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## Commentary

# Flow-Sensitive MR Imaging of Ventriculoperitoneal Shunts: In Vitro Findings, Clinical Applications, and Pitfalls

David G. McLone[1]

Castillo et al. [1] present another possibly useful tool for evaluating the patency of CSF shunts. During routine MR imaging, 23 patients were studied with T1-weighted fast field echo. A phantom was constructed, and the flow through a medium-pressure shunt system was imaged at flow levels thought to occur in patients. Although the number of patients studied was small, the results corresponded to the authors' experimental model. However, in only one patient were the clinical signs and symptoms, the MR interpretation, and the findings at surgery entirely in agreement. In another two patients, the MR flow study indicated a malfunction, but the shunts were patent at surgery. Interestingly, both of these patients improved after surgery, suggesting that manipulation of the shunt during the procedure improved function.

The authors correctly indicate in the title of their article that pitfalls exist. It is obvious that absence of flow in a pressure-regulated shunt system does not constitute malfunction, nor does adequate flow equal optimal shunt function. Yet, the information provided by this technique can be quite useful when combined with clinical information.

In the 1950s, when reliable methods for diverting CSF were developed, children with congenital or acquired hydrocephalus began to survive. Many of these children have normal intelligence and can look forward to independent living. However, the shunting devices are not perfect, and time has taught us that the problem of hydrocephalus is much more complex than simply plumbing. Fortunately, the brain can compensate for this nonphysiologic method of CSF drainage.

In infants, monitoring the head circumference and imaging the ventricular system by sonography through the anterior fontanel usually suffices. Once the sutures close, and the intracranial volume has become more fixed, the triad of headache, lethargy, and vomiting usually heralds the onset of a shunt malfunction. Unfortunately, most flu epidemics produce a similar pattern. Most children develop a characteristic pattern well recognized by the parents, usually the mother. Thus, the history given by a reliable parent remains the single best indicator. For 15 years, before CT scanning, we relied heavily on the mother to notify us when a shunt was not functioning properly.

Because of 24-hr availability and ease of interpretation, CT has now become our next line of investigation. The history of the patient and the CT scan establish the diagnosis in most cases. As MR imaging becomes more readily available, it should replace CT for many of these studies.

When the situation remains unclear, the shunt usually is tapped. This safe and reliable, yet invasive, procedure can give information about pressure and flow and provide CSF for study. We now can add flow MR imaging to continuous pressure monitoring, radionuclide imaging, and thermography as a method that may help in difficult diagnostic cases.

Several features indicate a "good" test for evaluating shunt function. Availability is paramount. Most children are seen in a semiemergent situation, and elective scheduling is often impossible. In addition, most of our shunts seem to fail in the evening. Other criteria would include ease of performance

This article is a commentary on the preceding article by Castillo et al.

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and rapid results. The test also should be highly reliable. Time will tell if flow MR imaging meets these criteria. A noninvasive test that is free of complications is extremely desirable, and flow MR imaging provides these advantages.

Pediatric neurosurgeons do follow-up examinations on a large number of patients who have shunting devices for a variety of problems related to CSF circulation. Malfunction of these devices is expected and usually is accompanied by characteristic signs and symptoms. Within this large population, a small number of patients have atypical manifestations that arise when their shunt fails, functions erratically, or actually overdrains fluid. It is this small group that fosters the innovative interaction between surgeon and radiologist. On CT, the neurosurgeon can see if the ventricles have changed, but in the absence of these changes, other dynamic studies such as flow MR imaging are extremely useful.

Castillo et al. are to be commended for correlating bench research with clinical observations. Larger numbers of patients obviously are needed to confirm these observations. Flow MR imaging appears to be a promising new method to help the neuroradiologists and neurosurgeons work through complex problems related to hydrocephalus.

REFERENCE

1. Castillo M, Hudgins PA, Malko JA, Burrow BK, Hoffman JC Jr. Flow-sensitive MR imaging of ventriculoperitoneal shunts: in vitro findings, clinical applications, and pitfalls. *AJNR* **1991**;12:667–671