POSITIVE CONTRAST VENTRICULOGRAPHY—A CRITICAL EVALUATION

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For over a third of a century, ventriculography has occupied a well-deserved position of importance as a diagnostic tool in the localization of intracranial space-occupying and obstructive lesions. Its success depends upon an adequate demonstration of the ventricular system with a contrast medium, usually negative, instilled directly, cisternally, or by the lumbar route. Room air, oxygen, or helium have been the gaseous agents of choice. It is the purpose of this paper to explore the past record of positive contrast media with an eye to their potential utilization in the present-day diagnostic armamentarium. This seems particularly desirable because of the scant attention the subject has received in this country, despite widespread publications in Europe and Latin America.

HISTORICAL BACKGROUND

The history of positive contrast ventriculography has centered around the search for a suitable substance. Davidoff has emphasized that such a compound must fulfill three criteria, namely: (i) It must provide superior contrast in roentgenography. (ii) It must be innocuous to the patient at the time of injection. (iii) It must be free of long-term deleterious effect.

Lipiodol, an iodized poppy-seed oil, was the first compound employed. In 1923 Sicard and co-workers reported instilling it into the ventricles and watching it descend into the lumbar sac without ill effect. However, it was not until 1928 that adequate ventriculograms were reported by Balado. Two years later, he communicated his additional experience using Lipiodol in 90 cases in efforts to demonstrate the 3rd ventricle, aqueduct and 4th ventricle. He found it superior to negative media and felt that Lipiodol was harmless. In 1935, Lysholm discussed his results using Lipiodol in 114 cases over a 2-year period. He noted that reliance on positive media had diminished as techniques of air studies improved. In addition, he considered Lipiodol undesirable because of very definite irritating properties, especially on the ependyma, if the material were allowed to remain in the ventricles. Furthermore, its high viscosity occasionally worsened the condition of patients with obstructive lesions of the aqueduct, necessitating repeated ventricular taps to relieve the intraventricular pressure. Marcovich et al. have reviewed the action of Lipiodol on the leptomeninges and have confirmed its irritating aftereffects in several autopsies.

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Recognizing the limitations of Lipiodol, efforts were made to find a suitable substitute by Antoni,\(^2\) in 1932, with the introduction of Thorotrast (thorium dioxide). The following year Schoenfeld and Freeman\(^17\) reported favorably on their experiences with Thorotrast. Twining and Rowbotham\(^23\) were also optimistic about its possibilities. In 1936, Freeman et al.\(^9\) summarized 20 cases in which Thorotrast was used. Despite one death, not necessarily attributable to the Thorotrast, the writers recommended the procedure. However, objections to thorium dioxide were subsequently raised on two counts. Because of its deposition in the cells of the reticuloendothelial system, excretion is limited. Concentrations of this radioactive material were suspected as carcinogenic agents. The ependyma and leptomeninges were also adversely affected. Alexander et al.\(^1\) confirmed its role in producing ependymitis. In 1938 Reeves and Stuck\(^16\) likewise demonstrated the severe histologic reaction of the leptomeninges. Unfortunately, the last has not been heard concerning the long-term deleterious effects of Thorotrast. As recently as 1953, Hughes\(^10\) reported a case of aseptic spinal meningitis 13 years after ventriculography. He strongly implicated the Thorotrast employed.

In 1942, clinical trials were conducted using a new contrast medium, Pantopaque (ethyl iodophenylundecylate). It was designed to replace Lipiodol in myelography. According to Steinhausen et al.\(^29\) its main advantages lay in its lower viscosity and minimal irritative qualities. Peacher and Robertson\(^15\) confirmed this in a large series of cases. In 1946, Bull\(^5\) began using Pantopaque in ventriculography. Over a 5-year period he employed the substance in 80 cases without ill effect. In spite of widespread utilization of Pantopaque, few reactions were reported. Nevertheless, occasional disturbing cases have been brought to light. Tarlov\(^22\) reported meningeal adhesions in the cauda equina 60 hours after Pantopaque myelography. Mackay\(^13\) has mentioned the occurrence of multiple extra-ocular palsies following cranial extension of Pantopaque from a lumbar myelography. Errors in technique during the instillation of Pantopaque may have accounted for some cases of spinal arachnoiditis. According to Winkelman et al.\(^24\) improper cleansing of detergent from syringes or the production of blood at the time of spinal puncture may be responsible for some of the adverse effects attributed to Pantopaque itself. By far the most damaging report is that of Erickson and van Baaren,\(^8\) which cites the history of a patient who died of adhesive arachnoiditis of the basilar cisterns. Pantopaque, from a myelogram 15 months earlier, was clearly shown to be the etiologic agent. How many additional cases of this kind will appear remains to be seen. It merely points up the uncomfortable truth that, despite its universal acceptance, Pantopaque is not innocuous. Consequently, a search for a safer medium is still desirable.

**INDICATIONS FOR POSITIVE CONTRAST VENTRICULOGRAPHY**

Positive contrast should never be considered a replacement of or an alternative to the standard approach. Gas ventriculography should always be the initial choice and its possibilities utilized to the fullest. To locate the
gas in the desired place requires patience and a willingness to manoeuvre the patient repeatedly if necessary. “Controlled” pneumoencephalography with limited amounts of gas has contributed to improved technique. Even more important has been the increased reliance on laminagraphy to bring out the configuration of small amounts of gas in the aqueduct and 4th ventricle. Nevertheless, there are occasions when it seems impossible to gain the necessary information from a negative contrast medium. Lysholm\textsuperscript{12} found this to be the case when there was marked obstruction to flow at the aqueduct or at the outlets of the 4th ventricle. Bull\textsuperscript{5} clearly pointed out the difficulties of demonstrating the aqueduct and 4th ventricle when they are decreased in size. In such instances, as little as 0.5 cc. of gas is all that may be routed from the 3rd ventricle caudally, and this may be lost into the basal cisterns before adequate films can be taken. In recent years, patients with intracranial lesions have been seen earlier by specialists when the symptomatology and physical signs are less classical. Gas encephalograms or ventriculograms in such cases may show minimal shifts or incomplete filling of the 4th ventricle. A decision for surgical intervention is then quite difficult. In these instances, confirmation by positive contrast studies is often possible.

**TECHNIQUE**

There has not been a uniformity of opinion about the various steps necessary to negotiate the passage of the dye from the lateral into the 3rd ventricle. This represents the crucial phase of the procedure. The starting point is always with the dye in the frontal horn of one lateral ventricle. Most writers have injected the dye into one lateral ventricle through a posterior burr hole, which is available when a gas ventriculogram has preceded. The patient is placed in the prone position, which allows the dye to drop immediately into the frontal horn by gravity. By tilting the occiput a little away from the injected side during the instillation of dye, one can avoid placing some of it in the temporal horn. Even if this happens, it is quite easy to manoeuvre it into the frontal horn. Turning the patient supine pools the dye in the occipital horn. Then, with the head dependent, the patient is again turned to the prone position by turning away from the injected side. Stone\textsuperscript{21} advocates direct injection of the dye into the frontal horn via a frontal burr hole. Injection of 11/2–2 cc. of Pantopaque has yielded very satisfactory films.

The following technique for manipulating the dye has been used with success. It is similar to that employed by Stone\textsuperscript{21} and his co-workers. No fluoroscopy is required.

The patient is placed prone on an operating table with one side of the head against a vertical Bucky. After injection, a lateral film is taken to confirm the original position of the dye (Fig. 1a). Then the chin is drawn forward to extend the head. Another lateral film is taken to check the progress of the dye movement. Folded towels or a wooden block under the chin help maintain the position while awaiting the wet film. After complete extension of the head, the dye still may not have passed posteriorly to the foramen of Monro. To facilitate this the table is tipped
in reverse Trendelenburg. At some point, the dye will be seen to drop into the 3rd ventricle on a check lateral film (Fig. 1b). It is important to continue the extension of the head or Trendelenburg slowly until all of the dye is in the 3rd ventricle. This having been accomplished, the patient is turned to the supine position to “trap” the dye in the 3rd ventricle. This is done by moderate extension of the head after the supine position has been attained (Fig. 1c). As can be seen from Fig. 1c, excessive extension may allow the dye to trickle back into the lateral ventricles. Now anteroposterior and lateral films can be taken, which will demonstrate the 3rd ventricle. Finally, the head is flexed slowly to allow the dye to pass into the aqueduct and 4th ventricle (Fig. 1d). Anteroposterior and lateral films are again taken and if visualization is adequate, the patient sits up to allow the dye to pass into the subarachnoid space and thence to the caudal sac for ultimate removal. If the last manoeuvre described above, of flexing the head to visualize the 4th ventricle, is done too quickly, the dye may escape before pictures can be secured.

It is important to emphasize that lateral tilting of the head is not necessary to guide the dye from the lateral ventricle into the 3rd. The reason for this is apparent when one examines a frontal horn in coronal section. Its configuration is such that the inferior portion acts as a wedge-shaped trough wherein the heavy contrast material collects. The foramen of Monro is merely an aperture at the posterior extremity. As the dye passes posteriorly,

![Fig. 1. Schematic representation of location of the dye with various positions of the ventricular system (adapted from Lysholm).](image-url)
it drops through the foramen by gravity. This method will occasionally fail
when the lateral ventricle becomes hugely dilated as in some obstructive
process. Then the floor of the frontal horn is converted to a flattened surface,
making it difficult to “pool” the dye. In addition, the foramen of Monro
then becomes an opening of insignificant size in comparison with the greatly
increased floor area of the ventricle.

The alternative method of guiding the dye is to rely on fluoroscopy, as
recommended by Lysholm\textsuperscript{12} and Bull.\textsuperscript{5} In this procedure, the dye is instilled
with patient in the sitting position, with the head flexed. The head is in-
clined slightly against a vertical screen which is on the side opposite the dye.
Then, under fluoroscopic guidance, the dye is allowed to pass posteriorly and
drop into the 3rd ventricle. Then the procedure is similar to that described
above for the remainder of the examination. Carrillo\textsuperscript{6} made use of fluoro-
scopy as a helpful adjunct in particular cases.

Manipulation under fluoroscopy is not as simple as it would appear. The
fluoroscopist must be experienced in recognizing the position and course of
a small amount of contrast material. Excessive tilting may allow the dye to
pass through the interventricular foramen into the opposite lateral ventricle
without any dropping into the 3rd ventricle. In addition, many of these pa-
tients are too ill to cooperate properly, especially if a gas study has just been
done.

The interpretation of positive contrast roentgenograms needs little am-
plification. The distortion from space-occupying or obstructive lesions is in
no wise different from that observed with negative contrast media except
that it is much easier to visualize since no superimposed shadows are present
to confuse the picture.

ILLUSTRATIVE CASES

\textit{Case 1.} J.H., a 65-year-old male, was admitted to the Hartford Hospital on Dec.
5, 1955, complaining of difficulty in gait of 6 months’ duration. This had been pro-
gressive, with veering to either side. For 6 weeks prior to admission he had experi-
enced dull frontal headaches. Nausea and vomiting supervened shortly before ad-
mission. A lumbar puncture at another hospital recorded a cerebrospinal fluid pres-
sure of 210 mm. of water; protein was normal.

\textit{Examination.} The optic discs showed some nasal blurring. Coordination was
impaired in the left upper extremity. His gait was ataxic, with a wide base, and tend-
ency to fall in all directions. There was a positive Chaddock’s sign on the right.

\textit{Laboratory Data.} Routine hematology, serology, fasting blood sugar, nonprotein
nitrogen and urine were within normal limits. A cephalin flocculation test was nega-
tive in 24 hours and 3 plus in 48 hours. A Bromsulphalein test revealed only 9 per-
cent retention in 45 minutes. Roentgenograms of the chest and skull were negative
as was an upper gastro-intestinal series.

\textit{Course.} On Dec. 7, 1955 ventriculography was performed, using oxygen. The
lateral and 3rd ventricles were dilated. However, the aqueduct and 4th ventricle
could not be visualized. Consequently, 2 cc. of Pantopaque were injected into the
left lateral ventricle and a satisfactory ventriculogram was obtained. The 4th ventri-
acle can be seen to be shifted to the right by a space-occupying mass on the antero-
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Fig. 2. Case 1. (a) Anteroposterior view showing shift to the right of the dye column in the 4th ventricle. (b) Lateral view with suggestion of depression of roof of the 4th ventricle.

posterior projection (Fig. 2a). The lateral view suggests that the mass is in the cerebellum depressing the inferior roof of the 4th ventricle (Fig. 2b).

Operation. The following day, a suboccipital craniectomy was performed (Dr. B. B. Whitcomb). A firm tumor was encountered in the left cerebellar hemisphere which extended to the ependymal surface of the 4th ventricle. The mass was completely removed.

Course. The patient did poorly and died 5 days after operation. Permission for autopsy was not granted.

Pathologic Diagnosis. Metastatic carcinoma, primary site unknown, with pancreas or lung as the likeliest probabilities.

Comment. The patient was quite fatigued following the gas ventriculogram. Consequently it was deemed unwise to attempt to instill oxygen by the lumbar route. The clinical picture alone, though suggestive, was not impressive enough to warrant exploration without radiographic confirmation. There is no reason to believe that the Pantopaque in any way contributed to his ultimate demise. The immediate post-ventriculography period was uneventful.

Case 2. G.D., a 43-year-old married female, was admitted to the Hartford Hospital on Dec. 12, 1955, complaining of severe suboccipital pain on the left of 6 weeks' duration. The pain had progressively increased in severity, with radiation forward, and on admission it was excruciating, accompanied by nausea and vomiting.

Past History. A right radical mastectomy had been performed in 1950 for carcinoma of the breast. In 1953 an ovarian metastatic mass was removed. In May, 1955 a solitary pulmonary metastasis to the lower lobe was removed by lobectomy. Hilar nodes were not involved.

Examination. Evidence of previous surgery was present. No metastases were apparent. There was tenderness on left suboccipital pressure. No other neurological abnormalities were noted.
Laboratory Data. Routine hematology, serology, and urine were within normal limits. Roentgenograms of the skull were normal. Repeat film of the chest showed no evidence of metastases. Lumbar puncture yielded clear fluid with a pressure of 310 mm. of water; no cells were seen; protein was 45 mg. per cent.

Course. Pneumoencephalography with 40 cc. of oxygen was performed on Dec. 14, 1955. Despite laminograms it was not possible to visualize the 4th ventricle adequately. It gave the appearance of incomplete filling. The lateral ventricles were large. The following day, Pantopaque ventriculography was performed through a left occipital burr hole. A small but definite shift of the 4th ventricle to the right was noted on the anteroposterior film (Fig. 3a).

Operation. A suboccipital craniectomy was performed (Dr. R. H. Dunsmore). With some difficulty a tumor mass was located deep in the left cerebellar hemisphere extending into the cerebellopontine angle. It was completely removed.

Course. Postoperatively the patient did very well and was discharged on Dec. 24, 1955 ambulatory and relatively asymptomatic. A roentgenogram of the lumbosacral spine identified the Pantopaque in the lumbar sac for eventual removal.

Comment. Considering the absence of neurologic signs, a strong suspicion of a metastatic lesion was the only lead in a patient complaining of headache. The elevated spinal fluid pressure could be questioned because of the possibility of inadequate relaxation. Exploration was indicated only with firm radiologic confirmation. Pantopaque was able to provide unequivocal evidence of a space-taking lesion.

Case 3. M.G., a 6-year-old boy, was admitted to the Hartford Hospital on Nov. 20, 1955. For several months his parents had noted staggering gait which was becoming worse. He had a tendency to fall to the left. Six weeks prior to admission intermittent vomiting occurred, especially in the morning. Drooping of the left eyelid was noted. He complained of seeing double when watching television, the images being side by side. Occasional headaches were recorded.
Examination. The patient was an irritable child with a slightly hoarse voice. There was ptosis of the left lid with a small left pupil. The jaw deviated to the left on opening the mouth. There was a right central facial weakness. The left corneal reflex was absent. Coordination tests revealed clumsiness in performing alternate movements of both hands. His gait was ataxic with falling to the left. Deep tendon reflexes were hyperactive in the lower extremities.

Laboratory Data. Routine hematology, serology, and urine were within normal limits. Roentgenograms of the chest and skull were normal. An electroencephalogram showed general dysrhythmia with some depression of activity over the left occiput.

Course. On Nov. 25, 1955, an air ventriculogram was performed. The lateral ventricles and the 3rd ventricle were dilated. The aqueduct appeared displaced in a superior-posterior direction. The 4th ventricle was not demonstrated. Air was injected via the lumbar route and failed to fill the 4th ventricle. Consequently, 2 cc. of Pantopaque were injected through one of the occipital burr holes. The 4th ventricle was demonstrated (Fig. 4a). The measurement from the clivus to the floor of the 4th ventricle was several millimeters beyond the upper limit of normal, confirming the clinical impression of a pontine tumor.

Operation. Because the child's course was one of progressive deterioration, the posterior fossa was explored (Dr. S. J. Silbermann). The cerebellar hemispheres were normal and the 4th ventricle was patent. No definite confirmation of a pontine tumor could be made. Because of the presence of hydrocephalus, a Torkildsen operation was performed.

Postoperatively his course was stormy, complicated by a staphylococcal meningitis and a cerebrospinal fluid fistula. He also experienced a brief episode of gastrointestinal bleeding with tarry stools and transient drop in blood pressure. With the aid of antibiotics and blood his condition stabilized sufficiently to allow efforts at re-appraisal. Because of his general condition, a repeat air study was not done. However, the Pantopaque study was repeated on Dec. 25, 1955 (Fig. 4b), which revealed increased distortion of the 4th ventricle. The tube was removed. After the drainage

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**Fig. 4. Case 3.** (a) Initial Pantopaque study showing pontine tumor. (b) Subsequent demonstration of progression of the lesion.
from the wound ceased, a ventriculoperitoneal shunt was done. The patient still failed to improve and finally expired on March 1, 1956. At autopsy a large cystic tumor, measuring 4 cm. in diameter, was found extending from the lower end of thepons to the cerebral peduncle on the left.

Pathologic Diagnosis. Glioblastoma multiforme.

Comment. As sometimes happens, it was not possible to identify this tumor at operation. However, the two Pantopaque studies confirmed the clinical impression of a brain stem tumor.

Case 4. C.S., a 9-year-old boy, was admitted to the Hartford Hospital on Jan. 8, 1956 with the chief complaint of vomiting and headache of 4 months' duration. Clumsiness had been evident for 2 months, with frequent falls. He also was subject to recurrent attacks of hiccoughing.

Examination. Findings were negative except for bilateral choked discs, more marked on the right.

Laboratory Data. Routine hematology, serology, and urine were normal. Roentgenograms of the skull revealed a beaten-silver appearance and probable diastasis of the coronal suture, both indicative of increased intracranial pressure.

Course. On Jan. 14, 1956 ventriculography with 60 cc. of oxygen was performed. The lateral and 3rd ventricles were dilated. Despite 25 cc. of oxygen injected by the lumbar route the posterior 3rd ventricle was not well demonstrated and no visualization of the aqueduct or 4th ventricle was accomplished. Therefore, 2 cc. of Pantopaque were employed and Fig. 5 shows the posterior 3rd and very beginning of the aqueduct. However, the dye would not flow beyond. The interpretation was aqueductal obstruction caused by atresia or tumor, perhaps extending from the 4th ventricle.

Operation. To rule out the possibility of tumor, a posterior fossa exploration was performed (Dr. B. B. Whitcomb). The cisterna magna was large. The cerebellar hemispheres were normal. There was no tumor of the vermis or within the 4th ventricle. Saline injected into the lateral ventricle trickled through the aqueduct very

Fig. 5. Case 4. Obstruction of the aqueduct, probably caused by atresia. Arrow depicts end of dye column at beginning of aqueduct.
slowly. A No. 8 rubber catheter was passed through the aqueduct into the 3rd ventricle. This was followed by a gush of fluid through the tube. The cephalic portion of the tube was cut off and left in the aqueduct. Observation after further injections of saline into the lateral ventricle showed much improved flow into the 4th ventricle.

Postoperatively the child has shown steady improvement. One month after operation a pneumoencephalography with 100 cc. of oxygen revealed filling of the entire ventricular system. No additional pathology was demonstrable.

Comment. This apparently is a case of atresia or stenosis of the aqueduct, cause undetermined. The Pantopaque study did rule out a posterior 3rd ventricle tumor and confirmed the suspicion of an obstructive aqueductal lesion. It did not obviate the necessity of exploring the 4th ventricle.

Case 5. J.M., a 40-year-old truck dispatcher, was admitted to Hartford Hospital on Feb. 9, 1956, for evaluation of intractable vomiting. Six weeks previously he began to suffer from recurrent attacks of vertigo associated with burning epigastric pain. A gastro-intestinal work-up at another hospital was negative. His gait became unsteady and persistent vomiting associated with mild headaches supervened.

Examination. There was disturbance of gait, with a tendency to drift to the right. Nystagmus was present on lateral gaze, more marked on looking to the right. Fasciculations of the left side of the tongue were noted.

Laboratory Data. Routine hematology, serology, and urine were normal. Roent-
genograms of skull and chest were normal. Lumbar puncture revealed a normal pressure with clear spinal fluid containing no cells and 61 mg. per cent protein.

Course. On Feb. 15, 1956 pneumoencephalography was attempted but no filling of the ventricular system was achieved. A Pantopaque ventriculogram was done using 2 cc. An irregular defect was shown to persist in the left part of the 4th ventricle (Fig. 6).

Operation. A suboccipital craniectomy was performed (Dr. R. H. Dunsmore). Exploration of the 4th ventricle demonstrated an abnormality in the medulla. The left portion of the floor was pale and elevated. From the obex extending cranially the normal landmarks were lost. The right side of the floor seemed normal but slightly displaced to the right. The abnormal area was punctured with a No. 27 gauge needle. No cyst was encountered. Instead, the underlying tissue had a firm rubbery consistency. It was considered too hazardous to attempt a biopsy.

Postoperatively, the patient's condition was unchanged. Radiation therapy was instituted.

Comment. This lesion was felt by the surgeon to be a tumor of the medulla. After the failure of the pneumoencephalogram, a routine ventriculogram might have yielded the necessary information. However, it was nicely demonstrated with ease using Pantopaque.

DISCUSSION

The cases cited above are fairly representative of the type of pathological entity that can be demonstrated advantageously with Pantopaque. Other authors have diagnosed 3rd ventricle and cerebellopontine angle tumors using this method. What is the explanation for the general neglect of positive contrast ventriculography? There are perhaps three main reasons that come to mind. It seems pertinent to inquire into the validity of each.

(1) The foremost objection is that gas, when properly used, will provide adequate visualization of the entire ventricular system. This has been discussed earlier and need not be repeated. No one would claim 100 per cent success with gas media, so even those with a high number of adequate gas studies might occasionally find a positive contrast medium of help. When laminagraphy is not available, the successes with gas will be considerably reduced.

(2) The risks involved in the use of Pantopaque, the safest positive medium, have been mentioned. It should not be forgotten that occasional mortalities have been attributed directly to gas studies. A high percentage of these deaths have occurred in patients with serious abnormalities such as neoplasms, obstructive processes and vascular disease. Consequently, it is not easy to assess the comparative safety of the two media in the individual case. When faced with imminent surgery on a patient who is deteriorating, the possibility of obtaining additional valuable information would seem to outweigh the long-term risks of Pantopaque arachnoiditis.

(3) Technical difficulty is not a reasonable objection. Experience in many clinics has shown that consistent filling of the ventricular system can be achieved.
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CONCLUSION

The history of positive contrast ventriculography has been reviewed, with special reference to various substances employed and techniques of obtaining satisfactory filling. Five representative cases have been reported, using Pantopaque, the safest available substance. This method has been found to be a real asset in the diagnosis of posterior fossa lesions.

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REFERENCES