Minimally Invasive Pediatric Neurosurgery

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INTRODUCTION

Pediatric neurosurgery, which by its nature overlaps multiple neurosurgical subspecialties, has benefited greatly from the advances in minimally invasive neurosurgical techniques. Not only can it take advantage of the progress in the areas of vascular, spine, trauma, and tumor neurosurgery, but as a subspecialty it has significantly advanced the minimally invasive treatment of hydrocephalus and intraventricular lesions.

There have been substantial technological advances in the treatment of hydrocephalus in the past half century. Ventricular shunts, our current mainstay of treatment, can be considered a minimally invasive alternative to the techniques that preceded them for the treatment of hydrocephalus. However, neuroendoscopy is now the leading edge technology in the treatment of this condition and has become an important part of the armamentarium of all pediatric neurosurgeons. The current goal in hydrocephalus is to treat the patient without a shunt, or at least to simplify shunt systems as much as possible by fenestration of loculated fluid spaces. In this chapter we review how pediatric neurosurgeons employ minimally invasive techniques in their practice for the treatment of hydrocephalus, cysts, tumors, and vascular and congenital abnormalities of the brain and spine.

HYDROCEPHALUS

Endoscopy

Hydrocephalus is a common entity in pediatric neurosurgery, and treatment often encompasses a large percentage of the neurosurgical volume in a pediatric institution. Whether the condition has been caused by congenital etiologies, intraventricular hemorrhage, infection, or tumors, minimally invasive techniques are becoming the standard in its treatment. Minimally invasive techniques using the endoscope and image guidance have led to improved shunt placement, simplification of shunt systems, and shunt independence in select patients.
A significant development in pediatric neurosurgery during the past decade has been the evolution of neuroendoscopy and its application to the management of childhood hydrocephalus. The first endoscopic neurosurgical procedure was performed by Lespinasse, a urologist, in 1910. He used a cystoscope to fulgurate the choroid plexus in two children (1). Walter Dandy used a “ventriculoscope” (a rigid cystoscope) to treat hydrocephalus via choroid plexus fulguration or third ventriculostomy (2), but this fell out of favor with the development of cerebrospinal fluid (CSF) diversion catheters. However, the cerebral ventricles, when pathologically dilated, are ideally suited to neurosurgical endoscopy. This fact, along with technological advances in optics and imaging, have brought on a resurgence in endoscopy for the treatment of pediatric hydrocephalus.

Armed with the endoscope as both a diagnostic and therapeutic surgical adjunct, the neurosurgeon can now fenestrate cysts and obstructing membranes. This permits the conversion of complicated shunts into more easily managed systems, and in many instances diversion of CSF can be accomplished without valve-regulated shunt systems. Advance planning of the endoscopic procedure with high-resolution neuroimaging helps to minimize potential confusion when the neurosurgeon encounters variable anatomy within the ventricular system. This can also be combined with stereotactic techniques for more precise localization when anatomy is altered by pathology.

Therapeutic procedures aimed at treating hydrocephalus with the endoscope can be divided into shunt catheter placement, membrane fenestration, and, in limited conditions, tumor resection aimed at relieving ventricular obstruction.

Many studies indicate that ventricular catheter blockage is the most common site of the shunt obstruction. Although no study has demonstrated improved shunt patency with catheter tip position (3,4), it is suggested by the fact that the most commonly found materials causing ventricular catheter obstruction are connective, glial, and granulomatous tissue. Concerning the optimal placement of the ventricular portion of a shunt system, endoscopy serves as an adjunct in that it provides an intraoperative confirmation of optimal catheter placement. This may be particularly useful in cases of multiple ventricular septations or small ventricles. Image guidance, especially employing intraoperative ultrasound, has also been responsible for improved catheter placement in ventricular shunting procedures. In very difficult cases, stereotactic image guidance or intraoperative planar imaging can also be useful. Although optimizing catheter tip position in the frontal horn may not be necessary for shunt longevity, confirmation of placement within the ventricle as opposed to a CSF cistern using these techniques has certainly prevented many reoperations.

Neonatal germinal matrix hemorrhage, as well as meningitis, usually produces a multiloculated hydrocephalus. This condition can lead to complex shunt systems and numerous shunt revisions in patients unfortunate enough to have loculated hydrocephalus. A variety of therapeutic options are available to treat multiloculated hydrocephalus, including placement of multiple shunt catheters, stereotactic aspiration, craniotomy with lysis of septations, and endoscopic fenestrations. Unfortunately, none is entirely effective in all cases, and