AN ATLAS OF POLYTOME PNEUMOGRAPHY

WITH PARTICULAR REFERENCE TO THE MIDLINE VENTRICLES OF THE BRAIN

TAHER EL GAMMAL
M.B., Ch.B., D.S., F.F.R.

MARSHALL B. ALLEN, Jr.
M.D.

AN ATLAS OF

POLYTOME PNEUMOGRAPHY

With Particular Reference to the Midline Ventricles of the Brain

---

By

TAHER EL GAMMAL, M.B., Ch.B., D.S., F.F.R.
Section of Neuroradiology
Medical College of Georgia
Augusta, Georgia

and

MARSHALL B. ALLEN, Jr., M.D.
Section of Neurosurgery
Medical College of Georgia
Augusta, Georgia

Assisted by

Paul Dyken, M.D.
Section of Pediatric Neurology
Medical College of Georgia
Augusta, Georgia

THOMAS BOOKS SYMBOL OF LEADERSHIP

CHARLES C THOMAS • PUBLISHER
Springfield • Illinois • U.S.A.

Published and Distributed Throughout the World by

CHARLES C. THOMAS • PUBLISHER
Bannerstone House
301-327 East Lawrence Avenue, Springfield, Illinois, U.S.A.

ISBN 0-398-03531-8

Library of Congress Catalog Number: 75-35561

With THOMAS BOOKS careful attention is given to all details of manufacturing and design. It is the Publisher's desire to present books that are satisfactory as to their physical qualities and artistic possibilities and appropriate for their particular use. THOMAS BOOKS will be true to those laws of quality that assure a good name and good will.

Library of Congress Cataloging in Publication Data

El Gammal, Taher, 1932–

An atlas of polytome pneumography.

Includes index.

1. Pneumoencephalography—Atlases. 2. Tomography—Atlases. I. Allen, Marshall B., joint author. II. Title.
RC386.5.E38 616.8'04'754 75–35561
ISBN 0–398–03531–8

Printed in the United States of America

Z—11

INTRODUCTION

Conventional pneumography has been used to evaluate intracranial structures for over half a century. It has proved to be a dependable means of demonstrating mass lesions, deep and superficial atrophy and porencephaly.

Computer assisted tomography (CAT) represents a new and, indeed, revolutionary dimension in the examination of the intracranial structures. The technique, not only outlines mass lesions of the cerebral hemispheres, but it indicates their relative density and the amount of displacement of adjacent structures. CAT is most efficient in demonstrating ventricular size and it is a sensitive indicator of the size and location of intracranial hemorrhage. Most importantly, patients undergoing CAT do not experience the discomfort or hazards of air or other contrast media placed in the subarachnoid or ventricular spaces. Thus, for most lesions of the cerebral hemispheres and for some lesions of the posterior fossa, air contrast encephalography is being replaced by CAT. This is not to mention angiography which supplanted pneumography for the identification of most mass lesions of the cerebral hemispheres almost two decades ago.

Why then should there be a new atlas of pneumography, especially at a time when newer techniques of identifying intracranial lesions are proving to be so successful? First, the polytome has added new sensitivity to pneumography, but it requires specialized techniques. For selected lesions, polytome pneumography cannot be equaled by other currently available diagnostic procedures. It can outline, with great precision, lesions in and adjacent to the sella where the CAT may be of limited value. Its capabilities far exceed those of the CAT for identifying both mass and atrophic lesions in the midline and posterior fossa where dense bone produces distortion in the CAT. Few institutions routinely utilize polytomography when performing air studies. We anticipate that it will be more commonly used in the future. It seems appropriate that an atlas which records the current techniques and the capabilities of modern equipment should be available. Finally, since there are areas in which pneumography is required for diagnosis, some patients must continue to experience the inconvenience and even dangers associated with this invasive procedure. It is therefore imperative that those patients receive the best possible examinations. We believe that polytomography offers optimal pneumographic recordings and that the techniques required for efficient use of the polytomographic examinations may not have been developed to fullest advantage in many institutions.

This atlas concentrates in areas where we feel that polytome pneumography offers the most advantages over other diagnostic procedures. In hydrocephalus, it usually identifies the site and nature of obstruction with great precision. While cerebral atrophy can be clearly demonstrated on the CAT scan, cerebellar atrophy is less well defined. The polytome clearly outlines these hidden atrophic lesions. Lesions in and around the sella are emphasized because this is an area where we believe that pneumography will be required, at least in the foreseeable future. Also, the polytome appears to be most efficient in demonstrating localized deformity of the temporal horns of the lateral ventricles, whether due to atrophy or medially placed intrinsic neoplasms. This is an area where the CAT may have limited value.

Finally, we have found polytome pneumoencephalography to be exceptional in demonstrating normal anatomy of the ventricular system and subarachnoid pathways near the base of the skull, demonstrating the size, shape and location of the normal foramina, canals, blood vessels and cranial nerves as well as the brain stem and surrounding structures. We anticipate that there will be fewer air studies in the future than in the past. It is therefore appropriate that our collected experience on the normal anatomy of the central nervous system using these techniques be recorded.

In this atlas we have concentrated on the findings of polytome pneumography, but where possible and appropriate, we have made correlations with angiography, positive contrast ventriculography, and CAT examinations. Relative values of these different examinations are demonstrated.

We propose that this atlas will be of interest to the neuroradiologists, the neurologists and neurosurgeons as well as the student of anatomy of the nervous system.

T. El Gammal
Marshall B. Allen, Jr.

ACKNOWLEDGMENTS

Secretarial Support

Mrs. Joyce Utley
Miss Ann Hodson

Reproduction of X-Rays

Deborah Feagin, R. T.
Tom Chumley
Kodak Company

Most of the Procedures Done

Nancy Lavin, R.T.

For His Support

W. H. Pool, Jr., M.D.

Kodak Company

For their advice in the
reproduction of the x-rays

Medical Illustrations

Mr. Nelson Harris for
reproduction of x-rays

CONTENTS

AN ATLAS OF
POLYTOME PNEUMOGRAPHY

CHAPTER I

TECHNIQUES FOR EXAMINING THE BRAIN AND SPINAL CORD WITH AIR

ROUTINE USE of the polytome in conjunction with pneumoencephalography was reported by Amundsen (1969). Our experiences with polytome pneumography began in 1968 and we have now examined several hundred patients. Our techniques have differed slighty from those of Amundsen in that he used a specifically designed chair for performing the procedures while we have continued to use the small stool which is provided by the manufacturer of the polytome unit.

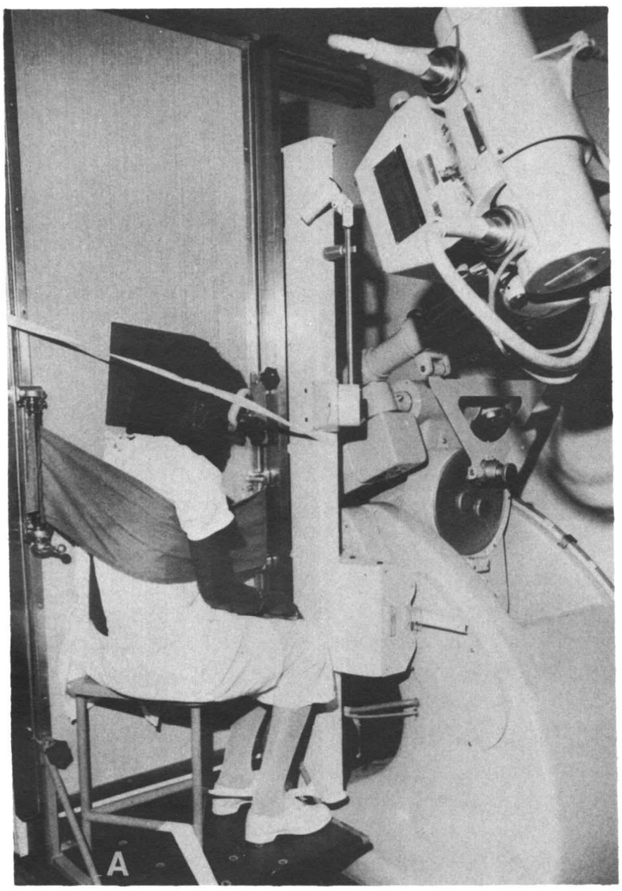


Figure I. 1 (a)

Successful polytomography requires absolute immobilization of the part being examined. Optimally for pneumoencephalography, a special chair with facilities for fixation and somersaulting should be used. None of the currently available somersaulting chairs functions optimally with the intact Philips Polytome Unit because of the limited space between the examining table and the radiographic tube. One company has developed a chair which may be used in the space available but it is not ideal for routine examinations. Stitt (1972) has modified the polytome unit by removing the table top, thus providing more space for a somersaulting chair, but this limits the capabilities of the unit for other procedures. One of our collaborators is attempting to develop a new chair for use with the polytome unit. In the interim we continue to use the original stool.

A. PNEUMOENCEPHALOGRAPHY

Technique

The patient is placed in the lateral decubitus position on the horizontally positioned table. His hips and knees are flexed and the triangular stool, provided with a polytome unit, is positioned below the patient's buttocks. After lumbar puncture with a 20 gauge spinal needle, the spinal fluid pressure is measured. The patient's body is strapped to the table by a pressure band. The table top is then rotated to the vertical position, leaving the patient sitting on the stool supported by the foot rest of the polytome table.

The head, supported with plastic foam pads, is fixed to a head holder in 15 to 20 degrees of flexion (See Fig. I–1a). Ten cc. of filtered air are introduced into the spinal canal and preliminary lateral tomograms of the craniocervical junction are taken to determine the position of the cerebellar tonsils. After injection of 30 to 40 cc. more air, in the adult, or 10 to 30 cc., in the child, repeat lateral tomograms are obtained to outline the midline ventricles and subarachnoid spaces of the posterior fossa. Of course, one may take tomographic cuts to outline the cervical spinal canal if this is desirable.

The patient's head is rotated 90 degrees in the vertical plane to face the polytome table top and again fixed to the head holder with pressure cups (See Fig. I–1b). It is important not to extend the neck during this rotation since this would allow air to escape from the midline ventricles. In this position, eight tomographic cuts are made at intervals four to five mm. beginning at the level of the foramen magnum and extending to the interpeduncular fossa.

Lateral tomograms are then made with the patient in the sitting position after the neck is extended (See Fig. I–1c). These films outline the brain stem, hypothalamus, suprasellar region and fluid filled anterior third ventricle.

After the needle is removed, the patient is repositioned so that his back is against the table top. The table is then rotated into the horizontal position where 4 to 8 additional tomograms outline the foramina of Monro, suprasellar region, the basal ganglia and the anterior part of the lateral ventricles. Repositioning of the patient may be required to fill the temporal horns.

For lateral views of the anterior third ventricle, the patient is moved to a Mutural chair (See Fig. I–1d) and the head is placed in the hanging position. The midline of the patient is usually adjusted at 22 to 23 cm. from the top of the table.

Modification for Infants and Children

With one minor modification, the same techniques described above may be used to examine children over the age of five years. The modification is in the lateral view made with the head hanging to visualize the anterior third ventricle. A cushion is placed on the chair below the patient's buttocks to enable proper centering for the tomograms.

For children below one year of age, a special cradle (vide-infra) is used. It may be attached to the table with the infant fixed in the sitting position (See Fig. I–2a). For children between 1 and 5 years of age, the same technique used for adults is used except that lateral tomograms of the third ventricle are made in the "head-down" position while the patient is fixed in the special cradle.

Children under 1 year of age are premedicated with Demerol®, Thorazine® and Phenergan®, doses depending upon the body weight. (Generally we used 2 mg. of Demerol, 1 mg of Thorazine and 1 mg. of Phenergan per kilogram BW). Children between the age of 1 and 12 to 15 years require general anesthesia. Cooperative adolescents and adults receive a mild sedative about one hour prior to undergoing encephalographic examinations, which are performed under local anesthesia.

B. VENTRICULOGRAPHY

In the past, we have used ventriculography as the initial diagnostic procedure on all patients suspected of having hydrocephalus. We anticipate that, in the future, most of suspected hydrocephalus will have a CAT scan as the initial evaluation in order to avoid unnecessary needling of the brain. Infants who have dilated ventricles in association with obvious dysraphic lesions will probably have a shunt implanted after which a detailed examination with air will be performed. Air will be injected through a Rickham reservoir.

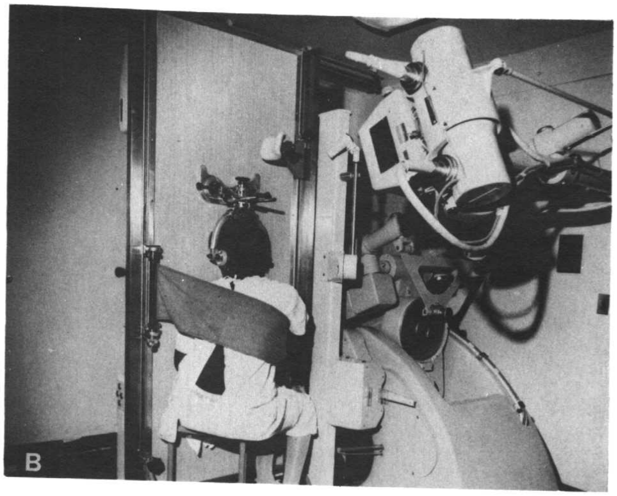


Figure I. 1 (b)

In patients without dysraphic lesions, detailed evaluation of midline structures will continue to be obtained after the initial CAT with polytome air studies. Air will be injected through a puncture of the larger lateral ventricle or by lumbar puncture when one is prepared to perform a ventricular tap. Air may be injected by both ventricular and lumbar routes in cases of complete block. Gases are introduced into the ventricular cavities frequently by direct puncture through the anterior fontanel in infants and young children. In young children, whose fontanels have closed, we often use puncture of the ventricles with a needle passed through the cranial suture. In older children and adults, requiring ventriculography, the gases are introduced through previously placed burr holes or ventricular catheters.

Initial ventriculographic examinations are made on infants after the introduction of 20 to 40 cc. of gas. After x-rays in the brow-up and brow-down positions, patients, below the age of 5 years, are fixed to a special cradle to evaluate the midline ventricles. It is imperative that the head be fixed in the straight frontal plane so that the air will be trapped in the midline structures rather than escaping to the enlarged lateral ventricles when the infant or child is rotated to the "head-down" position (See Fig. I–2b). Tomograms are made in the frontal and lateral planes in this position (See Fig. I–2b).

In cases of apparent occlusion of the aqueduct, the patients are left in the head-down position for ten to fifteen minutes. Air may pass to the fourth ventricle during this delay demonstrating the patency of the aqueduct. In some patients with hydrocephalus due to extraventricular obstruction, outlining the midline ventricles may be difficult because of the rapid passage of gas out of the ventricular system. Tomograms must be taken rapidly following rotation of the table. If air passes into the spinal canal before an adequate examination can be completed, the patient is changed from the "head-down" to the "head-up" position after the neck is flexed to trap air in the fourth ventricle, aqueduct and posterior third ventricle.

In some cases with a large third ventricle, most of the air accumulates there when the patient is placed in the routine "head-down" position (See Fig. I–3a). To get better visualization of the fourth ventricle, the cradle is rotated so that the patient is facing the vertically positioned table in the "head-down" position (See Fig. I–3b). The table is then tilted backward 30 to 40 degrees thus rotating the patient to 120 to 130 degrees from the horizontal (See Fig. I–3c). This allows more air to enter the fourth ventricle and permits better delineation of this structure. The tray must be rotated 90 degrees for lateral tomography (See Fig. I–3d).

Examination of the posterior fossa in adults after ventricular injection of air is difficult with the polytome unit. It is necessary to somersault patients. Our experience with the procedure is limited. We prefer to perform pneumoencephalograms whenever possible. We usually perform CSF shunting procedures after the diagnosis of hydrocephalus is made. This is followed by a pneumoencephalogram.

C. AIR MYELOGRAPHY

Air myelography is performed in adults after lumbar and/or cisternal puncture and air-fluid replacement in the spinal canal. We have limited experience using this technique in adults.

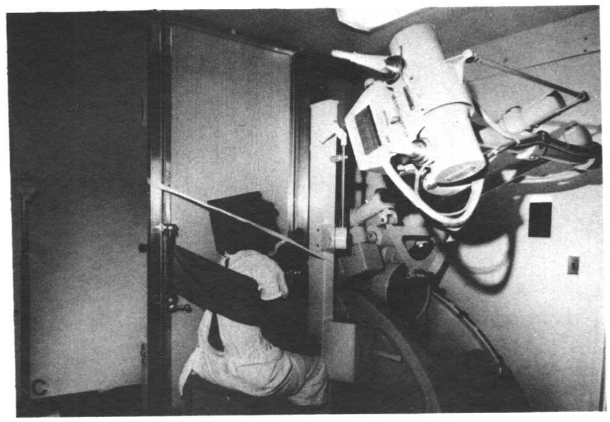


Figure I. 1 (c)

In infants and children, we have used two techniques for air myelography. The first technique is similar to that used in adults, namely following total fluid replacement by lumbar puncture.

The second technique involves the examination of the spinal canal after ventriculography or pneumoencephalography. This is used in patients below the age of 5 years. In the "head-down" position with the patient fixed to the special cradle, air in the ventricles escapes to outline the spinal canal (See Fig. I-2b). We frequently demonstrate hydromyelic cavities using this technique. We have seen the hydromyelic cavity extend to a dysraphic defect.

D. PROBLEMS IN TECHNIQUE

Pneumoencephalography in the sitting position: Failure to fill ventricles in the absence of intracranial mass lesions can be due to several causes. Subdural air injection, atresia of the foramen of Magendie and an incompetent cisterna magna are among the more commonly recognized etiologies. Momentarily high cerebrospinal fluid pressure can be a major factor. This could be caused by strapping the patient too tightly, blocking the venous return from the head, or it might be a result of excessive straining. In patients under general anesthesia, especially Ketamine®, high intracranial pressure may prevent proper ventricular filling. We have examples in which the ventricles failed to fill when the patient was under Ketamine anesthesia. A repeat pneumoencephalogram, performed under another anesthetic, resulted in good ventricular filling and normal findings.

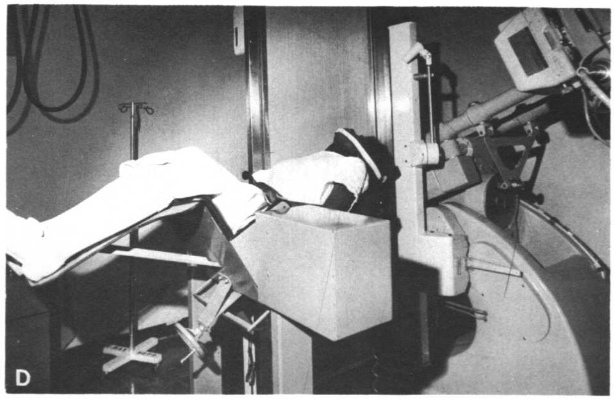
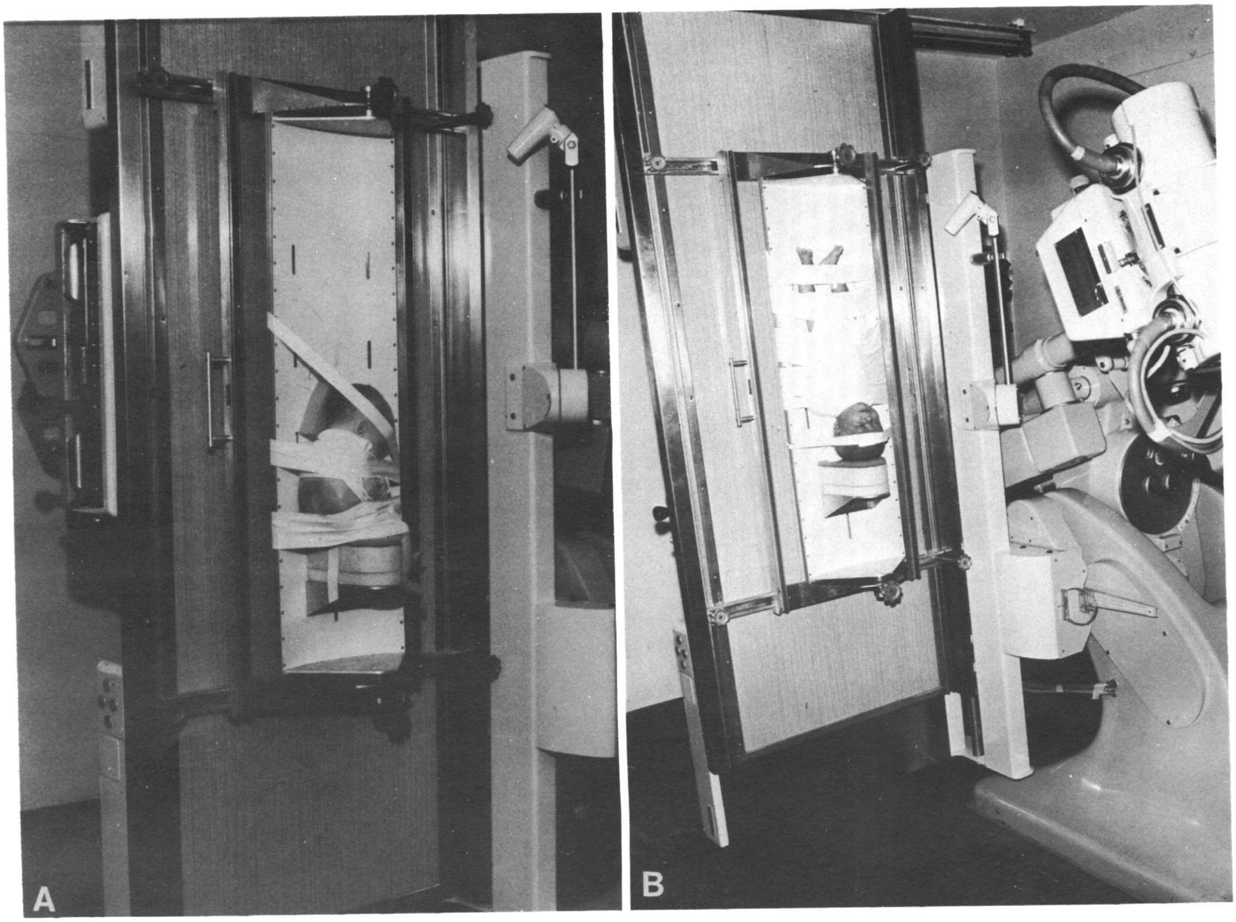


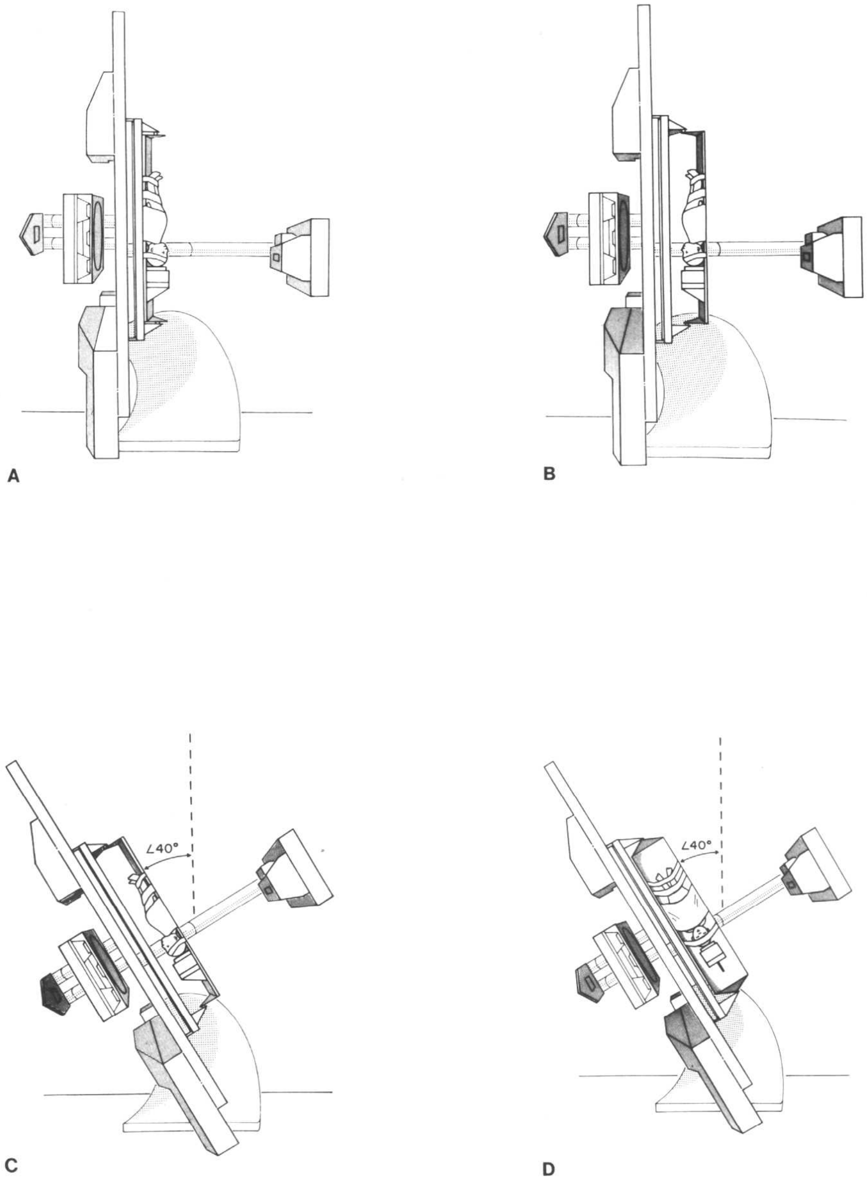
Figure I. 1 (d)

Figure I—2 (a & b)



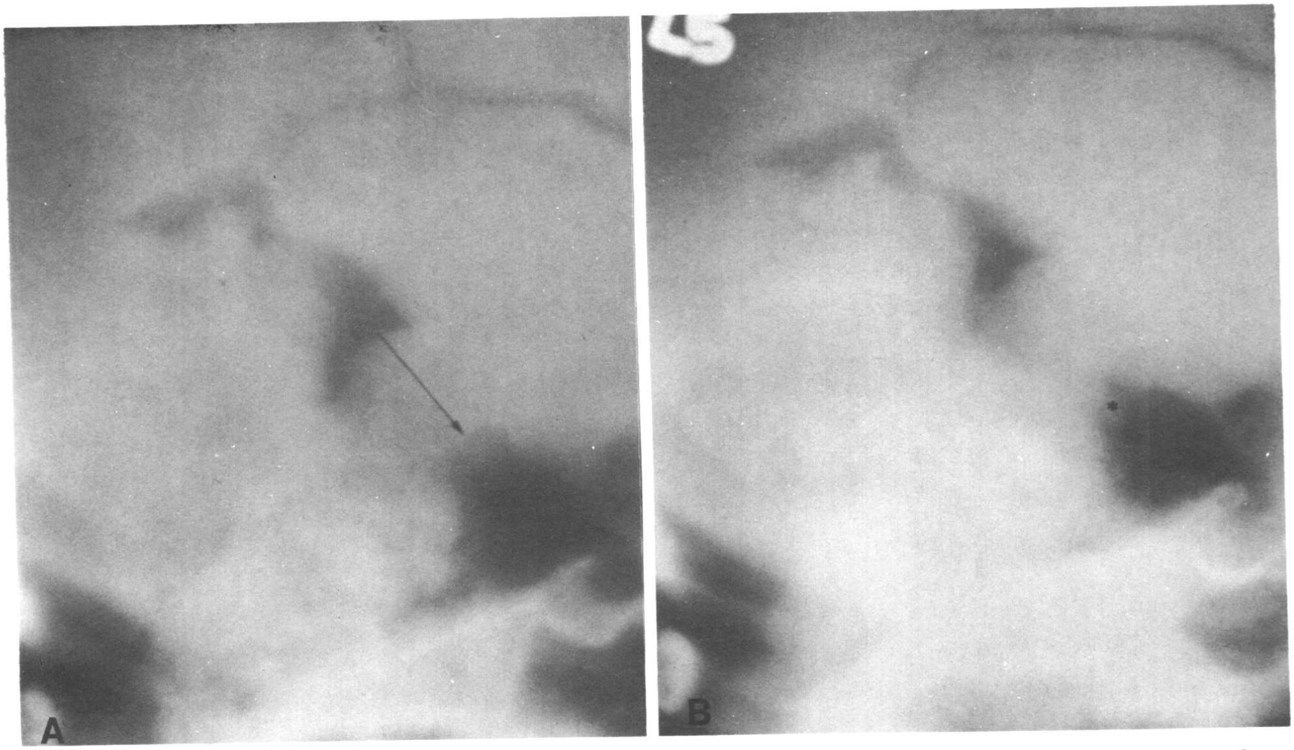
Reprinted **with** permission of *Radiology*.

Figure I—3 (a-d)



FAILURE TO FILL VENTRICLES
PNEUMOENCEPHALOGRAPHY

Fig. I–4 (a & b)

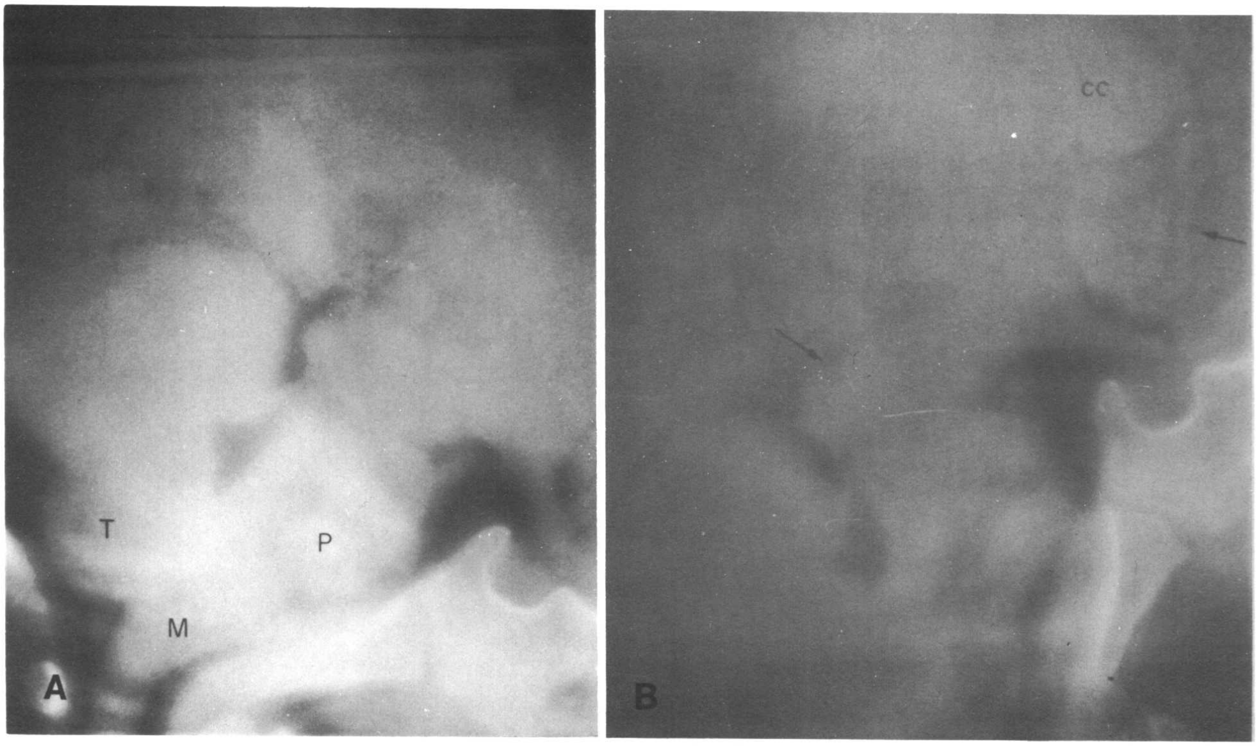


Air failed to enter the ventricles despite several injections in conjunction with changes in position of the head.

In (a), the midline cut shows the mesencephalon outlined. Its anterior border is quite well demonstrated (arrow).

In (b), a tomogram made slightly lateral to the midline shows an erroneous anterior border of the mesencephalon. The extra density, (asterisk), is formed by the lateral aspect of the mesencephalon and part of the cerebral peduncle.

Figure I—5 (a & b) FAILURE TO FILL THE VENTRICLES WHILE UNDER KETAMINE ANESTHESIA

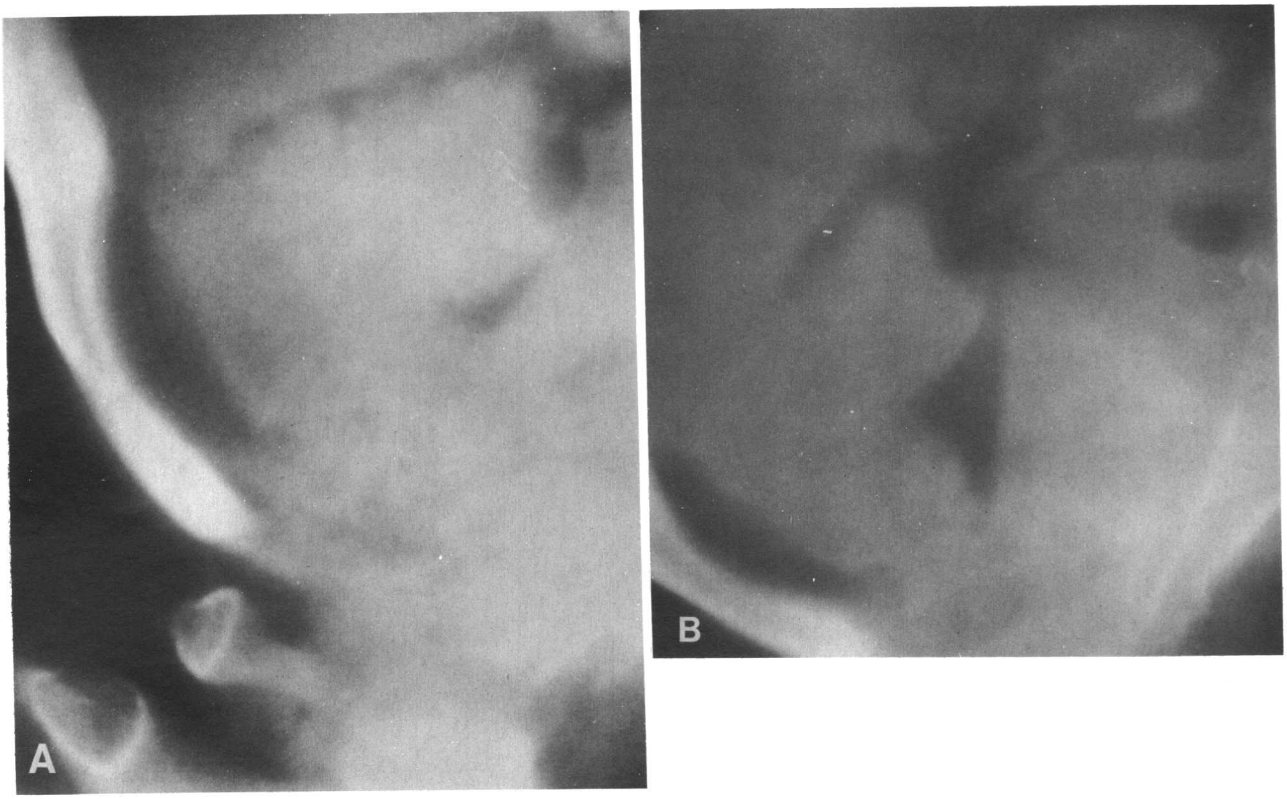


This child was under Ketamine anesthesia. The cerebrospinal fluid pressure was elevated (300 mm. water). Only a small amount of air entered the fourth ventricle.

In (a), note the medulla (M), and the pons (P), with the basilar artery anterior to it. Also note the cerebellar tonsil (T).

In (b), the quadrigeminal plate appears normal (posterior arrow). Note the genu of the corpus callosum (CC), and the anterior cerebral artery with its branches (anterior arrow).

Figure I—6 (a & b) FAILURE TO FILL VENTRICLES DUE TO INCOMPETENT CISTERNA MAGNA



This patient had an incompetent cisterna magna. In this case, the head should be placed in the neutral position or the neck should be held in slight extension to obtain filling of the ventricles.

In (a), the large cisterna magna is well filled and air passes over the surface of the cerebellum. A small amount of air is seen in the fourth ventricle. After extending the head, air passes into the fourth ventricle, aqueduct and third ventricle (b).