Pediatric Neurology 52 (2015) 389–397

Contents lists available at ScienceDirect

Pediatric Neurology

journal homepage: www.elsevier.com/locate/pnu

Topical Review

Minimally Invasive Pediatric Neurosurgery

Lance S. Governale MD [a,b,*]

[a] *Division of Pediatric Neurosurgery, Nationwide Children's Hospital, Columbus, Ohio*
[b] *Department of Neurosurgery, Ohio State University, Columbus, Ohio*

ABSTRACT

Advances in technology have facilitated the development of minimally invasive neurosurgical options for the treatment of pediatric neurological disease. This review seeks to familiarize pediatric neurologists with some of the techniques of minimally invasive pediatric neurosurgery, focusing on treatments for hydrocephalus, arachnoid cysts, intracranial mass lesions, and craniosynostosis.

Keywords: minimally invasive, neurosurgery, pediatric, endoscopy, trans-sphenoidal, hydrocephalus, arachnoid cyst, craniosynostosis

Pediatr Neurol 2015; 52: 389-397

Historically, neurosurgical procedures have required large operative exposures to achieve the surgical goal. Such exposures can subject the patient to the risks inherent to increased brain manipulation and longer recovery times. Although many conditions are still best treated with traditional surgical approaches, improved imaging, navigation, and endoscopic technology allow more procedures to be done in a minimally invasive manner. This review seeks to familiarize pediatric neurologists with some of the techniques of minimally invasive pediatric neurosurgery, focusing on treatments for hydrocephalus, arachnoid cysts, intracranial mass lesions, and craniosynostosis.

The goal of neurosurgery is always to treat pathology with as little perturbation of normal structures as possible. In the century since Cushing formalized American neurosurgery at what is now Harvard's Brigham and Women's Hospital in Boston and Johns Hopkins in Baltimore, improvements in diagnostic imaging, surgical navigation, and endoscopic techniques have facilitated less invasive and more effective surgical procedures.

Article History:
Received June 30, 2014; Accepted in final form December 30, 2014
* Communications should be addressed to: Dr. Governale; Division of Pediatric Neurosurgery; Nationwide Children's Hospital; 555 South 18th Street; Columbus, Ohio 43205.
E-mail address: lance.governale@nationwidechildrens.org

0887-8994/$ - see front matter © 2015 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.pediatrneurol.2014.08.036

Neurosurgical planning begins with localization of the lesion. In the beginning, the ever-important neurological examination was essentially the only tool available. Given the examination's inherent limitations, however, the surgical target could be somewhat imprecise, requiring large incisions and broad surgical exposure to ensure that the lesion would be found. The introduction of pneumoencephalography and angiography helped, but often only the secondary effects of the lesion could be visualized, not the abnormality itself. With the advent of computed tomography (CT) and magnetic resonance imaging (MRI), the lesion itself could finally be observed in increasingly precise detail. More recently, functional MRI of the gray matter and diffusion tensor imaging of the white matter have allowed even more precise planning of a minimally disruptive surgical corridor.

Once the surgical target and optimal surgical pathway have been identified, a specific operative approach must be developed for the operating room. Although every neurosurgeon should grasp the three-dimensional neuroanatomy that facilitates this process, technological aids can be of great confirmatory utility. Computerized frameless stereotactic navigation systems allow registration of three-dimensional space of the radiographs to the three-dimensional space of the patient. Once registered, a pointer or properly prepared neurosurgical instrument can be tracked on the radiographic display showing where the instrument is and in what trajectory it is headed. This

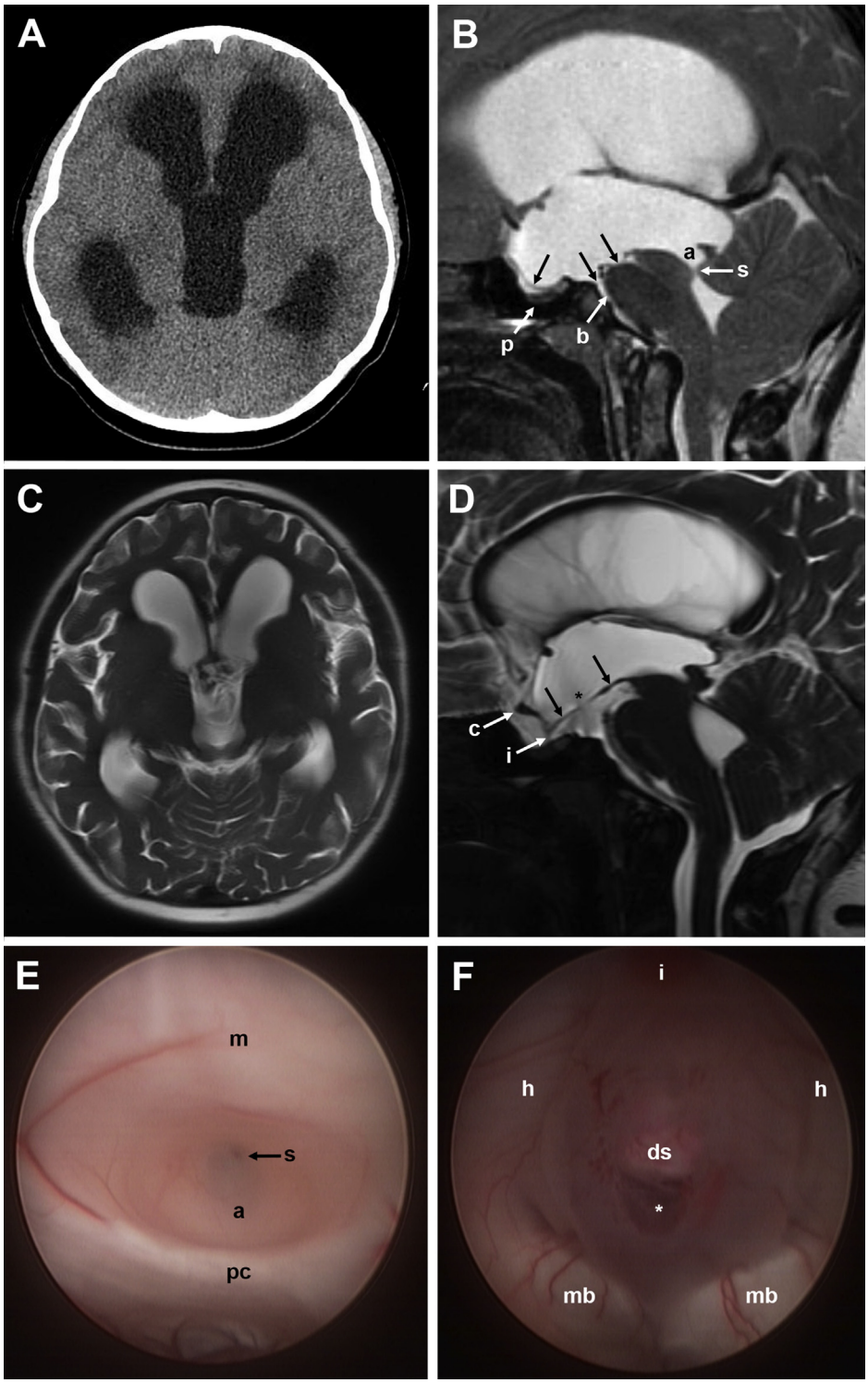

FIGURE 1.
Endoscopic third ventriculostomy (ETV). This 12-year-old girl presented with a 6 month history of syncope, headache, emesis, ataxia, urinary incontinence, and poor memory. Fundoscopy revealed papilledema and mild optic pallor. Axial computed tomography (A) revealed marked dilation of the lateral and third ventricles with transependymal absorption of cerebrospinal fluid. Sagittal T_2 magnetic resonance imaging (MRI; B) revealed aqueductal stenosis (s) and a dilated proximal aqueduct (a). The third ventricle floor (black arrows) was displaced inferiorly against the pituitary (p) and basilar artery (b). The brainstem and cerebellar tonsils were displaced inferiorly. Postoperatively, her symptoms and papilledema resolved and remained so at the 1 year follow-up. Axial single-shot fast spin-echo MRI at 4 months (C) revealed decreased ventricular size and resolution of transependymal flow. After ETV, the ventricles usually do not return to "normal" but instead establish a new baseline. Sagittal thin-cut T_2 MRI at 2 months (D) depicts the fenestration (*) with cerebrospinal fluid flow void through it. The third ventricle floor (black arrows) has returned to a normal position, and the optic chiasm (c) and pituitary infundibulum (i) are now visible. The inferior brainstem displacement and cerebellar tonsillar herniation have resolved. Endoscopic view of the posterior third ventricle floor (E) demonstrating the midbrain tegmentum (m) anteriorly, the posterior commissure (pc) posteriorly, the dilated proximal aqueduct (a), and the aqueductal stenosis (s). Endoscopic view of the anterior third ventricle floor (F) depicting the pituitary infundibulum (i) anteriorly, the hypothalamus (h) laterally, and the mammillary bodies (mb) posteriorly. The fenestration (*) lies between the dorsum sella (ds) and the basilar apex (not visible).