A TECHNIQUE FOR RAPID DIRECTED PNEUMOCISTERNO-VENTRICULOGRAPHY OF THE POSTERIOR FOSSA

H. VERBIEST, M.D.

Neurosurgical Department—State University—Utrecht—Netherlands

THE disadvantages of lumbar encephalography in the sitting position (Robertson, 1946; Lindgren, 1949) are the frequent occurrence of syncope and the discomfort of maintaining the erect position. Decker (1957) stresses the difficulty of applying general anaesthesia in this position, and remarks that even with the use of x-ray image amplifier and cine-camera, the patient frequently collapses. He therefore elaborated a method of lumbar encephalography in ventral decubitus which he applied especially in children. The administration of the anaesthetic is easier and positioning of the head is stable. Anteflexion of the head, which may be undesirable in patients with increased intracranial pressure, is no longer essential; on the contrary, the head may be placed in a comfortable position.

Morello (1953, 1958) believes that in cases of increased intracranial pressure a pressure cone is more likely to occur when lumbar encephalography is performed in the sitting position. This author also described lumbar encephalography with the patient in the prone position. The main features of this method are as follows. About 40 cc. of air are injected in the lumbar dural sac while the patient is in the Trendelenburg position. The needle is then removed, and by tilting the table slowly 25° upwards the air is moved to the posterior fossa. The author believes that this method is less disturbing to the patient and safer, while enabling good visualisation of the structures of the posterior fossa to be obtained.

Lenzi and Canossi (1956) practising fractional lumbar insufflation with the patient in ventral decubitus on a tilting table, indicated the positions of the tilting table, as well as the angles between Reid's base line and the tilting table, needed for efficient filling of the different posterior fossa structures. Fractional encephalography by means of suboccipital injection, although causing less discomfort to the patient, is rejected by Decker because the needle may obscure important details in the air pictures, because the examiner is insufficiently protected against exposure to x-rays, and because the needle must be withdrawn immediately if the patient collapses.

We have previously described a method of pneumocisterno-ventriculography of the posterior fossa by means of suboccipital injection of air with the patient in the prone position (Verbiest, 1956). This method avoids the disadvantages described by Decker, since the air, before being moved to the posterior fossa, is trapped in the spinal subarachnoid space from the point of injection to the top of the curvature of the thoracic spine. This can be effected during the injection, by placing the patient in a horizontal position with anteflexed head, or if anteflexion is undesirable, the patient's head is tilted slightly downwards by tilting the table. The total amount of air injected was 40-60 mls. The needle is then withdrawn and the air is moved into the posterior fossa by tilting the table. Originally in each lateral picture a spirit level, indicating the horizontal, was radiographed, since this provides information about the position of fluid levels in the airpictures as well as about the position of the head in relation to the horizontal. At first general anaesthesia was used for children though not for adults. This method appeared to cause fewer complications than lumbar insufflation.

RECENT IMPROVEMENTS IN TECHNIQUE

In the following years we improved our technique in regard to:

(1) fixation of the patient's head;
(2) correct adjustment of the midsagittal plane of the head and the central x-ray, ensuring maximal symmetry of the cranial contours in the postero-anterior (P.A.) pictures;
(3) avoidance of distortion in the air pictures by using a perpendicular central x-ray.
(4) the almost simultaneous taking of P.A. and lateral pictures by using two x-ray tubes.
(5) checking on the position of the head in relation to the horizontal, and the direction of the central x-rays through the skull to the corresponding P.A. film. These are radiographed in the lateral film and are important data for prediction of the degree of tilting for optimal filling of the 4th ventricle or the other posterior fossa fluid spaces, and for facilitating the interpretation of the findings in the P.A. picture respectively.

We aimed at the construction of an apparatus fulfilling the above-mentioned criteria, which would be simple and inexpensive, and not too large. The

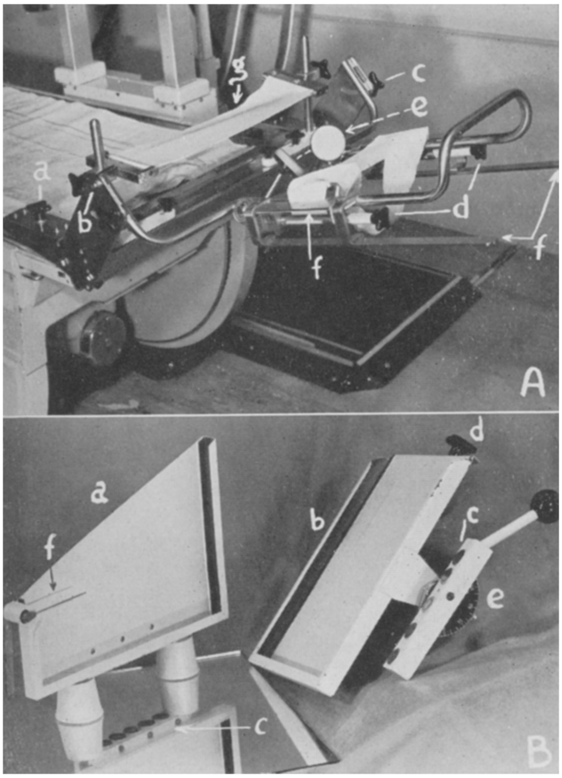

FIG. 1

A—Device attached with screws (a) to ordinary tilting table. Head support can rotate around axis (b) and be fixed in different positions by screws (c). Head fixed between 2 linen straps. Upper strap tightened by screw (d). Padded cheek supports (e). Cassette-holders are placed with their ferro-magnets against metal bars (f). Adjustable support for upper thorax (g). B—Profile (a) and P.A. (b) cassette-holders. Ferromagnets (c), those of profile cassette are reflected in mirror beneath. P.A. cassette-holder can rotate around horizontal axis and is fixed in wanted position by screw (d). Grade-meter (e). Needle indicating the horizontal in profile picture (f).

device that has been constructed can be attached to an ordinary tilting table. It also permits the use of general anaesthesia, providing enough space for the anaesthetic circuit and sufficient access to the patient's head for checking the airway (Fig. 1a). We are greatly indebted to Philips, Eindhoven, for manufacturing this device and to Mr. D. E. Berggren, head of the Philips Mechanical Design Department, who was of great help with the technical details.

I. Fixation of the Patient's Head.—With the patient in the prone position but his head free, a voluntary effort of the patient is needed to keep his head in the position wanted. Movements may occur in the agitated or tired patient or may be induced by vomiting or pain. These movements are especially troublesome at the moment when the 4th ventricle is filled by air, since the air escapes readily to the 3rd and lateral ventricles. The patient's forehead and occiput are fixed between two linen straps (Fig. 1a, 2b-d). The upper strap is tightened by means of screws on both the left and right sides of the head, since one screw would cause rotation of the head. Two padded supports are applied against the patient's cheeks. The fixation of the patient's head also has the advantage that it enables the exact calculation of the degree of tilting needed for adequate filling of the different fluid spaces, as will be described later.

Once the head is fixed the only causes of accidental displacement of air are sudden movements of the spinal or ventricular fluids during coughing or vomiting. These mechanisms could not always be suppressed by premedication, and in recent years pneumography has been performed under general anaesthesia in all our patients.

II. Correct Adjustment of the Midsagittal Plane of the Head.—A mirror with midline engraved is placed in the P.A. cassette holder (Fig. 2b). The central x-rays as well as the midsagittal plane of the head are adjusted to the midline of the mirror. The adjustment of the midsagittal plane of the head includes avoidance of lateral inclination and sideward rotation of the head. For this purpose a special instrument was designed (Fig. 2a) to effect this head position. It has the shape of a horse shoe and is placed by means of supports on the external occipital protuberance and the root of the nose. It has two lateral wings which are placed on the parietal scalp areas. The root of the nose is indicated by means of a sight, which is reflected in the mirror. The opposite, occipital end of the instrument, should point to the vertebra prominens.

In this position of the instrument the midsagittal plane of the skull passes through the dial in front of the instrument and through the spinous process of C VII. When the plumb needle parallels the midline of the dial and points to the midline of the mirror, the midsagittal plane of the skull is adjusted perpendicularly to the midline of the casette holder (Fig. 2b). Additional checking is obtained by looking into the mirror, where the nasal sight and the plumb needle should be reflected in the midline. The dial can rotate around a transverse axis so that the vertical position of the plumb needle is assured and is independent of the degree of flexion of the head. The lateral screws which tighten the upper strap are very useful in correcting minor deflections of the plumb needle.

III. Perpendicular Incidence of Central P.A. x-ray on film.—Oblique central rays are avoided, since they cause distortion of the picture. The P.A. cassette holder can rotate around a horizontal axis, and can be fixed in any position by means of one screw (Fig. 1b). Grade-meters attached to the

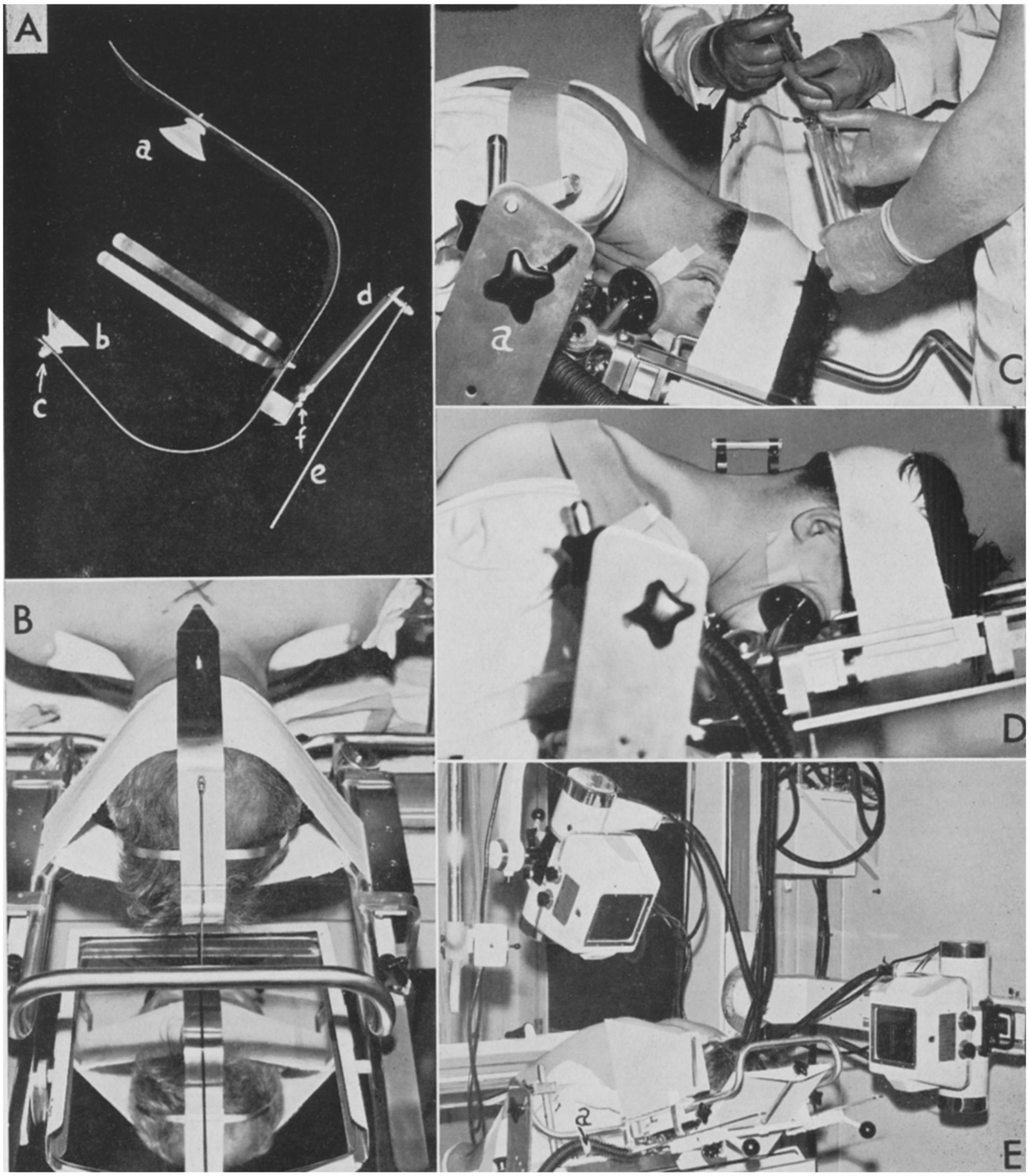

FIG. 2

A—Instrument for adjustment of midsagittal plane of head. Supports on external occipital protuberance (a) and root of nose (b). Nasal sight (c). Dial (d) and plumb needle (e). Dial can rotate around transverse axis (f). B—A mirror with engraved midline placed in P.A. cassette-holder. Upper extremity of the instrument of Fig. A. points to vertebra prominens indicated by a cross. The plumb needle points to midline of mirror and parallels midline of dial. Nasal sight, not visible in picture, also reflected in midline of mirror. C—Head support anteflected and fixed thus by screws (a). Suboccipital puncture and injection of air. D—Spirit level on nape of neck indicates its horizontal position. E—Placement of cassette-holders and positioning of x-ray Tubes. Anaesthetic circuit (a).

P.A. casette-holder and the x-ray tube serve to adjust them, as needed for a perpendicular incidence of the central ray on the film.

IV. The Use of Two x-ray Tubes.—This makes it possible to take the P.A. and lateral pictures within a short interval, which renders the films more comparable (Fig. 5). The cassette holders for the P.A. and lateral films are fixed to the head support by means of ferromagnets allowing rapid placement and removal (Fig. 1b and 2e).

V. Information Radiographed in the Lateral Picture.—a. The horizontal is represented by a needle, which moves around an axis and is provided with a counterweight with plumb function ensuring the horizontal position of the needle. This apparatus is fixed to the profile cassette holder (Fig. 1b). The radiographed horizontal indicates the fluid levels at every position of the head and is of great help in evaluating the inclination of cranial or intracranial structures in relation to the horizontal (Fig. 5). It enables us to estimate the degree of additional rotation needed for filling the 4th ventricle or other structures, as will be described later.

b. Since in every position of the head a pair of corresponding P.A. and lateral pictures is made, the direction of the central ray onto the P.A. picture is radiographed in the lateral by means of a needle pressed perpendicularly on the P.A. cassette-holder by a sucker. The other end is provided with a metal ball in order to distinguish this needle in the picture from the one used for indicating the horizontal (Fig. 5). From this information any desired change in the direction of the central P.A. x-ray can be exactly estimated in degrees. It also facilitates the interpretation of superimposed shadows in the P.A. view.

TECHNIQUE OF EXAMINATION

The patient's posture on the tilting table should be in accordance with the requirements for general anaesthesia in the prone position. Compression of the abdomen should be avoided, the patient being mainly supported below his anterior superior iliac spines and the upper chest and shoulders. An adjustable support for the upper chest and shoulders is connected with the device. After the patient's head has been fixed and positioned in the support as described above (see I and II), the head support is anteflexed or, if anteflexion of the head should be limited, the table is tilted to a slight Trendelenburg position. Suboccipital puncture is performed with a single needle, provided with a two-way stopcock (Fig. 2c).

Following Lindgren's advice to make the injections of air precede the releases of fluid, small quantities of C.S.F. are replaced by air. Although we found that a satisfactory filling of the posterior fluid spaces could be obtained with 25 ml. of air, better results were observed when about 40 ml. of air were injected. We now inject air until its rejection, which occurs after insufflation of 40-60 ml. of air. At this moment the spinal subarachnoid space between C I and the top of the thoracic spinal curvature is filled by the gas. The final injection is made under slightly increased pressure. A spirit level is placed on the neck of the patient and the table is tilted until the spirit level is horizontal (Fig. 2d). In this position the spinal portion of the cisterna magna, the medullary cisterns, and usually part of the intracranial cisterna magna, are filled by air. Sometimes the vallecula is also visualised and if the head is not anteflexed, air may already have penetrated into the 4th ventricle. The P.A. view is taken with the central x-ray parallel to the longitudinal axis of the medulla oblongata, as indicated by Robertson, in order to visualise the medullary cisterns and the air surrounding the dorsal portion of the medulla oblongata. In order to obtain clear pictures the head should be anteflexed on the neck.

There are two ways of determining the degree of inclination of the P.A. central x-ray to the skull. The most precise method is to first take the lateral picture

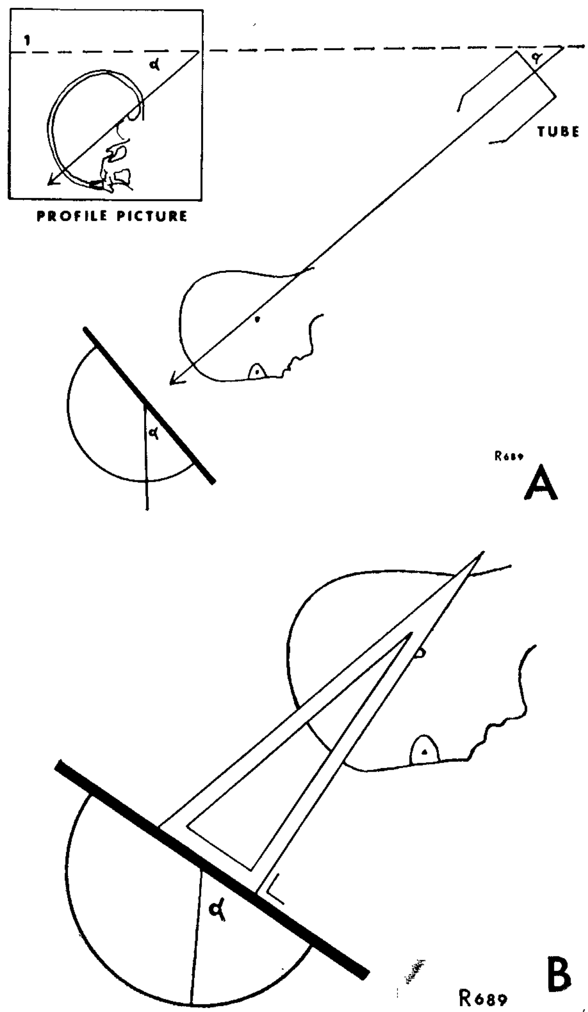

Fig. 3

A—Determination of inclination of P.A. x-ray Tube. In relation to the horizontal, radiographed in profile picture. B—Rougher estimation.

ture. The desired direction of the P.A. x-ray is drawn in this picture, and from the angle between this line and the radiographed horizontal the angling of P.A. tube and cassette holder can be evaluated (Fig. 3a). A rougher estimation is obtained when employing a right-angled triangle as used in drafting. Its long right side is placed beside the patient's head, parallelling the desired P.A. central x-ray, while the surface of the P.A. cassette holder is adjusted against its base. When the cassette is fixed in this position by means of the screw, its grademeter indicates the desired angling of the corresponding x-ray tube (Fig. 3b). After the profile and P.A. pictures have been taken the degree of upward tilting for filling the 4th ventricle is calculated. In order to save time and x-ray dosage it is of importance to predict with greatest possible certainty to what angle some straight line reference in the plain x-ray picture of the skull should be rotated upwards to obtain constant and satisfactory filling of the 4th ventricle independent of its normal anatomical variations. In the literature the line of reference most frequently used is the *orbito-meatal line.*

We have used the *clivus line*, a line drawn between the root of the dorsum sellae and the anterior margin of the foramen magnum.

The prediction of the necessary upward rotation of the clivus-line resulting in filling of the 4th ventricle independent of its normal variations, is based on a knowledge of:

(a) The variation in the angle between clivus-line and floor of the 4th ventricle.

(b) The range of angles between the floor of the 4th ventricle and the horizontal leading to its satisfactory filling by air.

Angle Between Floor of 4th Ventricle and the Clivus Line.—Measurements were made on "normal" pneumoencephalographic records in 52 adult patients of the present series and on those of 7 additional patients, performed after this period. All measurements were repeated on different days and it appeared that they could be subject to errors of + or — 3 degrees.

In each case the mean values were calculated. Fig. 4 shows the histogram of the frequency distribution of the angle between the clivus line and the floor of the normal 4th ventricle. Angles greater than 25 degrees were rare and angles less than 10 degrees were not found. Measurements in our cases with abnormal findings did not result in deviation from the normal values, with the exception of some pontine tumors where the floor, or part of it, parallelled the clivus line.

No correlation could be established between this angle and the vertical index or the basal angle of the corresponding skulls; neither was there a correlation between the 4th ventricle-clivusline angle and the vertical index and basal angle taken together. We found that in all 4th ventricle-clivusline angles under 15 degrees the basal angle of the skull was over 125 degrees, and in all 4th ventricle-clivusline angles over 23 degrees the basal angle was less than 120

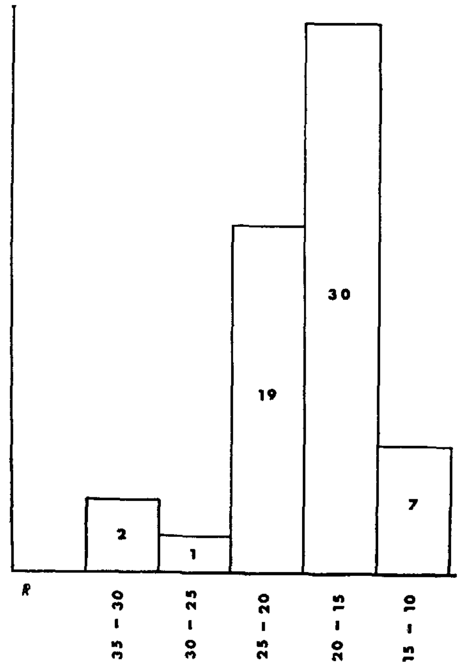

FIG. 4
Frequency distribution of angle between floor of 4th ventricle and clivus.

degrees, but the total number of cases is too small to draw definite conclusions.

The Angle Between the Floor of the 4th Ventricle and the Horizontal in Relation to the Filling of the 4th Ventricle by Air.—Since the horizontal is radiographed in the profile picture the filling of the 4th ventricle at different angles of its floor with the horizontal could be easily measured. In all cases at least three different angles could be measured and after the 4th ventricle-clivusline angle had been measured, it was also possible to determine at what angle between 4th ventricle and the horizontal the air had not yet entered into, or escaped from the 4th ventricle. The angle was called positive when the rostral extremity sloped upward in regard to the horizontal and negative when it sloped downward.

From these measurements the following conclusions could be drawn: In all but one case where satisfactory filling of the 4th ventricle occurred at positive angles of 2-10 degrees no air, or only a faint indication of it, was present in the posterior part of the 3rd ventricle. In 3 cases this phenomenon was still observed at angles of 13, 16 and 17 degrees, respectively.

In one case the filling of the posterior part of the 3rd ventricle as well as of the occipital horns of the lateral ventricles occurred already at an angle of + 7. Angles between + 10 and 25 degrees resulted in the filling of both the 4th ventricle and the posterior part of the 3rd ventricle.

Escape of air to the occipital horns of the lateral ventricles occurred at angles over 25 degrees; in a few cases this occurred already with angles between 15 and 25 degrees, and in one, already mentioned, at + 7 degrees. With angles over 35 degrees the 4th ventricle emptied.

Use of the Angle Between the Clivus Line and the Horizontal for Filling the 4th Ventricle with Air.—The foregoing data show that with an angle of — 5 degrees between clivus line and the horizontal the frequency distribution of the angle between the floor of the 4th ventricle and the horizontal will

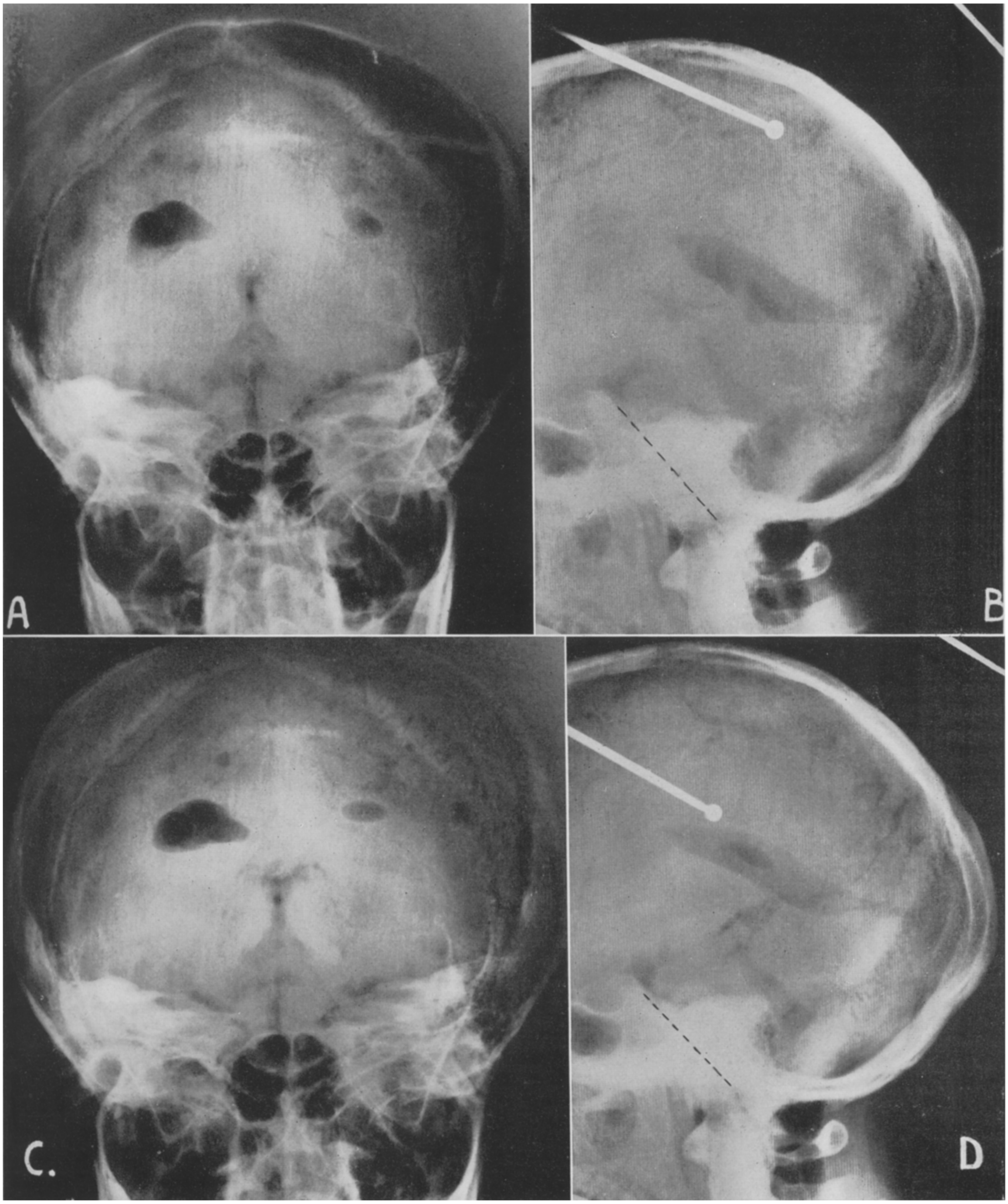

FIG. 5

A and B—Horizontal clivus-line results in filling of 4th ventricle, cerebello-pontine, pontine and interpenduncular cisterns. C and D—Positive angle of clivus-line with horizontal of 15 degrees; now the ambient cisterns are filled, but 4th ventricle is emptying. Clivus-line represented by interrupted line. Needle with ball at its end represents direction of central P.A. x-ray. In top right-hand corner horizontal is radiographed. In lower pair of pictures horizontal is drawn to save space, since horizontal needle is more deflected from skull circumference in this position.

vary, according to fig. 4, from 30 to 5 degrees. With the exception of the few cases with small angles between the clivus-line and 4th ventricle where filling will be achieved in only part of the cases, the others will be well visualised. Therefore the angle between the clivus line and the horizontal is measured in the first profile picture and this angle minus 5 degrees represents the degree of upward tilting necessary for visualising the 4th ventricle. The upward rotation may be effected by tilting the table or the headsupport or a combination of both. Before proceeding to this rotation the P.A. cassette is angled to the Towne position. In the group with small angles between 4th ventricle floor and clivus an additional 10 degrees upward rotation may be necessary.

In many cases where the 4th ventricle is filled, the ponto-cerebellar and ambiens cisterns are well visualised, but when these structures are not yet filled an additional upward rotation of 10 degrees is made. Filling of the pontine and interpenduncular cisterns occurs at positive angles between the clivus line and the horizontal.

Usually all desired information is obtained by 3 postero-anterior and 3 profile radiographs. In the group with abnormal findings there is one special category, viz. the cerebellar atrophies, where ventricular filling occurred at negative angles between 4th ventricle floor and the horizontal, varying from —13 to —2 degrees in 6 cases. Four had also dilated lateral ventricles and two had not. In three other cases of cerebellar atrophy complete filling of the 4th ventricle occurred with its floor in the horizontal position, none of them having a dilatation of the lateral ventricles of any importance. In those cases the filling of the posterior portion of the third ventricle and the occipital horns of the lateral ventricles also occurred at lower angles than in normal cases. Since most of these patients had been examined under general anaesthesia this early filling could not be caused by aspiration into the ventricles following the expulsion of fluid during coughing or straining. We have no explanation for this phenomenon.

Further Technical Points.—When the inferior limit of the air in the 4th ventricle parallels the horizontal in the profile picture, there is a possibility that it represents a fluid level, especially in dilated 4th ventricles. Therefore visualisation of the floor of the 4th ventricle can only be accepted with certainty if it makes a positive angle with the horizontal.

Pneumatisation of the mastoids may obscure the 4th ventricle in the profile view. In this case, before the 4th ventricle has emptied, autotomography according to the Ziedses des Plantes procedure is performed.

CONTRAINDICATIONS

An absolute contraindication is papilledema, rigidity of the neck, or other gross signs of intracranial hypertension. In cases of cerebellar or 4th ventricle tumors we obtained better pictures by performing ventriculography with small amounts of air, according to the Ziedses des Plantes method. If a correctly performed suboccipital puncture results in a dry tap the procedure should be discontinued. In cases of fusion of the atlas with the occipital bone or when the presence of an Arnold Chiari malformation is highly probable the cervical subarachnoid space may be punctured between C I and C II according to the technique of Sicard. This procedure is one for expert hands only.

INDICATIONS

The principal indication for applying our method of posterior fossa cisterno-ventriculography were: (a) Brain stem and pontine angle syndromes; (b) degenerative cerebellar disease and acute ataxia; (c) involvement of posterior fossa nerve roots where vertebral angiography has ascertained the absence of an aneurysm; (d) syndromes of syringomyelia, syringo-ponto bulbia, skeletal deformities of the cervical-occipital area, or a combination of any of them, particularly with the presence of an Arnol Chiari malformation; (e) atypical chronic occipital neuralgia (e.g. with increased C.S.F. protein content).

RESULTS

The effectiveness of our method is expressed in the following detailed report. Abnormal findings were recorded in 46 cases.

(a) **Tumors.**—As mentioned under contraindications, the indications in posterior fossa tumors are limited and chiefly formed by those of the pontine-angle or the region of the petrosal apex, and tumors mainly extending within the brain stem. The results of our method are given in Tables I and II.

Our findings with tumors in the pontine angle or near the petrosal apex are in accordance with the descriptions given by Liliequist (Fig. 6a-d). In all cases the air pictures provided ample information for the diagnoses. The same applies to pure mesencephalic-pontine or pontine tumors. The pontine tumors extending into the cerebellum or the pontine angle could not be recognized as such by means of the air pictures alone, but the diagnoses were made by combining the pictures with the clinical signs and symptoms.

(b) **Arnold Chiari Malformation in Adults.**—The Arnold Chiari malformation in infants associated with spina bifida and hydrocephalus is more readily diagnosed by ventriculography (via the fontanel) with a small quantity of air, using Ziedses des Plantes' procedure, as we demonstrated in an earlier paper (Verbiest, 1953).

It allows the demonstration of a concomitant atresia of the aquaduct, the visualisation of an

TABLE 1

TUMORS OF PONTINE ANGLE AND PETROSAL APEX. (all verified at operation)

	Cerebello-pontine angle tumors: 9 cases	Trigeminal neurinomas: 2 cases	Ependymoma of pontine angle: 1 case	Reticulo sarcoma petrosal bone: 1 case
Tonsillar herniation:	absent: 8 slight: 1	slight: 2	tumor extending into cisterna magna	absent
Fourth ventricle	perfect filling and displaced: 6 normal position: 1 poor filling and displaced: 1 no filling: 1	displaced and perfect filling: 2	filling of rostral portion	displaced and perfect filling
Pontocerebellar cisterns	no filling ipsilateral: 7 no filling on both sides: 1 bilateral filling but partial on involved side: 1	partial filling of ipsilateral: 1 no filling of ipsilateral: 1	no filling of ipsilateral	no filling of ipsilateral
Ambient cisterns	bilateral filling but elevation or widening on involved side: 7 poor filling: 2	elevation and widening of ipsilateral: 1 no filling: 1	asymmetric filling	elevation of ipsilateral
Medullary cisterns	ipsilateral widening: 8 symmetric filling: 1	ipsilateral widening: 1 symmetric filling: 1	no filling	widening of ipsilateral
Tumor outlined by air	6 cases	2 cases	1 case	—

TABLE 2

TUMORS OF BRAIN-STEM: 6 CASES. (All verified at operation or (and) autopsy)

	Mesencephalic-pontine: 2 cases	Pontine: 2 cases	Pontine, with outgrowth in pontocerebellar angle: 1 case	Pontocerebellar: 1 case
Tonsillar herniation	absent	absent	down to C I	halfway foramen magnum and C I
Fourth ventricle and vallecula	well filled angulation in rostral part of its floor	well filled with its floor parallelling the clivus	no filling	small and displaced
Pontocerebellar cisterns	normal	normal	absent on ipsilateral side; normal on opposite side	poorly filled
Ambient cisterns	small: 1 case no filling: 1 case	normal	small on ipsilateral side; normal on opposite side	normal
Pontine cistern	normal	flattened	flattened	flattened
Medullary cisterns	normal	no filling	no filling	not filled
Cisterna magna	well filled	well filled	small	small

elongated 4th ventricle, the checking of the communication between 4th ventricle and the spinal subarachnoid space, the demonstration of the cerebellar herniation into the spinal canal, and the patency of the basal cisterns. At first we also used ventriculography in adults, in whom the presence of an Arnold Chiari malformation was considered.

In a number of cases spinal insufflation of air may save the patient from ventriculography. In most patients the air could be injected between the foramen magnum and C I, but in some of them the puncture was applied between C I and C II. In case of dry tap the procedure is discontinued.

In our experience (Table III) satisfactory visualisation of the malformation was obtained when the elongated cerebellar tonsils projected no further downward than the posterior arch of the atlas.

No filling of the 4th ventricle was obtained when the tonsils reached as far as C II. Besides, in part of this group the pontocerebellar, ambient, and medullary, cisterns were not filled by air and operative exploration revealed a marked arachnoiditis. In

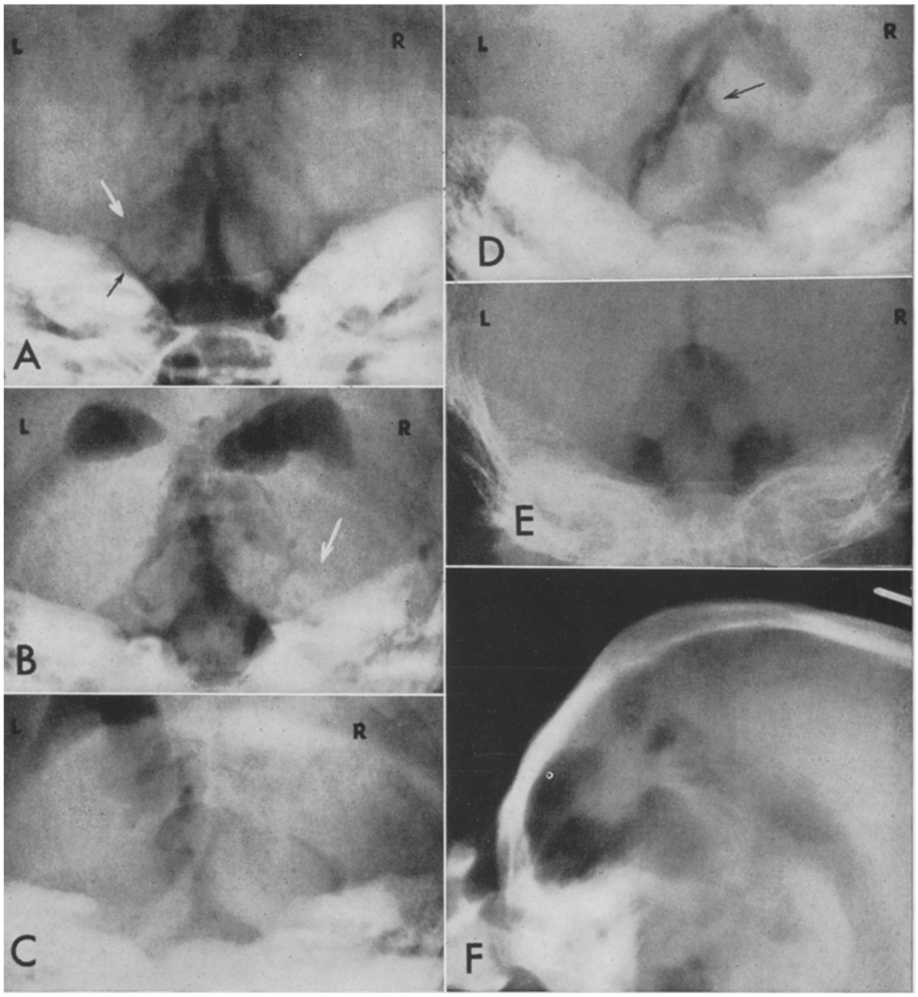

FIG. 6

A—Small left-sided acoustic neurinoma outlined by air (arrows), slight dilatation of ipsilateral ambient cistern. B—Walnut-sized right-sided acoustic neurinoma (arrow) and widened ambient and medullary cisterns ipsilaterally. C—Large right-sided acoustic neurinoma completely outlined by air: Displacement of 4th ventricle to the left. D—Ependymoma extending in intracranial cisterna magna and partly in right pontine angle. Dilated right ambient cistern. Tumour outlined by air. Only the rostral part of 4th ventricle filled by air (arrow). E—Infantile cerebellar atrophy; widening of 4th ventricle and of medullary and pontocerebellar cisterns. F—Profile view of same case as in 6 E.

this category of patients the examination should be completed by a ventriculography, unless the neurosurgeon feels justified to refrain from this procedure because of the presence of skeletal deformaties in the cervical-occipital area or the clinical picture, e.g. that of hydromyelia. Two of the Arnold Chiari patients had intermittent gastric or intestinal disturbances, a peculiar symptom described by Garcin and Oeconomos (1953).

(c) Cerebellar Atrophies.—Twelve cases have been examined (Table IV). The table demonstrates that the congenital forms can be divided into pure cerebellar atrophies and those associated with cerebral atrophy. This difference was also expressed in the clinical symptomatology. In three out of 5 adult cases the cerebellar atrophy was associated with cerebral atrophy, in the other two the lateral ventricles were unfortunately not examined.

The congenital forms all displayed marked dilatation of the 4th ventricle, the foramen of Magendie, and the posterior fossa cisterns, except the ambient cisterns (Fig. 6e and f). In the adult forms, the posterior fossa cisterns were not dilated, while 4 of the 5 cases showed slight to moderate dilation of the 4th ventricle, and only one displayed marked widening.

Collection of air over the cerebellum, giving a picture of marked cerebellar foliation, was demon-

TABLE 3

ARNOLD CHIARI MALFORMATION IN ADULTS: 10 CASES

	Tonsillar elongation down to inferior margin of C II: 5 cases, I-V	Tonsillar elongation down to C I: 1 Case, VI	Tonsillar elongation down to halfway for. magnum and C I: 4 cases, VII-X
Fourth ventricle and vallecula	no filling: I and IV (marked arachnitis at operation)	filling of 4th ventricle, not of vallecula	well filled in all cases
Pontocerebellar cisterns	Well filled in 3 cases: II-III-V	poorly filled	well filled in all cases
Ambient cisterns	well filled in 3 cases: II-III-V	no filling	well filled in all cases
Medullary cisterns	well filled in 2 cases: II and III	no filling	well filled in all cases
Cisterna magna	small in all cases	small	large in 2 cases: VII and VIII small in 2 cases: IX and X

The roman numerals indicate the case numbers:

I.—Fusion of atlas to occipital bone and spastic-atactic syndrome, nystagmus;
II.—No skeletal malformation, pontine and atactic symptoms;
III.—No skeletal malformation, syndrome of cervical syringomyelia;
IV.—No skeletal malformation and ponto-mesencephalic syndrome;
V.—No skeletal malformation, spastic syndrome with intermittent exacerbations accompanied by painful tenesmus and incontinence of feces;
VI.—Basilar impression and syringomyelia;
VII.—No skeletal malformation and syndrome of cervical syringomyelia;
VIII.—Anomalies of atlanto-occipital joints and spastic-atactic syndrome;
IX.—No skeletal anomalies and syndrome of cervical syringomyelia;
X.—Basilar impression, fusion of atlas to occipital bone, cephalea, hollow feet and intermittent abdominal pains.

All cases with the exception of case IX were verified at operation.

strated in 4 of 5 adults, and 1 of 7 congenital cases. Case 4 presented air in the superior cerebellar cistern.

In all 12 cases the present method of posterior fossa encephalography resulted in a satisfactory demonstration of the anomalies.

(d) **Miscellaneous Cases.**—In two cases of non-tumoral pontine angle syndromes the ponto-cerebellar cistern on the involved side was not visualised, while all the other posterior fossa fluid spaces could be filled by air and appeared to be normal. A possibility of arachnoiditis was considered.

In a third case a deformity in the ipsilateral ponto-cerebellar cistern appeared at operation to be caused by a large, but otherwise normal, flocculus. In a patient with an otogenous, laterally localised, cerebellar abscess where ventriculography failed to fill the fourth ventricle, our method failed as well and only demonstrated the presence of tonsillar herniation.

In an infant with communicating hypertensive ventricular dilatation and obstruction in the anterior part of the basal cisterns the air pictures demonstrated a small filling defect in the anterior border of the spinal cisterna magna. Operation revealed a pea-sized ependymoma attached to the dorsal surface of the spinal medulla. The relation between this lesion and the communicating hydrocephalus was not established.

(e) **Normal Airpictures.**—In 54 cases the air pictures did not demonstrate expansive, atrophic, or obliterative processes and therefore the anatomy of the posterior fossa fluid spaces was considered normal.

These cases were particularly interesting since they supplied the material for measurements and positioning, in regard to the filling of the different fluid spaces.

In 52 of 54 cases the 4th ventricle was well visualised and in 46 cases complete filling of all posterior fossa fluid spaces was obtained. In 5 cases there was complete filling of the posterior fossa cisterns except for the ambient cisterns and in one case complete filling with the exception of poorly filled pontocerebellar cisterns.

In two cases only the intracranial and spinal cisterna magna were visualised, while the rest of the air had escaped to the subdural space. In one of the two patients a repeated insufflation of air a fortnight later again resulted in a subdural escape of air.

TABLE 4, a

CEREBELLAR ATROPHY: 12 CASES

CONGENITAL CEREBELLAR HYPOPLASIA: 6 INFANTS AND ONE ADOLESCENT

Associated with cerebral atrophy	Age	Congenital cerebellar symptoms	Other symptoms	Vallecula. for. magendie and 4th ventricle	Posterior fossa cisterns	Lateral and 3rd ventricle
Case 1:	3 y.	present	mental retardation; epilepsy	marked dilatation	all dilated with the exception of poorly filled ambient cisterns	slight dilatation
Case 2:	3 y.	present	mental retardation; epilepsy	marked dilatation	no filling of ambient cisterns; all other cisterns markedly dilated. P.	moderate dilatation
Case 3:	11 y.	present	spasticity; mental retardation and progressive deterioration	marked dilatation	normal ambient cisterns; all other cisterns markedly dilated	pronounced dilatation
Not associated with cerebral atrophy						
Case 4:	7 y.	present	none	marked dilatation	normal pontine and ambient cisterns; all other cisterns markedly dilated	normal
Case 5:	4 y.	present	none	marked dilatation	as in case 4	normal
Case 6:	3 y.	present	none	marked dilatation	no filling of ambient cisterns; other cisterns markedly dilated	left lateral ventricle slightly wider than right. No obvious dilatation
Case 7: Telangiectatic cerebellar atrophy	17 y.	present	dysarthria; choreatic movements telangiectases of ocular conjunctivae	marked dilatation	large cisterna magna; dilated medullary cisterns procedure interrupted by non-co-operative patient	normal

TABLE 4, b

ACQUIRED CEREBELLAR ATROPHIES IN ADULTS

	Age	Duration of illness	Symptoms	Vallecula, for. magendie, 4th ventricle	Posterior fossa cisterns	Lateral and 3rd ventricles
Case 8:	64 y.	4 y.	ataxia; deafness; pontine symptoms	slight dilation	complete filling of normal cisterns. P.	not filled
Case 9:	46 y.	10 y.	ataxia; vertigo; deafness	moderate dilatation	no filling of ambient cisterns; poor filling of ponto-cerebellar cisterns. normal other cisterns. P.	dilated (and dilated cerebral sulci)
Case 10:	60 y.	2, 5 y.	ataxia	slight dilatation	complete filling, normal cisterns. P.	dilated
Case 11:	44 y.	2 y.	ataxia	slight dilatation	complete filling, normal cisterns. P.	not filled
Case 12:	45 y.	several years	psycho-neurotic syndrome and neurovegetative disturbances; examination performed because of finding of widened 4th ventricle at routine pneumo-encephalography	pronounced	complete filling, normal cisterns	dilated

P.=collection of air over the cerebellum with marked cerebellar foliation.

Normal findings were recorded in patients with the following clinical diagnoses:—

	cases
Menière and pontine angle syndromes:	19
Vertigo:	3
Non-tumoral pontine syndromes:	9
Cervical syringomyelia:	3
Cervical hydromyelia accompanied by skeletal cervical-occipital deformity:	2
Cervical-occipital skeletal anomaly:	1
Acute ataxia:	3
Heredo-ataxias or congenital tremors:	3
Trigeminal neuropathy (see Spillane and Wells):	2
Other involvement of posterior cranial nerve roots, including 3 cases of carcinomatous meningitis:	6
Atypical occipital neuralgia:	3
	54

SUMMARY

A technique is described for posterior fossa encephalography and cisternography with the patient in a prone position on a tilting table. It permits stable fixation and exact positioning of the head and allows general anaesthesia with good access to the patient's airway. Experiences in 100 patients are reported and analysed.

REFERENCES

DECKER, K. (1960). *Klinische Neuroradiologie.* Stuttgart: Thieme.

DECKER, K. (1957). *Fortschr. Röntgenstr.*, **87**, 707.

GARCIN, R. & OECONOMOS, D. (1953). *Les aspects neurologiques des malformations congénitales de la Charnière Cranio.* Paris: Masson.

LENZIE, M. & CANOSSI, G. C. (1956). *Acta radiol.*, **46**, 87.

LILIEQUIST, B. (1959). *Acta radiol.* Suppl., **185**.

LILIEQUIST, B. (1959). *Acta radiol.* Suppl., **186**.

LINDGREN, E. (1949). *Acta radiol.*, **31**, 161.

MORELLO, A. (1953), *J. Neurosurg.*, **10**, 552.

MORELLO, A. (1958). *Acta Neurochir.*, **6**, 81.

ROBERTSON, E. G. (1941). *Encephalography.* Melbourne: McMillan.

ROBERTSON, E. G. (1946). *Further Studies in Encephalography.* Melbourne: McMillan.

ROBERTSON, E. G. (1957). *Pneumoencephalography.* Springfield: Thomas.

VERBIEST, H. (1953). *J. Neurol. Neurosurg. Psychiat.*, **16**, 227.

VERBIEST, H. (1956). *Brit. J. Radiol.*, **29**, 440.

VERBIEST, H. (1958). *Acta Neurochir.*, **6**, 233.

ZIEDSES DES PLANTES, B. G. (1950). *Acta radiol.*, **34**, 399.