Experimental Hydrocephalus
Part 1: A Technique for Producing Obstructive Hydrocephalus in the Monkey

THOMAS H. MILHORAT, M.D.
Branch of Surgical Neurology, National Institute of Neurological Diseases and Stroke,
National Institutes of Health, U.S. Public Health Service,
Bethesda, Maryland

In 1914 Dandy and Blackfan demonstrated that hydrocephalus could be produced in dogs by obstructing the aqueduct of Sylvius. The observation was of fundamental importance and for many years spurred intense interest in the physiology and pathology of the ventricular system. With time, however, it became evident that several problems existed. First, the surgical techniques were complicated and were reliable only in the hands of a few. Second, the techniques failed to produce consistent results, and even when they were successful the hydrocephalus that developed was rarely advanced before 3 to 8 weeks. Third, attempts to produce hydrocephalus in species other than the dog were largely unsuccessful.

A number of investigators have suggested modifications of the original technique of Dandy and Blackfan. Unfortunately, none of these techniques provided a substantially superior experimental model, and for lack of such a model much of the early momentum in hydrocephalus research was lost.

The following report describes a new and relatively simple experimental technique for producing obstructive hydrocephalus in the monkey. The details of the technique, its reliability, and the advantages of the experimental model are discussed.

Materials and Methods

In this study we used 230 rhesus monkeys (Macaca mulatta) weighing 4 to 6 lbs and ranging in age from 1½ to 2 years. Under light Sernylan anesthesia, the animals were positioned face down in a stereotaxic head holder so as to flex the neck forward as much as possible. With strict surgical precautions, a small bilateral suboccipital craniotomy was made through a posterior midline incision (Fig. 1 left). The defects in bone and dura were made as small as possible to reduce the effects of surgical decompression. The foramen of Magendie, which is a true foramen in the monkey, was then dilated by introducing a blunt-nosed staphylorrhaphy into the cavity of the fourth ventricle (Fig. 1 right). By this maneuver, the orifice of the foramen was easily widened, and no further manipulation or retraction of the cerebellum was required.

A No. 8 Foley catheter was then introduced into the cavity of the fourth ventricle and its tip advanced to the level of the caudal aqueduct. To assure proper seating of the entire balloon within the cavity of the fourth ventricle, it was necessary to cut off the nose of the catheter so that it protruded no more than 4 to 5 mm beyond the balloon (Fig. 2 left). Since many of the balloons inflated unsymmetrically, the catheter was introduced so that the expanding mass was directed toward the roof rather than the floor of the fourth ventricle, to avoid unacceptable trauma to the floor of the fourth ventricle and brain stem. Once the balloon was in place, it was inflated with saline so as to produce a mass of 1 to 1.5 cc. The catheter was then tied off with double ligatures of heavy silk. This maneuver completely sealed the cavity of the fourth ventricle and blocked the exit of the caudal aqueduct (Fig. 2 right).

It was found that when the balloon was inflated with air rather than saline, it frequently collapsed after several days. This probably results from diffusion of air through the slightly permeable walls of the balloon and emphasizes the importance of
clearing the saline syringe of any air bubbles. Similarly, inflation of the balloon with various contrast substances, such as Hypaque, was not successful, for the opaque material proved injurious to the rubber of the balloon and resulted in spontaneous rupture in some cases.

When the animals were used for continuing experiments, great care was taken to secure the catheter once it was tied off. This was done by suturing the catheter to dura after the latter had been closed as completely as possible. Another heavier anchoring suture to muscle or skin was also used, and the wound was carefully closed in layers of medium silk. The catheter was then brought out through the lower pole of the incision or through a separate stab wound, and the catheter was completely incorporated into a bulky figure-of-eight tape dressing. By this means it was possible to return the animals to their cages with little or no danger of injury to the catheter.

Although it was probably unnecessary, animals on long-term experiments were treated with prophylactic antibiotics.

Fig. 1. Left: Surgical exposure of the posterior fossa. For purposes of illustration the defects in bone and dura have been made slightly larger than usual. Right: The foramen of Magendie is dilated by introducing a bluntnosed staphlorraphy into the cavity of the fourth ventricle, which makes it possible to introduce a No. 8 Foley catheter into the ventricle without further manipulation.

Fig. 2. Left: Intact and amputated No. 8 Foley catheters inflated to a volume of 1.5 cc with saline. Right: No. 8 Foley catheter in place within the 4th ventricle. The balloon has been inflated to a volume of 1.0 cc with saline.