Of the patients with severe or transient complications (other than hematoma of the neck) none had hypertension.

Discussion

Recent reviews have emphasized the diagnostic reliability of carotid angiography in vascular anomalies (4), suspected brain tumors (1b, 5), traumatic cerebral states (6), and occlusive vascular diseases (7). Our observations confirm the recommendations of the authors in the first three groups.

Prior to angiography, the diagnosis of vascular anomaly could not be confirmed except by surgical exposure or autopsy. Since air studies are not reliable in demonstrating vascular anomalies or aneurysms, angiography is the procedure of choice in establishing such diagnoses. In 43% of the patients in this series in whom such a lesion was suspected, the anomaly was satisfactorily demonstrated by angiography. In an unpublished series of similar cases studied by one of us *(Fink)* at Montefiore Hospital, five aneurysms were demonstrated in 14 suspects.

Similar results are recorded by other authors (4), and numerous recommendations have been made to increase these results. Routine vertebral injection, combined with bilateral carotid punctures, will demonstrate anomalies in the posterior portion of the Circle of Willis (14). Oblique A—P views at 45 degrees have been recommended to demonstrate small aneurysms of the carotid (4d). With these modifications in the procedure, it is to be expected that the incidence of positive identification of anomalies will increase.

The role of angiography in the management of spontaneous subarachnoid hemorrhage is not clear. Recent reviews emphasize the importance of demonstrating the lesion where surgical intervention is indicated (4b, e). The effect of angiography during the acute phase of bleeding has not been clarified. Many authors have recommended angiography only after the bleeding has ceased. Others, such as Wechsler and Gross (7b), suggest early use of angiography during active bleeding. This principle of waiting until bleeding ceased was adhered to in the cases in this series, and no statement of the effect of angiography on bleeding can be made.

Angiography is the diagnostic procedure of choice when a supratentorial brain tumor is suspected. It is recommended for lesions located in the anterior two-thirds of the cerebrum. Occipital lobe, posterior fossa and some midbrain tumors are not consistently demonstrable by this technique. Angiography is recommended in subjects with papilledema, since this procedure, unlike air studies, does not make immediate surgical intervention necessary (5, 7). Furthermore, numerous reports emphasize the differences in the patterns made by gliomas, meningiomas, intracerebral hematomas and vascular tumors (1, 2, 3c, 5). Such clues are helpful to the surgeon in planning the operative procedure. In a few of our cases, multiple foci of a metastatic tumor were demonstrable on the films, clarifying the management of the case. Such discriminations are usually not possible by other diagnostic techniques.

The diagnostic reliability of angiography in cases of brain tumor is high. In this series, 25 of 29 confirmed brain tumors were outlined by angiography. In a series of 96 brain tumor suspects, 39 of 42 verified neoplasms were demonstrated (5a). In the series from Montefiore Hospital angiography revealed the neoplasm in 45 of 52 confirmed cases. Similar satisfactory correlations are seen in the negative angiograms of these three series. This diagnostic reliability of 88% compares favorably with encephalography. The value of air studies in brain tumor diagnoses has been frequently reported. In one such study by Grant (8), ventriculography demonstrated the lesion in 130 of 150 cases—an incidence of 87%; while pneumoencephalography in 69 cases, revealed the tumor in 81%.

Further indications for angiography are in cases of traumatic intracranial hemorrhage. Numerous reviews emphasize the displacement of the anterior cerebral artery and separation of the fine vessels from the calvarium on the A—P film as diagnostic of subdural hematoma (6). Furthermore, angiography differentiates intracerebral and subdural lesions, altering the surgical approach (6a). This was clearly demonstrated in two of our patients in whom subdural hematoma was suspected, but in whom the angiogram demonstrated an intracerebral mass.

In cases of cerebral vascular accident angiography appears less helpful. Failure of a vessel to fill may be due to a variety of reasons including slowing of the circulation, vascular spasm, and anomalies of the system. These factors have been emphasized (7b). Angiography, however, is not contraindicated in vascular disease. It provides a useful means in differentiating a thrombosis from an intracerebral clot, or from a tumor, in cases where the diagnosis is unclear.

While the indications for angiography are many, they cannot be evaluated without a discussion of the risks involved. The complications of the procedure are of three types: (a) transient local phenomena; (b) transient cerebral vascular phenomena; (c) permanent severe deficits. In the first group of transient phenomena are burning pains in the head during injection, hematoma of the neck, and allergic reactions. Hematoma of the neck is a potentially dangerous complication (see our Case VII) but in a recent review no sequellae were observed (9). Allergic reactions are infrequent and usually mild. It was noted in this series that the routine intracutaneous or conjunctival testing for sensitivity was not found satisfactory in predicting these complications.

Transient hemiparesis, aphasia, seizures and elevated blood pressure have been reported following angiography (10). In this series these complications were observed in nine cases—an incidence of 8%. A similar incidence was observed in the Montefiore Hospital series. That these phenomena are probably due to temporary vascular insufficiency (spasm?) is evidenced by the clinical pattern of neurological findings and their duration. Of seven patients with hemiparesis, the deficits had disappeared within three hours in three patients, while in three others it was gone in 24 hours. In one of the subjects angiography was repeated in the other side six days later, without complication. In the seventh patient, arteriography had demonstrated an aneurysm of the internal carotid artery on the left and the common carotid artery was ligated on that side. One month later, angiography was repeated on the right side and following the first injection of diodrast, the patient developed a right hemiplegia. This disappeared during the ensuing 72 hours.

Vascular syndromes of the anterior and middle cerebral arteries have been observed. In one patient a lower limb monoplegia developed after two injections of diodrast. A third injection on the same side was done within 15 minutes of the appearance of the defect. The arterial views obtained showed good filling of all branches. The monoplegia disappeared within 12 hours. These complications were not observed in patients with hypertension.

Deterioration of a patient's condition or death following angiography has been reported in a number of instances. Bull (5d) summarizes the mortality rate of the procedure as 3 per 1000, which he states compares favorably to ventriculography. More recently, Dunsmore, Scoville and Whitcomb (10b) report three fatalities in 147 cases, and Olsson (11) reports three cases of "deterioration of patient's condition" in a series of 360 angiograms.

There were two fatalities in our present series, and one patient had a severe aggravation of a pre-existing hemiparesis. Each of these patients, like those of Dunsmore, Scoville and Whitcomb and Olsson, were severely ill before the procedure.

In contrast to this are the large series of Curtis (5b), Wickbom (1c), Torkildsen (5c), Lindgren (1a), and Green and Arana (1b) wherein no deaths were related to the procedure. It is possible that with widespread use of angiography, subjects with more advanced cerebral lesions are selected for these studies and the risks thereby increased.

A number of reports by Olsson and associates (3b, 11, 12) emphasize the summation of the toxic effects of large doses of diodrast given over a short period of time. They indicated the nature of the toxicity as an increased permeability of the blood vessels and a change in hemodynamics. Furthermore, the relation between concentration of diodrast and toxicity was demonstrated by Gross (13) when he introduced diodrast for angiography. His observation that seizures follow the use of 50% and 70% diodrast has been confirmed by numerous investigators.

Despite the use of 35% diodrast and low total dosages of diodrast, in this series, complications ensued. There was no significant relation between dosage and complications. Other factors must be operative and some hint has been given in the observation on circulation time (4f) and the effect of other injurious agents summating with diodrast (3).

Conclusion

Angiography is preeminent in the management of cases of intracranial disease suspected of vascular anomalies, supratentorial tumors, and traumatic hematomas. It is a satisfactory non-surgical method of demonstrating a vascular anomaly, malformation or aneurysm. In the diagnosis of supratentorial masses it will outline 90% satisfactorily. In addition to establishing the presence of a tumor, arteriography is superior to other diagnostic technics in yielding evidence as to the type of mass and its locus. In cases with papilledema, surgery is not made immediately mandatory by the procedure. It is not a satisfactory method in demonstrating obscure and diffuse lesions of the ventricular system, or tumors of the posterior fossa or occipital lobe.

In cases of traumatic intracranial lesions, angiography is a satisfactory method in outlining subdural hematomas, and differentiating such lesions from intracerebral hematoma or tumor.

Angiography is not clearly helpful in cerebrovascular thromboses and hemorrhages.

Complications are, for the most part, transient, and would not seem to limit the procedure in most cases. The complications are not directly related to hypertension, anesthesia, number or bilaterality of injections, or amount of diodrast. Other factors play a more important role and further study is necessary.

Summary

A series of 117 percutaneous carotid angiograms were reviewed to evaluate the indications for and risks involved in angiography. A variety of intracranial conditions were studied including supratentorial tumors, vascular anomalies, traumatic hematoma and cerebrovascular disease. Fifty-five patients with evidence of intracranial tumors were subjected to angiography, and a positive diagnosis was made in thirty. These diagnoses were confirmed in 83% of the cases. In only two subjects were the films misinterpreted. Of the negative films, the diagnoses were confirmed in 50%; in only two cases did the angiograms fail to show a lesion later demonstrable by air studies. Of 21 patients with suspected intracranial vascular anomalies, nine were outlined by angiography. In two of these, the angiograms revealed an anomaly not manifest on air studies. In a group of seventeen patients suspected of traumatic intracranial hematoma, a positive diagnosis was made in seven cases. These diagnoses as well as the negative findings in eight cases, and intracerebral tumors demonstrated in two cases, were all confirmed by subsequent studies. In cases of cerebrovascular lesions angiography was not of diagnostic value. Transient complications of angiography were seen in one-third of the patients, and consisted of hematoma of the neck, hemiparesis, seizures, and urticaria. In five patients (4%) complications were severe and permanent. These cases are described and the factors discussed.

The authors conclude that the limited risks of cerebral angiography do not detract from its usefulness in the management of intracranial vascular malformations, suspected supratentorial tumors and traumatic lesions.

Zusammenfassung

117 durch perkutane Injektion in die Arteria carotis gewonnene Angiogramme werden vom Gesichtspunkte der Indikationen und Gefahren besprochen. Supratentoriale Tumoren, Gefäßanomalien, traumatische Haematome und Erkrankungen der Gehirngefäße

werden besprochen. 55 Patienten mit Zeichen von intrakraniellen Tumoren wurden mit Angiographie studiert; in 30 wurde eine positive Diagnose gestellt. In 83% der Fälle wurde die Diagnose bestätigt. In 2 Fällen wurden die Filme falsch gedeutet. In 50% der negativen Filme wurden die Diagnosen bestätigt. Nur in 2 Fällen vermochte das Angiogramm nicht eine durch Luftfüllung demonstrierbare Läsion zu zeigen. In einer Gruppe von 21 Patienten mit vermuteten intrakraniellen Gefäßanomalien wurde in 9 Fällen die Gefäßstörung demonstriert. In 2 dieser Fälle zeigte Angiographie die Anomalie, während Luftfüllung ein negatives Resultat ergab. In einer Gruppe von 17 Patienten mit Verdacht auf traumatisches intrakranielles Haematom wurde eine positive Diagnose in 7 Fällen gestellt. Diese Diagnosen, wie auch die negativen Befunde in 8 Fällen, und intracerebrale Tumoren, die in 2 Fällen demonstriert wurden, konnten durch weitere Studien bestätigt werden. In Fällen von Gehirnläsionen, die durch Gefäßprozesse bedingt waren, hatte Angiographie keinen diagnostischen Wert. In $^{1}/_{3}$ der Fälle kam es zu vorübergehenden Komplikationen (Haematoma des Halses, Halbseitenlähmung, Krämpfe, Urticaria). Bei 5 Patienten (4%) waren die Komplikationen schwer und dauernd. Diese Fälle und ihre Besonderheiten werden besprochen. Die Autoren gelangen zu der Schlußfolgerung, daß die begrenzten Risiken der cerebralen Angiographie von der Anwendung dieses wertvollen Verfahrens in Fällen von Gefäßanomalien, supratentoriellen Tumoren und traumatischen Läsionen nicht abhalten sollen.

Résumé

Les auteurs passent en revue une série de 117 angiographies carotidiennes percutanées, dans le but d'évaluer les indications et les risques qu'elles comportent. La série d'affections intracraniennes étudiée comprend des tumeurs supratentoriales, des anomalies vasculaires, des hématomes traumatiques et des affections vasculaires du cerveau. Cinquante-cinq patients présentant une symptomatologie de tumeur intracranienne furent soumis à l'angiographie et un diagnostic positif put être fait dans trente cas. Ces diagnostics se confirmèrent dans 83% des cas. Chez deux patients seulement, les radiographies furent mal interprétées. Parmi les angiographies négatives, le diagnostic clinique fut confirmé dans 50% des cas; dans deux cas seulement les angiogrammes ne montrèrent pas de lésion qui, plus tard, put être mise en évidence par injections d'air. Parmi 21 patients suspects d'anomalie vasculaire

intracranienne, 9 purent être révélés par l'angiographie. Dans deux cas, les angiogrammes révélèrent une anomalie que les ventriculogrammes n'avaient pas rendu manifeste. Dans un groupe de 17 patients suspects d'hématome traumatique intracranien, un diagnostic positif fut confirmé dans 7 cas. Ces diagnostics, de même que les résultats négatifs de 8 autres cas, et les tumeurs intracérébrales démontrées dans 2 cas, furent tous confirmés par des études ultérieures. Dans les cas de lésions cérébrales d'origine vasculaire, l'angiographie est restée sans valeur diagnostique. Des complications passagères de l'angiographie furent observées dans un tiers des cas et consistèrent en hématomes de la région du cou, hémiparèses, crampes, et urticaire. Chez 5 malades (4%), des complications durables et plus graves apparurent. Ces cas sont étudiés en détail et les facteurs en cause discutés.

Les auteurs concluent que les risques limités de l'angiographie cérébrale ne sauraient faire renoncer à une méthode aussi utile pour le diagnostic des malformations vasculaires intracraniennes, des tumeurs supratentoriales et des lésions traumatiques.

REFERENCES

1. a) *Lindgren, E.:* Br. J. Radiol. *20*, 326, 1947. – b) *Green, J. R.*, and *Arana, R.:* Am. J. Roent. and Rad. Ther. *59*, 617, 1948. – c) *Wickbom, I.:* Acta Radiol. Suppl. *72*, 1, 1948. – 2. a) *Moniz, E.:* "L'Angiographie Cérébrale", Masson & Cie, Paris, 1934. – b) *Lima A.:* "Cerebral Angiography". Oxford Univ. Press, London, 1950. – 3. a) *Olsson, O.:* Acta Radiol. *35*, 65, 1951. – b) *Broman, T.*, *Forssman, B.*, and *Olsson, O.:* Acta Radiol. *34*, 135, 1950. – c) *Torkildsen, A.:* Acta Psych. and Neur. Suppl. *55*, 1, 1949. – 4. a) *Lowman, R. M.*, and *Duff, S. D.:* Amer. J. Roent. and Rad. Ther. *53*, 341, 1945. – b) *Poppen, J. L.:* Radiol. *53*, 347, 1949. – c) *Wickbom, I.:* Acta Radiol. *34*, 387, 1950. – d) *Löfstedt, S.:* Acta Radiol. *34*, 339, 1950. – e) *Wechsler, I. S.*, *Gross, S. W.*, and *Cohen, I.:* J. Neur. Neurosurg. and Psych. *14*, 25, 1951. – f) *Raney, R.*, *Raney, A. A.*, and *Sanchez-Perez, J. M.:* J. Neurosurg. *6*, 222, 1949. – 5. a) *Culbreth, G. F.*, *Walker, A. E.*, and *Curry, R. W.:* J. Neurosurg. 7, 127, 1950. – b) *Curtis, J. B.:* Brit. J. Surg. *38*, 295, 1951. – c) *List, C. F.:* Radiol. *55*, 327, 1950. – d) *Bull, J. W. D.:* Postgrad. Med. Jour. *26*, 157, 1950. – e) *Fabritius, H. F.*, *Frovig, A. G.*, and *Kristiansen, K.:* Arch. Neurol. and Psychiat. *61*, 352, 1949. – 6. a) *Wickbom, I.:* Acta Radiol. 32, 249, 1949. – b) *Kristiansen, K.:* Surgery *24*, 755, 1948. – c) *Webster, J. E.*, *Dawson, R.*, and *Gurdjian, E. S.:* J. Neurosurg. *8*, 368, 1951. – d) *Raney, R. B.*, and *Raney, A. A.:* Calif. Med. *73*, 342, 1950. – 7. a) *Govons, S. R.*, and *Grant, F. C.:* Arch. Neurol. and Psychiat. *55*, 600, 1946. – b) *Wechsler, I. S.*, and *Gross, S. W.:* J. A. M. A. *136*, 517, 1948. – c) *Lusignan, F. W.*, and *Gross, G. O.:* Calif. Med. *73*, 240, 1950. – d) *Morris, A. A.*, and *Fulcher O. H.:* Surg. Clin. North Amer. *30*, 1783, 1950. – 8. *Grant, F. C.:* Arch. Neurol. and Psychiat. *27*, 1310, 1932. – 9. *Berdal, P.*, and *Emblem, L.:* Acta Psych. and Neurol. *26*, 1, 1951. – 10. a) *Chusid, J. G.*, *Robinson, F.*, and *Margules-Lavergne, M. P.:* J. Neurosurg. *6*, 466, 1949. – b) *Dunsmore, R.*, *Scoville, W. B.*,

and *Whitcomb, B.:* J. Neurosurg. *8*, 110, 1951. – 11. *Olsson, O.:* J. Neurol. Neurosurg. and Psychiat. *12*, 312, 1949. – 12. *Broman, T.*, and *Olsson, O.:* Acta Radiol. *30*, 326, 1948. – 13. *Gross, S. W.:* Arch. Neurol. and Psychiat. *46*, 704, 1941. – 14. *Sugar, O., Holden, L. B.*, and *Powell, C. B.:* Amer. J. Roent. and Rad. Ther. *61*, 166, 1949.

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A CLINICAL EVALUATION OF CAROTID ANGIOGRAPHY*

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Since carotid angiography has become a routine procedure in the management of intracranial conditions, an evaluation of its use is necessary. Both the indications and hazards of the procedure must be considered in recommending it for diagnostic purposes. It seemed valuable, therefore, to review the angiograms done on the neurological service of a general hospital. During the past 20 months, 117 percutaneous diodrast angiograms were completed by members of the resident house staff. The majority were done directly by the authors.

A variety of neurological conditions including suspected brain tumors, vascular anomalies, subdural hematomas, vascular diseases and diffuse degenerative diseases were selected by the attending staff as suitable candidates for angiography. In each case, a percutaneous carotid angiogram was performed according to the usual descriptions (1). Either local infiltration by novocaine or general anesthesia by pentothal or surital was used. A Cournand-Grino needle was inserted into the carotid artery at the level of the thyroid cartilage. In most instances the common carotid artery was cannulated; in a few instances the internal carotid alone.

Ten to twelve cc. of 35% diodrast solution were used in each injection. A simple manual multiple cassette holder was used. This permitted three consecutive lateral films and a single antero-posterior (A-P) view.

In each case the A-P and lateral films were immediately developed, and, if indicated, the injection was repeated. If no pathology was noted on these films, the procedure was repeated on the other side whenever advisable. Bilateral procedures were

carried out in 26 subjects.

RESULTS:

Diagnoses of various conditions were made prior to angiography. Of these, "brain tumor suspects" made up the largest group; suspected vascular anomalies and subdural hematoma were the next largest groups (see Table I). The interpretation of the films was based on descriptions by Moniz (2a), Lima (2b), and Green & Arana (1b).

Brain Tumor Suspects:

Of 55 patients in whom intracranial masses were suspected, angiographic diagnoses of brain tumor were made in thirty. Of these, 25 were confirmed by subsequent surgery or air studies. Confirmation was not obtained in three patients because further studies were contraindicated by patient's age or family's refusal to give permission. In two cases the angiograms were interpreted incorrectly and these cases are described.

Case 1: D.H. a 48 year old woman was admitted to Bellevue Psychiatric Hospital because of headaches and progressive confusion. The examination revealed early papilledema, left central facial palsy, skull tenderness on the right and memory deficits. An electroencephalogram showed a right cerebral focus.

Bilateral carotid angiography under general anesthesia revealed definite elevation (displacement) of the parietal branches of the right middle cerebral artery. Subsequent to this procedure the spinal fluid syndrome was noted to be positive for active syphilis. Anti-luetic treatment was instituted and the patient improved rapidly.

Five weeks later, the right carotid angiogram was repeated.

TABLE I

ANGIOGRAPHIC DIAGNOSES

Group	No. of Patients	Pos.	Neg.	Not Diagnostic(a)	Pos. Diagnosis Confirmed	Neg. Diagnosis Confirmed	Incorrect Diagnosis
Intracranial Mass	55	30	22	3	25	11	4
Vascular Anomaly and Aneurysms	21	9	11	1	2(b)	1	(c)
Subdural Hematoma	17	9(d)	8	-	9	7	-
Occlusive Vascular Disease	11	7	4	-	6(e)	1	-
Other (f)	13	2	10	1	-	5	-

Notes:

(a) Technically unsatisfactory films.

(b) Two cases confirmed by surgery, but 7 other patients with anomalies demonstrated on arteriograms were not subjected to further studies.

(c) The 11 patients with negative arteriograms were not subjected to further study.

(d) Includes seven diagnoses of subdural hematoma, one of intracerebral hematoma and one of brain tumor.

(e) Failure of the anterior or middle cerebral, or internal carotid artery to fill on at least two consecutive injections, while the remainder of the circulation filled well.

(f) Includes three "follow-up" angiograms, seven patients with diffuse degenerative disease and three patients with lesions of the skull.

These films showed the parietal vessels to have a normal configuration.

Case II: O.O., a 64 year old male was admitted because of recent onset of grand mal seizures and left-sided weakness. Examhation revealed a mild left hemiparesis, most marked in the lower extremity. There was a positive Babinski response and increased reflexes. The cerebrospinal fluid syndrome was normal.

A right carotid angiogram under local anesthesia was performed and demonstrated good filling of the anterior and middle cerebral arteries. There was straightening and depression of the pericallosal artery on the lateral views; and increased vascularity near the termination of the anterior cerebral artery on the A-P film. These changes were interpreted as evidence of a parasaggital tumor mass displacing blood vessels.

A pneumoencephalogram was done and this did not demonstrate the mass. The patient improved without treatment and was discharged. He was readmitted a few weeks later with evidence of an acute brain stem syndrome. In view of the course of the illness and multiplicity of lesions, it was believed that the patient's symptoms were due to degenerative changes, and not a neoplasm. No further studies were undertaken.

In this group of suspected brain tumors 22 angiograms did not show any pathology. Eleven of these were confirmed by air studies or autopsy. In two patients, however, satisfactory angiograms failed to demonstrate lesions later demonstrated by other studies.

Case III: F.M., a 57 year old man was admitted to the hospital because of left hemiparesis, bladder and bowel incontinence, and grand mal seizures of 4 weeks duration. On examiation, there

were severe personality changes, and a spastic left hemiparesis with pathological reflexes. Cerebrospinal fluid syndrome was normal.

A right carotid angiogram under pentothal anesthesia was done. Two sets of lateral films and one A-P view were taken. The films showed no evidence of cerebral tumor.

One week later a ventriculogram demonstrated a large right fronto-temporal mass. The presence of a malignant glioma was confirmed by surgery.

Case IV: J.S., a 49 year old man developed left sided seizures and aphasia during hospital treatment for furunculosis. On neurological examination there was evidence of a lesion in the right hemisphere. On skull x-ray the pineal shadow was shifted to the left.

An arteriogram on the right side under general anesthesia was done and no pathology demonstrated. A pneumoencephalogram, however, revealed a deformity of the right frontal horn.

The patient expired one month after angiography and at post-mortem, multiple cerebral abscesses were demonstrated bilaterally.

Other erroneous angiographic diagnoses were made in patients who proved to have vascular thromboses. In two patients with signs of a brain tumor, the angiograms revealed an avascular area in the parieto-temporal region with displacement of middle cerebral vessels. Surgical exploration revealed edematous necrotic brain tissue, without evidence of tumor. Each case came to autopsy and in both thrombosis of a branch of the middle cerebral artery was found. The angiograms could not be differentiated from those seen in cases of tumors in the same region.

Vascular Anomolies: Twenty-one patients suspected of intracranial vascular anomolies or aneurysms were subjected to angiography. The angiograms were bilateral in only three of these, and

unilateral in the other nine. One set of films were not satisfactory and were not repeated.

Seventeen of these patients had manifested spontaneous subarachnoid hemorrhages. In nine cases an anomoly was clearly outlined on the arteriogram. Five of these were aneurysms at the base, and four, vascular malformations of the hemisphere. No anomaly was demonstrated in eleven cases.

Confirmation of findings by other methods of study was most difficult to obtain in this group. In the nine cases where the anomaly was demonstrated, further confirmation was achieved in two cases. In one, an angiomatous malformation was amputated at operation. In the other, an aneurysm of the anterior communicating artery was dissected at post mortem. Air encephalograms were normal in two patients, despite the angiographic evidence of a large angioma of the cerebrum. The specificity of angiography in the diagnosis of vascular malformations is demonstrated by such cases.

Of the eleven patients with negative angiographic findings, two were subjected to air studied. These films were normal. The other nine patients were discharged without further study.

Subdural Hematoma: The diagnosis of subdural hematoma was made angiographically in seven of seventeen patients suspected of traumatic intracranial hematomas. The characteristic separation of the vascular patterns from the internal table of the skull as seen on the A-P projection was the basis for these diagnoses. In each of these cases the diagnosis was confirmed by trephination.

Furthermore, in the eight patients in whom a diagnostic vascular pattern was not seen, diagnosis of no blood in the subdural space was made. These diagnoses were all confirmed by pneumoencephalography.

In two patients angiography demonstrated an intracerebral mass, rather than a subdural process. In one case, this diagnosis made it possible for the surgeon to approach the lesion by a well localized and definitive procedure. The diagnosis was confirmed in the second at autopsy.

<u>Vascular Disease:</u> Angiographic studies were done in 11 patients in whom occlusive vascular disease was believed to be the basis for their neurological findings. Failure of a portion of the vascular distribution to fill on two consecutive injections was observed in seven of these cases, and normal vascular patterns were seen in the other four. In the first group incomplete filling of the middle cerebral artery was seen in four cases; of the anterior cerebral artery in one case; and of the internal carotid artery in two cases. The vessels which appeared involved on the films were in each instance the same vessels as indicated by the patient's clinical syndrome.

In four of these patients pneumoencephalography demonstrated areas of atrophy in the involved region of the brain. In one case, post mortem studies confirmed the angiographic findings. No confirmation was obtained in the other six cases.

<u>Miscellaneous Group:</u> Of the 13 angiograms in the group, seven were done in patients with diffuse cerebral disease of a degenerative type. These films were not characteristic but in each case air studies demonstrated an enlarged ventricular system without shift or deformity. In three patients with lesions of the skull angiography failed to demonstrate any cerebral involvement. Pneumoencephalograms were done in only two of these patients and were normal.

<u>Complications:</u> In an evaluation of the indications for a diagnostic procedure the incidence and severity of complications

must be considered. In this series of 117 angiographic studies, 36 patients suffered a total of 43 complications. There were five cases with severe and permanent complications. In all other instances the complications were mild and transient. Of the transient complications, 22 hematomas of the neck were recorded. This was recorded only when the hematoma was large. In one case, in a child, the hematoma was large enough to cause tracheal shift and respiratory difficulties. It was necessary to intubate the patient and maintain the airway during the evening of the procedure. Transient hemiparesis or transient increase in an existing hemiparesis was seen in 7 cases, and a grand mal seizure was observed in 2 patients. In each instance the phenomena disappeared within 48 hours. In 4 cases urticaria, chills and vomiting followed angiography, and seemed to represent an allergic response to the diodrast. In one patient, in whom a vascular anomaly was demonstrated, fresh blood was manifest in the spinal fluid the morning after the procedure.

Of the severe complications, death occurred within 24 hours of angiography in two patients (cases V, VI). In three other patients severe complications were directly related to angiography. In a young child an osteomyelitis of the transverse process of the fifth cervical vertebra resulted after a difficult cannulization (case VII). A permanent mixed aphasia (Case VIII) and an intensification of a pre-existing hemiparesis (Case IX) were also observed.

<u>Case V:</u> G.B. male, 62. Craniotomy, three months before arteriography, had demonstrated a right middle fossa spongioblastoma polare which was spreading along the sphenoid ridge and had crossed the midline. The patient completed a course of x-ray therapy and was alert and ambulant. A vertebral angiogram was suggested to evaluate

the intracranial mass. The patient was sedated with demerol, scopolomine and luminal. Three injections of 11 cc each, of 35% diodrast, were made. The record states that: "while attempt was made to enter right common carotid, patient became cyanotic, respirations shallow, and pulsations of the artery, which were strong, became weak." The patient expired within 20 hours after developing hematemesis, melena, and two grand mal seizures. No autopsy was obtained.

Case VI: R.W., a 40 year old male, was admitted because of sudden onset of headache and stiff neck. The spinal fluid was grossly bloody and the diagnosis of a spontaneous subarachnoid hemorrhage made. Patient developed pneumonia and ran a septic course. This responded to antibiotic therapy and patient seemed well one month after admission when he developed a second episode of subarachnoid bleeding. One week later, while patient was comatose, a right carotid angiogram was done. The films were not diagnostic and patient expired within 18 hours of the procedure.

An aneurysm of the anterior communicating artery with hemorrhage extending into the lateral ventricles was seen at post mortem.

Case VII: N.B., a 5 year old girl, was admitted because of petit mal seizures for two months. Examination demonstrated left homonymous hemianopsia and an electroencephalographic focus of abnormal activity on the right parieto-occipital region.

A right percutaneous carotid angiogram was done under general anesthesia, with difficulty, and a normal vascular pattern demonstrated. Patient had a large hematoma of the neck with tracheal shift, necessitating intubation that night. Patient recovered rapidly, but complained of pains in the neck and kept the head fixed with chin turned to the left. Repeated x-ray examinations

eventually disclosed an area of rarification in the transverse process of the fifth cervical vertebra. This responded to immobilization and chemotherapy. When seen six months later, the child had recovered completely.

Case VIII: M.C., a 30 year old male, was admitted to the neurological service because of left sided headaches of a few years duration and three episodes of loss of consciousness during the previous six months. On examination there was diminution in perception of tactile stimuli in the right hand. This defect was exaggerated by double simultaneous stimulation. Electroencephalography demonstrated a persistent focus in the left parietal region. The pneumoencephalogram was normal.

A left percutaneous carotid angiogram was done. Four injections of diodrast were made. After the last injection a complete hemiplegia, hemisensory syndrome and hemianopsia was observed on the right. The patient was totally aphasic but responsive. During the ensuing weeks the weakness and sensory changes cleared, so that when seen one year after the episode, only minimal sensory changes in the right upper extremity were observable. The aphasia, however, after some initial resolution, persisted. The patient expressed himself with difficulty and made many errors, could not carry out complicated commands, and made errors in imitating mouth and hand movements.

The angiographic films were interpreted as within normal limits except that the vessels of the middle cerebral group were few in number and widely separated.

Case IX: E.B., a 64 year old man, was admitted because of headache and "nervousness" of some months duration; and repeated

episodes of loss of consciousness without convulsive movements for one month. On examination there were mental changes, hyperreflexia and a positive Babinski on the left, but no manifest weakness or sensory changes.

A right percutaneous angiogram was done with local anesthesia using four injections of diodrast. Immediately after the last injection the patient lapsed into a torpid state, his eye movements became dissociated, and the left upper and lower extremities were flaccid. During the ensuing days, the torper diminished until the patient could respond verbally to command, but the hemiplegia became spastic. It persisted until the patient was transferred to another hospital one month later.

The angiograms were interpreted as normal. A pneumoencephalogram revealed bilaterally dilated ventricles without shift or distortion.

A number of factors such as sensitivity to the contrast medium, (3a) the amount of drug and rapidity of injection (3b), and existing hypertension (3c), have been suggested as causes for complications. In the present series, these factors are not outstanding in the patients who developed complications when these are compared to the uncomplicated cases.

Either conjunctival or intradermal diodrast sensitivity tests were carried out in every subject. In one case, the onset of wheezing, sweating, and palpitation after the intradermal test caused us to cancel the studies. In all other subjects, including the patients with complications, the sensitivity tests were negative. This was notably true in the four patients who developed "allergic-like" reactions of urticaria, chills, and vomiting, following the angiography, but who failed to react to the test dose.

There is no apparent relation in the data between complications

(excluding hematoma of the neck) and the number of injections of diodrast (see Table 2).

TABLE 2

No. of injections	1	2	3	4	5	6	more than 6	Total*
No. of patients with complications	1	0	6	6	2	1	0	16
No. of pts. without complications	3	9	27	22	13	8	3	85

*Excluding 16 uncomplicated cases in whom total dosage was not recorded.

Similar analyses of the factors of anesthesia and the number of carotid punctures at one session (unilateral or bilateral angiography) reveal no significant correlation between these factors, taken singly, and the incidence of complications.

Arterial hypertension was not a contraindication in the selection of patients for angiography. Ten hypertensives (all with diastolic pressures of 100mm. Hg. or more, and systolic pressures of more than 160mm. Hg.) were subjected to angiography, and in none of these were there any complications. Of the patients with severe or transient complications (other than hematoma of the neck) none had hypertension.

DISCUSSION:

Recent reviews have emphasized the diagnostic reliability of carotid angiography in vascular anomalies (4), suspected brain tumors (1b, 5), traumatic cerebral states (6), and occlusive vascular diseases (7). Our observations confirm the recommendations of the authors in the first three groups.

Prior to angiography, the diagnosis of vascular anomaly could not be confirmed except by surgical exposure or autopsy. Since air studies are not reliable in demonstrating vascular anomalies or aneurysms, angiography is the procedure of chpice in establishing

such diagnoses. In 43% of the patients in this series in whom such a lesion was suspected, the anomaly was satisfactorily demonstrated by angiography. In an unpublished series of similar cases studied at Montefiore Hospital, five aneurysms were demonstrated in 14 suspects.

Similar results are recorded by other authors (4), and numerous recommendations have been made to increase these results. Routine vertebral injection, combined with bilateral carotid punctures, will demonstrate anomalies in the posterior portion of the Circle of Willis (14). Oblique A-P views at 45 degrees have been recommended to demonstrate small aneurysms of the carotid (4d). With these modifications in the procedure, it is to be expected that the incidence of positive identification of anomalies will increase.

The role of angiography in the management of spontaneous subarachnoid hemorrhage is not clear. Recent reviews emphasize the importance of demonstrating the lesion where surgical intervention is indicated (4b, e.) The effect of angiography during the acute phase of bleeding has not been clarified. Many authors have recommended angiography only after the bleeding has ceased. Other, such as Wechsler and Gross (7b), suggest early use of angiography during active bleeding. This principle of waiting until bleeding ceased was adhered to in the cases in this series, and no statement of the effect of angiography on bleeding can be made.

Angiography is the diagnostic procedure of choice when a supratentorial brain tumor is suspected. It is recommended for lesions located in the anterior two-thirds of the cerebrum. Occipital lobe, posterior fossa and some midbrain tumors are not consistently demonstrable by this technique. Angiography is recommended in subjects with papilledema, since this procedure, unlike air studies, does not

make immediate surgical intervention necessary (5,7). Furthermore, numerous reports emphasize the differences in the patterns made by gliomas, meningiomas, intracerebral hematomas and vascular tumors (1,2,3c,5). Such clues are helpful to the surgeon in planning the operative procedure. In a few of our cases, multiple foci of a metastatic tumor were demonstrable on the films, clarifying the management of the case. Such discriminations are usually not possible by other diagnostic techniques.

The diagnostic reliability of angiography in cases of brain tumor is high. In this series, 25 of 29 confirmed brain tumors were outlined by angiography. In a series of 96 brain tumor suspects, 39 of 42 verified neoplasms were demonstrated (5a). In the series from Montifiore Hospital angiography revealed the neoplasm in 45 of 52 confirmed cases. Similar satisfactory correlations are seen in the negative angiograms of these three series. This diagnostic reliability of 88% compares favorably with encephalography. The value of air studies in brain tumor diagnoses has been frequently reported. In one such study by Grant (8), ventriculography demonstrated the lesion in 130 of 150 cases - an incidence of 87%; while pneumoencephalography in 69 cases, revealed the tumor in 81%.

Further indications for angiography are in cases of traumatic intracranial hemorrhage. Numerous reviews emphasize the displacement of the anterior cerebral artery and separation of the fine vessels from the calvarium on the A-P film as diagnostic of subdural hematoma (6). Furthermore, angiography differentiates intracerebral and subdural lesions, altering the surgical approach (6a). This was clearly demonstrated in two of our patients in whom subdural hematoma was suspected, but in whom the angiogram demonstrated an intracerebral mass.

In cases of cerebral vascular accident angiography appears less helpful. Failure of a vessel to fill may be due to a variety of reasons including slowing of the circulation, vascular spasm, and anomalies of the system. These factors have been emphasized (7b). Angiography, however, is not contraindicated in vascular disease. It provides a useful means in differentiating a thrombosis from an intracerebral clot, or from a tumor, in cases where the diagnosis is unclear.

While the indications for angiography are many, they cannot be evaluated without a discussion of the risks involved. The complications of the procedure are of three types: (a) transient local phenomena; (b) transient cerebral vascular phenomena; (c) permanent severe deficits. In the first group of transient phenomena are the burning pains in the head during injection, hematoma in the neck, and allergic reactions. Hematoma in the neck is a potentially dangerous complication (see our Case VII) but in a recent review no sequellae were observed (9). Allergic reactions are infrequent and usually mild. It was noted in this series that the routine intracutaneous or conjunctival testing for sensitivity was not found satisfactory in predicting these complications.

Transient hemiparesis, aphasia, seizures and elevated blood pressure have been reported following angiography (10). In this series these complications were observed in nine cases -- an incidence of 8%. A similar incidence was observed in the Montefiore Hospital series. That these phenomena are probably due to temporary vascular insufficiency (spasm?) is evidenced by the clinical pattern of neurological findings and their duration. Of seven patients with

hemiparesis, the deficits had disappeared within three hours in three patients, while in three others it was gone in 24 hours. In one of the subjects angiography was repeated in the other side six days later, without complication. In the seventh patient, arteriography had demonstrated an aneurysm of the internal carotid artery on the left and the common carotid artery was ligated on that side. One month later, angiography was repeated on the right side and following the first injection of diodrast, the patient developed a right hemiplegia. This disappeared during the ensuing 72 hours.

Vascular syndromes of the anterior and middle cerebral arteries have been observed. In one patient a lower limb monoplegia developed after two injections of diodrast. A third injection on the same side was done within 15 minutes of the appearance of the defect. The arterial views obtained showed good filling of all branches. The monoplegia disappeared within 12 hours. These complications were not observed in patients with hypertension.

Deterioration of a patient's condition or death following angiography has been reported in a number of instances. Bull (5d) summarizes the mortality rate of the procedure as 3 per 1000, which he states compares favrably to ventriculography. More recently, Dunsmore, Scoville and Whitcomb (10b) report three fatalities in 147 cases, and Olsson (11) reports three cases of "deterioration of patient's condition" in a series of 360 angiograms. There were two fatalities in our present series, and one patient had a severe aggravation of a pre-existing hemiparesis. Each of these patients, like those of Dunsmore, Scoville and Whitcomb and Olsson, were severely ill before the procedure.

In contrast to this are the large series of Curtis (5b),

Wickbom (1c), Torkildsen (5c), Lindgren (1a), and Green and Arana (1b) wherein no deaths were related to the procedure. It is possible that with widespread use of angiography, subjects with more advanced cerebral lesions are selected for these studies and the risks thereby increased.

A number of reports by Olsson and associates (3b, 11, 12) emphasize the summation of the toxic effects of large doses of diodrast given over a short period of time. They indicated the nature of the toxicity as an increased permeability of the blood vessels and a change in hemodynamics. Furthermore, the relation between concentration of diodrast and toxicity was demonstrated by Gross (13) when he introduced diodrast for angiography. His observation that seizures follow the use of 50% and 70% diodrast has been confirmed by numerous investigators.

Despite the use of 35% diodrast and low total dosages of diodrast, in this series, complications ensued. There was no significant relation between dosage and complications. Other factors must be operative and some hint has been given in the observation on circulation time (4f) and the effect of other injurious agents summating with diodrast (3).

CONCLUSION:

Angiography is preeminent in the management of cases of intracranial disease suspected of vascular anomalies, supratentorial tumors, and traumatic hematomas. It is a satisfactory non-surgical method of demonstrating a vascular anomaly, malformation or aneurysm. In the diagnosis of supratentorial masses it will outline 90% satisfactorily. In addition to establishing the presence of a tumor, arteriography is superior to other diagnostic technics in yielding evidence as to the type of mass and its locus. In cases with

papilledema, surgery is not made immediately mandatory by the procedure. It is not a satisfactory method in demonstrating obscure and diffuse lesions of the ventricular system, or tumors of the posterior fossa or occipital lobe.

In cases of traumatic intracranial lesions, angiography is a satisfactory method in outlining subdural hematomas, and differentiating such lesions from intracerebral hematoma or tumor.

Angiography is not clearly helpful in cerebrovascular thromboses and hemorrhages.

Complications are, for the most part, transient, and would not seem to limit the procedure in most cases. The complications are not directly related to hypertension, anesthesia, number or bilaterality of injections, or amount of diodrast. Other factors play a more important role and further study is necessary.

<u>SUMMARY:</u>

A series of 117 percutaneous carotid angiograms performed at Bellevue Hospital of New York City were reviewed to evaluate the indications and risks of angiography.

The authors conclude that the limited risks of angiography do not detract from its usefulness in the management of vascular malformations, suspected supratentorial brain tumors and traumatic intracranial lesions.

SUMMARY

A series of 117 percutaneous carotid angiograms were reviewed to evaluate the indications for and risks involved in angiography. Patients with a variety of intracranial conditions were studied including supratentorial tumors, vascular anomolies, traumatic hematoma and cerebrovascular disease.

Fifty-five patients with evidence of intracranial tumors were subjected to angiography, and a positive diagnosis was made in thirty. These diagnoses were confirmed in 83% of the cases. In only two subjects were the films misinterpreted. Of the negative films, the diagnoses were confirmed in 50%; in only two cases did the angiograms fail to show a lesion later demonstrable by air studies.

Of 21 patients with suspected intracranial vascular anomolies, nine were outlined by angiography. In two of these, the angiograms revealed an anomoly not manifest on air studies. In a group of seventeen patients suspected of traumatic intracranial hematoma, a positive diagnosis was made in seven cases. These diagnoses as well as the negative findings in eight cases, and intracerebral tumors demonstrated in two cases, were all confirmed by subsequent studies.

In cases of cerebrovascular lesions angiography was not of diagnostic value.

Transient complications of angiography were seen in one-third of the patients, and consisted of hematoma of the neck, hemiparesis, seizures, and urticaria. In five patients (4%) complications were severe and permanent. These cases are described and the factors discussed.

The authors describe the usefulness of angiography in

differentiating between the variety of intracranial conditions. They conclude that the limited risks of cerebral angiography do not detract from its usefulness in the management of intracranial vascular malformations, suspected supratentorial tumors and traumatic lesions.

REFERENCES

1. (a) LINDGREN, E.: Technic of direct cerebral angiography. Br.J.Radiol., 20: 326-331, August, 1947.

   (b) GREEN, J.R. and ARANA, R.: Cerebral angiography. Am.J.Roent.& Rad.Ther., 59: 617-650, May, 1948.

   (c) WICKBOM, I.: Angiography of the carotid artery. Acta Radiol. Suppl. 72: 1-90, 1948.

2. (a) MONIZ, E.: "L'Angiographie Cerebrale", Masson y Cie, Paris, 1934.

   (b) LIMA, A.: Cerebral Angiography. Oxford Univ. Press, London, 1950.

3. (a) OLSSON, O.: Antihistaminic Drugs for inhibiting untoward reactions to injections of contrast medium., Acta Radiol., 35: 65-70, Jan. 1951.

   (b) BROMAN, T., FORSSMAN, B. and OLSSON, O.: Further experimental investigations of injuries from contrast media in cerebral angiography. Acta Radiol., 34: 135-143, August, 1950.

   (c) TORKILDSEN, A.: Carotid angiography: With special reference to the diagnosis of cerebral gliomas. Acta Psych. & Neur.Suppl., 55: 1-168, 1949.

4. (a) LOWMAN, R.M. and DUFF, S.D.: Arteriography for the demonstration of intracranial aneurysms. Amer.J.Roent.&Rad.Ther., 53: 341-347, April, 1945.

   (b) POPPEN, J.L.: Aid of arteriograms in diagnosis and treatment of intracranial aneurysms. Radiol., 53: 347-352, March, 1949.

   (c) WICKBOM, I.: Angiographic examination of intracranial arterio-venous aneurysms. Acta Radiol., 34: 387-398, November, 1950.

   (d) LÖFSTEDT, S.: Intracranial arterial aneurysms. Acta Radiol., 34: 339-349, November, 1950.

   (e) WECHSLER, I.S., GROSS, S.W. and COHEN, I.: Arteriography and carotid artery ligation in intracranial aneurysms and vascular malformations. J.Neur.Neurosurg. & Psych., 14: 25-34, Feb.,1951.

   (f) RANEY, R., RANEY, A.A. and SANCHEZ-PEREZ, J.M.: The role of complete angiography in neurosurgery. J.Neurosurg., 6: 222-237, May, 1949.

5. (a) CULBRETH, G.C., WALKER, A.E. and CURRY, R.W.: Cerebral angiography in 'brain tumor suspects', J.Neurosurg., 7: 127-138, March, 1950.

   (b) CURTIS, J.B.: Cerebral angiography. Brit.J.surg., 38: 295-331, January, 1951.

   (c) LIST, C.F.: Cerebral angiography. Radiol., 55: 327-329, Sept.,1950.

   (d) BULL, J.W.D.: Cerebral angiography. Postgrad.Med.Jour., 26: 157-166, March, 1950.

REFERENCES

5. (e) FABRITIUS, H.F., FROVIG, A.G. and KRISTIANSEN, K.: Percutaneous cerebral angiography and cerebral abscess. Arch.Neurol.&Psychiat. 61: 352-368, April, 1949.

6. (a) WICKBOM, I.: Angiography in post-traumatic intracranial hemorrhages. Acta Radiol., 32: 249-258, October, 1949.

(b) KRISTIANSEN, K.: Cerebral angiography in the diagnosis of intracranial hematomas. Surgery. 24: 755-768, November, 1948.

(c) WEBSTER, J.E., DAWSON, R. and GURDJIAN, E.S.: The diagnosis of traumatic intracranial hemorrhage by angiography. J. Neurosurg. 8: 368-376, July, 1951.

(d) RANEY, R.B. and RANEY, A.A.: The contribution of cerebral angiography in diagnosis. Calif.Med., 73: 342-349, October,1950.

7. (a) GOVONS, S.R. and GRANT, F.C.: Arteriographic visualization of cerebrovascular lesions. Arch.Neurol.&Psychiat. 55: 600-618, June, 1946.

(b) WECHSLER, I.S. and GROSS, S.W.: Cerebral arteriography in subarachnoid hemorrhage. J.A.M.A., 136: 517-521, Feb., 1948.

(c) LUSIGNAN, F.W. and GROSS, G.O.: Intracranial angiography in the treatment of cerebral vascular accidents. Calif.Med., 73: 240-247, September, 1950.

(d) MORRIS, A.A. and FULCHER, O.H.: Carotid angiography; Its value in premalignant intracranial conditions. Surg.Clin.North Amer. 30: 1783-1796, December, 1950.

8. GRANT, F.C.: Ventriculography and encephalography. Their value in the localization and treatment of intracranial lesions. Arch.Neurol.&Psychiat. 27: 1310-1341, June, 1932.

9. BERDAL, P. and EMBLEM, L.: Percutaneous carotid angiography: Local complications in the throat with special reference to the larynx and pharynx. Acta Psych. & Neurol., 26: 1-5, January, 1951.

10. (a) CHUSID, J.G., ROBINSON, F. and MARGULES-LAVERGNE, M.P.: Transient hemiplegia associated with cerebral angiography. J.Neurosurg. 6: 466-474, November, 1949.

(b) DUNSMORE, R., SCOVILLE, W.B. and WHITCOMB, B.: Complications of angiography. J.Neurosurg., 8: 110-118, January, 1951.

11. OLSSON, O.: Cerebral angiography: Tolerance for contrast media of diodrast type. J.Neurol.Neurosurg. & Psychiat., 12: 312-316, Nov.,1949.

12. BROMAN, T. and OLSSON, O.: Tolerance of cerebral blood vessels to a contrast medium of the diodrast group. Acta Radiol., 30: 326-342, November, 1948.

13. GROSS, S.W.: Cerebral arteriography: Its place in neurological diagnosis. Arch.Neurol.&Psychiat., 46: 704-714, Oct., 1941.

14. SUGAR, O., HOLDEN, L.B. and POWELL, C.B.: Vertebral angiography. Amer.J.Roent. & Rad.Ther., 61: 166-182, February,1949.