ENCEPHALOGRAPHY IN THE INVESTIGATION OF CERTAIN CEREBRAL CONDITIONS IN CHILDHOOD:

PART I*

By Members of the Staff of the Royal Aberdeen Hospital for Sick Children.

This paper is a presentation and discussion of the information to be gained by studying the outline of the brain in a series of patients admitted to the Royal Aberdeen Hospital for Sick Children, in whom some cerebral defect was at least a possible diagnosis. The method chosen was encephalography, a procedure which aims at substituting air for the total volume of cerebrospinal fluid, and thereafter determining the distribution of the air, and of the cerebral tissues, by a study of skiagraphs. It was originally described by Dandy, and has proved to be of great value in the diagnosis of intracranial space-occupying lesions. Studies similar to the present investigation have been made by Crothers, Vogt and Eley¹ and by Guttman².

Technique of encephalography.

Preliminary examination of the patient.—It is essential that a careful preliminary physical and neurological examination be made of each patient. This must include an ophthalmoscopic examination, for one of the absolute contraindications to the use of the procedure is the presence of papilloedema. The presence of enlargement of the head is also an absolute contraindication, as pointing to an obstructive lesion in the posterior fossa of the skull. The examination also includes an assessment of any defect of intellect which may be present.

Anaesthesia.—Anaesthesia by a mixture of nitrous-oxide and oxygen with a trace of ether has been employed. It has been found entirely adequate, both for the surgical manipulations and for maintaining unconsciousness while the x-ray pictures are taken.

Technique.—The child is anaesthetized upon the x-ray couch. When anaesthesia is sufficiently deep, the patient is raised to the sitting position, and maintained in this by bending the body forward over a stool

* Part II will appear in the June issue. At the special request of the authors their names are not mentioned since the work was essentially that of a team.
The head should be held forwards rather than backwards. The position has certain definite advantages: it permits the fullest possible drainage of cerebrospinal fluid, it ensures that air shall rise to the depleted spaces, and it maintains an even distribution of the air over both halves of the brain. The air is introduced by lumbar puncture.* To the needle is

* For this, the shorter of the needles specially manufactured by Messrs. Weiss of Oxford Street, London, for injection of the branches of the fifth nerve, has been very satisfactory.
connected an adapter, and this leads to a 20 c.c. Record syringe through a length of four inches of thin, readily collapsible rubber tubing. The various fittings must be accurate so as to provide air-tight joints. The fluid usually flows freely; it is removed in amounts of about 10 c.c., and replaced by an equal quantity of air (fig. 2) drawn into the syringe through a filter of surgical gauze (fig. 3). For the average case, a sufficient allowance for the expansion of air at the temperature of the body is 2 c.c. for each 100 c.c. of fluid. This allowance is best made at the first substitution (i.e. 10 c.c. of fluid are withdrawn, only 8 c.c. of air injected). Forcible suction must not be used; it causes too rapid an upset in the balance of intracranial pressures and, moreover, may drag a nerve root against the point of the needle, so that the flow stops. As a rule the weight of the plunger of a smoothly-acting syringe supplies all the suction that is necessary, and the merit of the thin rubber tubing in the connection lies in its collapse if the withdrawal of fluid tends to become hurried.

The attempt should be made to remove the fluid as completely as possible, and towards the end the child's head should be tilted backwards, to empty the dependent portions of the frontal horns of the ventricles. Finally, the plunger will move to and fro in the syringe, without exhausting any further fluid. In cases that have proved to be relatively normal radiographically, the average quantity withdrawn has varied from 50 c.c. to 80 c.c. A portion of the fluid is retained for chemical and cytological examination, the Wassermann test, and any further investigation considered to be desirable.
Radiographic technique.—Antero-posterior and lateral skiagraphs of the skull are taken previously. Encephalograms are taken with the patient supine, the desired position of the skull being maintained by a looped band passed round the head. This is kept taut by attaching to each end of the loop a sandbag weighing one pound. These are allowed to hang over the edges of the couch (fig. 4). Three views are necessary: an antero-posterior, taken with the head in maximum flexion, and right and left lateral views.

The technical details follow:—
Diaphragm: Bucky, flat type.
Focal distance to film: 30 inches.
Exposure time: 1·5 seconds.
Current: 30 m.a.

![Fig. 4.—Method of maintaining position of head during exposure of film.](https://example.com/image.png)

K.V.P. determined from table, after measurement of the antero-posterior and lateral diameters of the skull with the foot-measure used in shoe shops.

<table>
<thead>
<tr>
<th>Measurement in inches</th>
<th>K.V.P.</th>
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<tbody>
<tr>
<td>4·4</td>
<td>50</td>
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<tr>
<td>4·7</td>
<td>52</td>
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<td>6·7</td>
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<td>6·9</td>
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<td>7·4</td>
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</table>
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After-treatment.—There is remarkably little reaction after the procedure. During the first one or two days, the temperature will be raised two or three degrees Fahrenheit, and some vomiting is usual. Headache is present for a similar period, but is easily controlled, especially if the child be not restless. It has been noted that the reaction to encephalography has been most marked in the cases in which gross cerebral defects were demonstrated in the skiagraphs. The foot of the bed is raised on blocks twelve inches high, a position which tends to free the medulla from the foramen magnum, and on the day after the procedure an enema of magnesium sulphate solution is given. By the fourth or fifth day all reaction seems to have disappeared. There has not been any mortality connected with the procedure and no undesirable after-effects have been observed. Indeed, as will be pointed out later in this communication, following encephalography the condition of the child is occasionally improved. If a space-occupying lesion is demonstrated, it will usually be best to proceed with craniotomy: for this reason the skiagraphs must be inspected before the child is returned to the ward.

The interpretation of encephalograms.

Although considerable experience is required in deciding whether a given encephalogram is abnormal, there are certain standards by which the normal is estimated, and it will be convenient to consider these at this point.

When the air reaches the cistern magna, over the posterior surface of the medulla oblongata and vermis, it may be distributed in one or both of two ways:

(1) It may enter the intra-cerebral ventricular system through the foramina of Majendie and of Luschka, and displace the fluid from the ventricles. In a majority of cases at least some air enters the ventricular system, but occasionally it fails to do so. It is important to understand that absence of ventricular shadows in the skiagraphs does not necessarily indicate the presence of a pathological condition, for it would appear that in most of such cases some minor anatomical peculiarity in the foramina leading from the fourth ventricle prevents the entrance of air, although it does not offer any obstacle to the normal circulation of cerebrospinal fluid. On the other hand, it happens occasionally that all the injected air enters the (usually dilated) ventricular system. This finding always indicates the presence of some intracranial pathological process, and it will be elaborated in a later section.

(2) The air may follow the extra-cerebral course of the cerebrospinal fluid, and pass in the median line by way of the cisterna pontis, cisterna interpeduncularis, and cisterna chiasmatis. From the last-named cistern five pathways debouch:—
FIG. 5.—The distribution of air in the ventricular system and subarachnoid spaces, after Fay.
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(a) Over the corpus callosum in the median line. (Unpaired.)

(b) Along the fissure of Sylvius and from thence over the Rolandic area and towards the vertex. From the Rolandic pathway there are numerous offshoots; most of these pass over the frontal and parietal lobes and very few pass posteriorly over the occipital lobe. (Paired.)

(c) By way of the cisterna interpeduncularis and cisterna intercommunicans to the cisterna venae magnae cerebri. (Paired.)

Fig. 6.—Normal encephalogram, antero-posterior view. Compare fig. 5.
The distribution of air in a perfect encephalogram is indicated in fig. 5 which has been constructed by Fay; and the appearance of normal encephalograms is shown in fig. 6 (antero-posterior view) and fig. 7 (lateral view).

In the interpretation of an encephalogram, there should be examined in turn:

1. The size of the ventricles, whether increased on one or on both sides. Increase in size of the ventricles may be of an obstructive nature (fig. 8),

![Fig. 7.—Normal encephalogram, lateral view (Pendergrass). Compare fig. 5.](image)

due either to the presence of a lesion which prevents the free egress of cerebrospinal fluid, or to failure of the absorbing mechanism, so that the whole cerebrospinal circulation is stagnant. On the other hand, it may be of a compensatory type (fig. 9), and result from an attempt to take the place of an atrophic area of the ventricular wall. In the first type, the dilatation will obviously be bilateral and symmetrical; in the second, the dilatation is apt to produce a pouching of one ventricle, over an area
corresponding to the loss of cerebral substance, an appearance which has been termed 'wandering' ventricle. It is to be noted that space-occupying lesions in the hemispheres will produce lateral deviations of the ventricular system; but these are outside the scope of this paper.

(2) The size of the basal cisterns, which is increased in cases of failure of absorption of the cerebrospinal fluid.

(3) The distribution of the pathways over the hemispheres; whether this is more extensive (for example, encroaching upon the occipital lobe), or partly absent, in areas of adhesive leptomeningitis.
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(4) The width of the pathways over the hemispheres. Normally this is about 3 mm. When convolutional atrophy is present, it may be greatly increased.

Examples of these pathological appearances will be presented in the second part of this contribution.

Fig. 9.—'Wandering' ventricle on right.

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