CEREBRAL ANGIOGRAPHY IN CHILDREN
AN ANATOMOCLINICAL EVALUATION
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During the last few years numerous papers pertaining to cerebral angio-
graphy have been written. Most of the authors included cases of angio-
graphy in children, but usually the number has been small and a proper evaluation of how children tolerate the procedure as well as its use-
fulness in this age group has not been presented. We have thought it worth-
while to analyze a series of 50 cases of different conditions in children verified
by necropsy or operation, in which cerebral angiography has been carried
out as an adjunct to neurologic diagnosis.

TECHNIQUE

In the great majority of the cases in this series angiography was per-
formed by direct exposure and injection of the common carotid artery in the
neck (open technique). In only 7 cases was puncture of the vessel made di-
rectly through the skin (percutaneous technique). A short transverse in-
cision, 2 or 3 cm. long, at the level of the cricoid cartilage, is enough to expose
the vessel after a brief dissection with scissors. Barbiturates and local infil-
tration with novocain provide a good anesthesia in patients within the first 2
years of life, but general anesthesia, using ethyl chloride and open drop ether,
had to be given in most of the remaining cases to secure adequate immo-
bilization during the radiographic exposures. Infants have a short neck
making the procedure more difficult, but in the later ages children with long
and skinny necks are most suitable for the percutaneous technique if co-
operation can be secured.

COMPLICATIONS

The following complications were encountered:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convulsions</td>
<td>3</td>
</tr>
<tr>
<td>Pneumomediastinum</td>
<td>2</td>
</tr>
<tr>
<td>Bernard-Horner syndrome</td>
<td></td>
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</tbody>
</table>

Convulsions appeared during the test in 3 cases. All 3 patients had had
convulsions for some time before angiography was performed. One was suf-
ferring from encephalitis, 1 from focal epilepsy and 1 from subarachnoid
hemorrhage. Two of them were injected with a 75 per cent solution of the
contrast medium, the use of which was subsequently discontinued, being re-
placed by a 35 per cent solution. The convulsions were Jacksonian or tonic
and generalized, disappearing spontaneously in a few minutes following the
injection.
There were 3 patients who showed a cervical sympathetic paralysis which disappeared within a period of 8 weeks. All these patients were operated upon by the open technique and probably the sympathetic chain was damaged during the dissection of the carotid artery in the neck. In 2 cases there was moderate polypnea with subcutaneous crepitation in the neck during 24 to 48 hours following the procedure. Roentgenograms of the chest revealed a pneumomediastinum that cleared up spontaneously without consequence. Following the injection some patients complained of soreness of the neck for 24 to 48 hours and were relieved by ice bags.

Usually the injection was done on the side where the lesion was suspected, but bilateral and multiple injections (as many as five), using 50 cc. of 35 per cent solution, have been repeated without any apparent disturbance. We have used as contrast media Diodrast (Winthrop), Neo Iopax (Shering) and Pyelectan (Glaxo), with little difference in results and complications, as long as the solution was not higher than 35 per cent concentration. We did not see such complications as thrombosis, embolus, recurrent laryngeal palsy, hematoma and sensitivity reactions, described by previous authors in cases of adults, all the complications herein studied being benign and reversible.

ANATOMOCLINICAL STUDY

Angiography was performed 66 times in a series of 50 children ranging from 9 days to 15 years in age. These patients were affected by various neurological conditions in which it was thought that an angiographic study might be of some help in the diagnosis. In 23 cases the vascular pattern was found to be abnormal, providing important information about the character of the disease in most instances (Table 1).

<table>
<thead>
<tr>
<th>Final Diagnosis</th>
<th>No. of Cases Studied</th>
<th>Pathologic Angiograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain tumor</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Hydrocephalus not due to brain tumor</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cerebral malformations</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Acrocephalosyndactylism</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vascular disease</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Others*</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>50</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

* Including encephalitis, diffuse and focal atrophy, subarachnoid hemorrhage, toxoplasmosis (?), meningovascular lues, and orbital tumor (3 cases).

BRAIN TUMORS

Of the 12 cases of brain tumor studied, 4 failed to show any pathologic change of the cerebral vessels: 2 brain-stem gliomas, 1 craniopharyngioma,
and 1 cystic astrocytoma of the cerebellum. The carotid as well as the vertebral artery was injected in the cases of the posterior fossa lesions. On the other hand, 5 tumors of the cerebral hemisphere were shown definitely by the arteriograms. Astrocytomas and hemangioblastomas, either cystic or solid, appeared as avascular areas spreading away the arteries in the cortex (Figs. 1, 2 and 3). Glioblastomas pushed the vessels away but there was in-

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**HYDROCEPHALUS**

Although the clinical diagnosis of hydrocephalus may be obvious in infants, due to the enlargement of the head, in later ages this disorder is sometimes mistaken for a chronic expansive intracranial lesion. However, the

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**Fig. 1.** E.P., a 12-year-old boy. Increased intracranial pressure and left facial weakness. Percutaneous arteriogram. The middle cerebral artery is pushed upwards. Cystic astrocytoma of right temporal lobe.
Fig. 2. O.H., a 7-year-old girl. Slight headache and difficulty in writing for a month. Increased reflexes and right facial weakness. No signs of pressure. Left parietal focus in EEG. Left parietal solid subcortical astrocytoma.

Fig. 3. J.C. Recurrent convulsions 4 years followed by increased pressure. Cystic hemangioblastoma of left temporoparietal area.
Fig. 4. F.A. Progressive symptoms of increased pressure with amblyopia. Combined angiogram and ventriculogram. Right frontal glioblastoma.

Fig. 5. Combined ventriculogram and arteriogram in hydrocephalus. Typical appearance of the arteries in an advanced case.
differential diagnosis may be aided by angiography. Internal hydrocephalus is easily recognized by characteristic alterations in the vascular pattern, especially as shown in the arteriogram. In the lateral view the usually sharp bend of the middle cerebral artery is changed into a broad curve, the vessel running in a diagonal course. On the other hand, the anterior cerebral artery makes a wider curve surrounding the corpus callosum (Fig. 5). Though these findings are typical of internal hydrocephalus, they give no information as to its cause and usually further studies should be carried out in order to arrive at a definite diagnosis.

MALFORMATIONS

There are a certain number of infants who show an enlargement of the head and increased intracranial pressure but who are not suffering from the usual internal hydrocephalus. They are affected by an extensive cerebral dysplasia and a collection of fluid under pressure. We have called this malformation hydroencephalodysplasia.* The differentiation between internal hydrocephalus and hydroencephalodysplasia should be established since the malformation has a poor prognosis and is not suitable for surgery.

In congenital internal hydrocephalus, angiography reveals elongated arteries in the characteristic arrangement described above. On the other hand, in hydroencephalodysplasia the internal carotid artery is small and hypo-

* To be published.
plastic, and its branches are abnormal, incomplete or absent. The Sylvian group has been seen to be formed by only two arteries running parallel to one another, without branches (Fig. 6). The internal carotid artery may end abruptly in a small bunch of fine vessels. The middle cerebral artery has been shown without any of the ascending branches to the cortex (Figs. 7 and 8). The abnormality of the vessels changes from one case to another, depending on the amount of cerebral tissue that is absent. In contrast, the external carotid artery and branches are well developed in all cases.

Clinically this malformation can be suspected whenever a child with an enlarged head shows signs of optic atrophy, arrested development, or spasticity. Unfortunately before the 4th or 5th month of age these symptoms are not easily recognized. Subdural punctures yielding fluid in great amounts make the diagnosis quite possible but angiography gives a typical picture.

Porencephaly is another malformation that can be revealed by arteriography. As in other dysplasias, the diagnosis is based on the absence of a number of cerebral arteries. It is a requisite of correct diagnosis that the remaining arteries be well filled, otherwise artefacts in technique with filling defects could be misleading. There is also no complementary collateral circulation as occurs in thrombosis. It is possible that not all porencephalic cysts can be diagnosed by angiography since it is known that a number of them are covered by a thin layer of nervous tissue crossed by vessels (Figs. 9 and 10).

BLOOD-VEssel DISEASE

Angiography shows its most beautiful results in the diagnosis of blood-vessel lesions, particularly malformations and aneurysms. The clinical symptoms of these lesions in children are scanty and the disease therefore is frequently not kept in mind by the general practitioner and probably goes
unrecognized among the often-seen cases of epilepsy, hemiplegia and cerebral hemorrhage of the early ages.

A spontaneous hemorrhage (intracerebral or subarachnoid) may be the only clinical expression of a vascular cerebral malformation (Fig. 11). The importance of its diagnosis is emphasized by the fact that localized lesions are nowadays amenable to surgery. Usually the case appears as one of chronic convulsions until a vessel ruptures and a spontaneous hemorrhage occurs. The only way of making an early diagnosis is by performing angiography in children with convulsions that show any evidence of a focal cerebral lesion (Fig. 12).
The existence of a peripheral angioma associated with neurological symptoms does not necessarily imply that a similar lesion will be revealed by cerebral angiography. In 2 cases of Sturge-Weber syndrome the angiograms failed to show abnormalities, and in a case of Parke-Weber congenital hemangiectasis, in which a huge angioma of the leg was well shown in angiograms of the affected extremity, the cerebral vessels were normal in spite of the fact that the patient suffered from convulsions. In another case, in which there were extensive arteriovenous malformations of the extracranial blood vessels, angiography failed to reveal intracranial abnormalities. Our material does not include studies of cerebral hemorrhage in the newborn; this deserves special consideration.

RESUME

The author analyzes and correlates the anatomoclinical and X-ray findings in 50 children on whom cerebral angiography was performed for neurologic purposes. The technique proved to be safe although not easy to perform in infants. The results were of value in the diagnosis of a number of supratentorial tumors, vascular malformations and hydrocephalus. The procedure has been used with success in discovering cases of cerebral malformation in infancy (porencephaly, hydroencephalodysplasia). Illustrative examples are presented.

RESUMEN

Los autores analizan y correlacionan las características anatomo-clínicas
con los hallazgos radiológicos de cincuenta niños en los cuales se realizó la angiografía cerebral, con fines de diagnóstico. La técnica resultó segura aunque no fácil en los lactantes. Resultó ser de valor en el diagnóstico de los tumores cerebrales supra-tentoriales, malformaciones vasculares ó hidrocefalia interna. También fue empleada con éxito en el diagnóstico de las malformaciones cerebrales que pueden ser vistas en la infancia (anencefalia, porencefalia, hidrencefalodisplasia). Estas conclusiones son ilustradas con ejemplos.

REFERENCES