Total brain opacification in children during angiography

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O'Connor and Neuhauser (1963) have shown that normally vascular viscera in children may become opaque during excretory urography. Avascular masses simultaneously become visible because they do not contain contrast material. They called the phenomenon total body opacification. In 1919, Walter Dandy wrote, 'From the data obtainable from the combination of intraventricular and intraspinal injections (of air) it is difficult to see how intracranial tumours can escape localization'. Application of the principle described by O'Connor and Neuhauser to intracranial diagnosis promises to bring closer the hope of Dandy. With the use of appropriate amounts of contrast material and roentgenograms made with low kilovoltage (KV) during the capillary phase, the substance of the brain appears momentarily radio-opaque, while the CSF spaces, including the ventricles, are radiolucent (Liliequist, 1967; Harwood-Nash, 1972). It is the purpose of this report to emphasize the value of total brain opacification in normal and abnormal states in children.

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Methods

Endotracheal anaesthesia is used so that intracranial pressure and cerebral perfusion can be modified by adjustments in arterial P_{CO_2}. The endotracheal tube also protects the airway during manipulation of the patient's head. Since contrast agents are osmotic diuretics, the infant's water balance must be observed closely. Heat lost by the relatively large head may be compensated for by a heat lamp as a supplement to the heating pad which is used routinely. Rectal temperatures are monitored during the examination.

With sterile precautions and Seldinger technique, a small polyethylene catheter is introduced into the femoral artery and advanced with fluoroscopic control into the appropriate vessel to be studied. Finest detail is obtained with selective injections, but occasionally, because of the extreme tortuosity of the internal carotid artery in infants and newborns, one must be satisfied with common carotid injections. It is almost always possible to obtain selective injections of the vertebral artery, and with pressure injection reflux into the opposite vertebral occurs. The smallest possible catheter which will carry the appropriate contrast is used. The sizes of these catheters, wire guides, and the contrast injection schedules are shown in the Table.

### TABLE
#### Details of injection

<table>
<thead>
<tr>
<th>Weight of patient (kg)</th>
<th>Needle size (gauge)</th>
<th>Guide (inches)</th>
<th>Catheter size (French)</th>
<th>Contrast injection (cm^3/sec × sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Internal carotid</td>
<td>Vertebral</td>
</tr>
<tr>
<td>0-8</td>
<td>21</td>
<td>0.018</td>
<td>3.0*</td>
<td>3 x 1.5 §</td>
</tr>
<tr>
<td>8-15</td>
<td>20</td>
<td>0.021</td>
<td>4.0†</td>
<td>4 x 1.5</td>
</tr>
<tr>
<td>15-30</td>
<td>19</td>
<td>0.025</td>
<td>4.0†</td>
<td>5 x 1.5</td>
</tr>
<tr>
<td>30-adult</td>
<td>18</td>
<td>0.035</td>
<td>5.0‡</td>
<td>6 x 1.7</td>
</tr>
</tbody>
</table>

*Cook Pert LDPE i.d. 0.022/o.d. 0.040" tubing. †Cook Pert 0.037/0.053" tubing. §BD RPX Hanafee 0.045H"/0.065". §May need less; judgement made by watching rapidity of contrast washout fluoroscopically.
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FIG. 1.—Normal findings. Lateral view, angiotomogram, mixed capillary and venous phase. The open arrows show the normal position and size of the 4th ventricle in the infants. The inferior vermis vein (IVV) serves to identify the inferior portion of the vermis.
After careful positioning and determination of adequate run-off of contrast around the catheter by fluoroscopic observation, the catheter is connected to a pressure injector,* with the precaution that no air bubbles are in the system.

Films are exposed at 2/sec during the arterial and capillary phase and 1/sec during the venous phase. It may be necessary to prolong filming in infants with increased intracranial pressure. Generally, the circulation time is modified by the anaesthesiologist and his control over the arterial Pco₂.

Two to one magnification, subtraction, and angiotomography (Smith et al., 1971; Newton and Kerber, 1972; Tillitt et al., 1972) are used routinely. The radiographic tube has a 0.3 mm focal spot and 2 mm of aluminium inherent filtration. The KV range varies from 62 to 64 kilovolt peak (KVP) at 2.5 mA and 200 msec time for newborns and infants. All studies are done using meglumine iothalamate 60% (Conray 60) containing 600 mg/ml meglumine iothalamate.

An example of normal findings is shown in Fig. 1.

Patients

Case 1. A cerebrospastic girl aged 6 years had ataxia and petit mal seizures, which were becoming more frequent. She had left-sided hemiplegia. Her left forearm was held pronated, and the left elbow was stiff. Deep tendon reflexes were excessive. Babinski's sign was equivocal on the right side. Roentgenograms of the skull showed focal thinning of the diploe in the right parietal region. Total brain opacification revealed an avascular mass in this region (Fig. 2).

Case 2. A boy aged 3½ years had always had a large head. Development and consciousness were normal until 4 days before admission when he became lethargic, began to vomit, and showed ptosis of the right upper lid. Head circumference was 56 cm (97th centile). His neck was stiff. He was unable to move his right eye. Both pupils reacted normally. The veins of the fundus of the

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*Viamonte-Hobbs Pressure Injector. A steel barrel syringe must be used as the plastic barrel cannot achieve the pressure response needed.

**Fig. 2.**—Case 1. Brain opacification phase, selective internal carotid injection. Arrows outline the junction between normal arterial-capillary phase of brain and the large avascular space. Since the arteries did not entirely reach the surface of the inner table on the frontal view (not shown), a diagnosis of subarachnoid cyst was favoured over porencephaly.
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right eye pulsated and were distended; the medial margin of the right disc was blurred. Sensation to pin-prick was normal. Deep tendon reflexes were normal, and Babinski's sign was absent. Total brain opacification showed an avascular mass in the parieto-occipital region (Fig. 3).

Case 3. A boy aged 7 years with haemophilia A had been first admitted at age 2½ months because of abnormal enlargement of his head. A diagnosis of aqueductal obstruction was based on ventriculographic findings. He was treated with a Holter ventriculoatrial valve. 2 days before the last admission he tripped and struck the back of his head. He became lethargic and developed left hemiplegia. While he was being examined in the emergency room, he stopped breathing. After resuscitation, he was found to have a temperature of 40 °C. His skin was dry, his head was enlarged, and he was obtunded. The shunt appeared to be patent. He was given antihaemophilic globulin cryoprecipitate. Total brain opacification during cerebral angiography showed a large, avascular, extra-axial mass in the posterior fossa, which at operation proved to be a cyst (Fig. 4).

Case 4. A girl aged 2½ months had chorioretinitis and an enlarged head. Her birthweight was 1·2 kg after a pregnancy complicated only by the onset of labor at 7 months. Her Apgar score was four at 1 minute and three at 5 minutes. She had respiratory distress and was not discharged from hospital until 3 weeks after birth. She gained weight slowly and was irritable. When she was examined at age 2½ months, she had a rectal temperature of 35 °C. Head circumference was 38·5 cm (10th centile) and she weighed 4·4 kg (3rd centile). Her skull transilluminated throughout. Her retinas were
scarred and had deposits of black pigment. She did not smile, and she did not follow moving objects with her eyes. Her muscle tone was normal; deep tendon reflexes were 3+ in the arms, 2+ at the right knee, and 4+ at the left knee. Babinski's sign was present bilaterally, and sustained clonus was present at the left ankle. Roentgenograms of the skull showed enlargement, widened sutures, and bilateral intracranial calcification anteriorly in the shape of thin crescents. Serum titre for cytomegalovirus was 1 to 64. Cerebral angiography showed a large avascular mass in the quadrigeminal region (Fig. 5a and b).

Case 5. A girl aged 9 years had been nauseated and weak for 2 months. She was ataxic and had difficulty in talking, chewing, and swallowing. Examination showed absence of corneal reflexes, weakness of extraocular and facial muscles, inability to move the tongue, and a poor gag reflex. She had an intention tremor. She walked on her heels with a broad-based gait. Babinski's sign and ankle clonus were present bilaterally. Deep tendon reflexes were normal. Total brain opacification showed the deformity and displacement of the radiolucent fourth ventricle which are characteristic of brain stem glioma (Fig. 6).
FIG. 5.—Case 4. (a) Brain opacification phase, selective vertebral injection. The cerebellar hemispheres are depressed (black arrows), and the thalamus (open arrows) and basal ganglia (open crossed arrow) are opacified. (b) Combined brain opacification-venous phase. Elevation of the posterior mesencephalic vein (pm) and the straight sinus (ss) indicates a large avascular mass in the area of the quadrigeminal plate. At operation an arachnoid cyst was removed.
FIG. 6.—Case 5. Lateral angiotomogram, selective vertebral injection. The clinical diagnosis was brain stem glioma. Arrows outline the deformed and posteriorly displaced 4th ventricle. X-ray therapy was only briefly palliative. At necropsy a brain stem glioma was found.

Discussion

Diagnosis in cerebral angiography has been based on the characteristic displacement of vessels as they are made visible by the passage of radio-opaque material through them. Total brain opacification adds the new dimension of radiolucent ventricles and radiolucent avascular masses.

O'Connor and Neuhauser (1963) attempted brain opacification in several children with intracranial lesions without success. They concluded that the skull was too opaque and vascular for the technique to be successful. Lillequist (1967), by means of subtraction, was able to show that during the capillary phase all of the brain but the ventricles became opaque. Harwood-Nash (1972) terms this phase the ‘cerebrogram’; he has also succeeded with vertebral angiography in showing the cervical part of the spinal cord and medulla during the capillary phase.

It is likely that total brain opacification will in many cases replace ventriculography and pneumencephalography since it depicts vessels, ventricles, and brain while lessening trauma and risk.

References

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