New designs of ventricular catheters for hydrocephalus by 3-D computational fluid dynamics

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Introduction

Based on a landmark study by Lin et al. of the two-dimensional flow in ventricular catheters (VC) via computational fluid dynamics (CFD), we studied in a previous paper the three-dimensional flow patterns of five commercially available VC. We calculated that most of the total fluid mass flows through the catheter's most proximal holes. In this paper we design five VC prototypes with equalized flow characteristics.

Methods

We study five prototypes of VC by means of CFD in three-dimensional (3-D) automated models and compare the fluid-mechanical results with our previous study of currently in use VC. The general procedure for the development of a CFD model calls for transforming the physical dimensions of the system to be studied into a virtual wire-frame model which provides the coordinates for the virtual space of a CFD mesh. The incompressible Navier-Stokes equations, a system of strongly coupled, nonlinear, partial differential conservation equations governing the motion of the flow field, are then solved numerically.

Learning Objectives

Describe the importance of 3D simulation in neurosurgical designs

Results

By varying the number of drainage holes and the ratio hole/segment, whether with a simple or tapered hole type, we obtained improved flow characteristics in five prototypes of VC. In particular, we equalized the flow pattern through the different hole segments of the new VC prototypes, as disclosed by 3-D CFD.

Conclusions

New catheter designs with variable hole diameter, number of holes, and ratio hole/segment along the catheter allow the fluid to enter the catheter more uniformly along its length, thus reducing the chance of its becoming occluded.

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