Neurosurgical Classic—VIII

ROBERT H. WILKINS, M.D.
National Cancer Institute, Bethesda, Maryland

The May 1963 issue of the Journal of Neurosurgery contained a reprint of Dr. Walter Dandy’s classical 1918 paper on ventriculography. His companion work on encephalography is reproduced below.

RÖNTGENOGRAPHY OF THE BRAIN AFTER THE INJECTION OF AIR INTO THE SPINAL CANAL

BY WALTER E. DANDY, M.D.*
OF BALTIMORE, MD.

(From the Department of Surgery, The Johns Hopkins Hospital and University)

As was shown in a recent publication, one or more of the cerebral ventricles can be sharply outlined in a röntgenogram if the ventricular fluid be withdrawn and replaced by an equal quantity of air. In the course of this work it was soon noted that in many cases some of the air had passed out of the ventricular system and could be seen in filaments on the surface of the brain, that is, in the sulci. In order to reach the sulci from the point of injection in a lateral ventricle, the air must have followed the normal pathways by which cerebrospinal fluid circulates. It must have passed through the foramen of Monro into the third ventricles, thence into the fourth ventricles, through the aqueduct of Sylvius, and then, having left the ventricular system, it must have entered the cisterna magna by way of the foramen of Magendie and the paired foramina of Luschka. Finally, from the cisterna magna it must have passed along the various cisternae under the base of the brain and then by numerous branches have reached the termination of the subarachnoid space—the sulci. Not infrequently, the entire subarachnoid space was graphically defined by the air shadows.

These observations at once gave promise of new possibilities in intracranial diagnostic study. Many lesions of the brain affect part of the subarachnoid space directly or indirectly. In hydro-

cerephalus of the communicating type, adhesions at the base of the brain obliterate the cisternae and the cerebrospinal fluid cannot reach the sulci over the cerebral hemispheres; a local area of subarachnoid space may be obliterated by a tumor situated on or near the surface of the brain; a defect in the brain due to atrophy must necessarily be filled with cerebrospinal fluid, which may maintain communication with the subarachnoid space. These, and no doubt many other conditions, should be demonstrable by the absence or by the presence of air over the cerebral hemispheres.

After the injection of air into a cerebral ventricle a certain amount will soon appear on the external surface of the brain if the head is carefully manipulated so that the air is guided to the small aqueduct of Sylvius and the fourth ventricle. But the time of escape of air from the ventricles and of its appearance in the cerebral sulci are variable. The more completely the ventricles are filled with air the greater the probability that it will appear externally; and the more dilated the iter and the foramina of Luschka and Magendie (as in hydrocephalus) the more readily will air appear externally. Nevertheless, it was evident that at best the amount of air that will reach the cerebral sulci must vary greatly, according to the conditions existing in each individual case.

The problem therefore before us was: How can we in every case be sure of obtaining a complete injection of the subarachnoid space? The solution lies in the direct injection of air into the spinal canal. By this method the influence of the ventricular system is entirely eliminated; the air passes directly into the cisterna magna and thence into the ultimate ramifications of the subarachnoid space.

The technic is essentially similar to that described elsewhere for intraventricular injections. A small quantity of spinal fluid is withdrawn and an equal amount of air injected into the spinal canal. This process of substitution is repeated until the fluid ceases to appear on aspiration. There is no need to sterilize the air, because it is always free from pathogenic organisms.

Undoubtedly this procedure is not devoid of danger. Medullary distress, even fatal results, might well follow from increased intracranial pressure if the amount of air injected were even slightly in excess of the fluid withdrawn. The danger would certainly appear to be much greater in intrasinous than in intraventricular injec-

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tions, because in the latter direct pressure on the medulla in large measure is inhibited by the tentorium cerebri. In my own cases no bad effects have followed and the results have led me to believe that with proper care and judgment the procedure is entirely harmless. I have always left the open needle in the spinal canal for two or three minutes after the injection has been finished, thus rendering the intraspinal pressure directly under control. If the needle is left open, the intraspinal becomes equal to the atmospheric pressure, which is less than the normal intraspinal pressure. This reduced pressure is an additional safeguard against any possible development of a "reactive" intracranial pressure.

The position of the body is all-important, in intraspinal injections—in fact, in all air injections, because the air rises as the fluid gravitates. The head must be at least twenty degrees higher than the needle. With each injection the air will then rush to the brain and a new supply of fluid will fall to the point of the needle. No doubt the sitting posture would be more satisfactory, because it would allow a more complete and uniform injection of the subarachnoid spaces over both cerebral hemispheres. In the recumbent position, which I have used exclusively, mainly for the comfort of the patient, it is possible that the injection may be more complete over the surface of the higher hemisphere than over the lower hemisphere, and that on turning the patient from one side to the other (in order to take both right and left lateral views of the head) important changes in the distribution of the air may be induced by the effects of gravity. In the sitting posture, rotation of the head would not alter the position of the air in the spaces, because gravity would not be brought into play, and a more accurate photograph of the "air mantel" on each hemisphere would be obtained. If, however, the intracranial subarachnoid space is thoroughly injected, there should be but little change due to gravity and the recumbent posture should prove practically as effective as the sitting posture. Additional experience will probably indicate the position of choice.

I have injected air intraspially into eight patients—four children and four adults—from Professor Halsted's service, without any bad effect. The amount of air has varied from 40 to 120 c.c. In one patient a mild headache followed but disappeared in three hours; vomiting but no headache occurred in another case; in the others no complaints were made. In reality, the effects should be much the same as those following the usual lumbar puncture.

One difficulty in the injection procedure should be mentioned. The aspiration must be gentle because the needle may plug at times, presumably with fibres of the cauda equina. If the suction is very gentle this may be obviated. In no case was there pain from injury to the nerves.

It must always be remembered that spinal punctures are very dangerous in all patients with intracranial tumors. A spinal puncture should never be made (if a tumor is present) unless the intracranial pressure has been previously relieved by a ventricular puncture or by some other procedure.

What becomes of the air? Air disappears from the subarachnoid space quite rapidly. It is absorbed as from other tissue spaces and undoubtedly passes directly into the blood. Usually no air is demonstrable in the roentgenogram twenty-four hours after the injection. Absorption from the subarachnoid space is many times faster than from the ventricles.

Practically all cerebrospinal fluid is absorbed from the subarachnoid space; very little from the ventricles, and the absorption of ventricular fluid occurs only after it has passed into the subarachnoid space.2 When air is injected into a lateral ventricle, its rate of absorption seems to depend upon the freedom of access to the subarachnoid space. If the ventricles are normal the air will disappear in the course of a few days. If an internal hydrocephalus is present, the absorption time is greatly increased because an obstruction prevents the air from reaching the subarachnoid space. In cases of ventricular dilatation it may require two to three weeks for the air to disappear. The rate of absorption of air from the ventricles and the subarachnoid space appears to be relatively the same.