Parametric Study of the Design of Ventricular Catheters for Hydrocephalus

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Introduction

Background: To drain the excess of cerebrospinal fluid in a hydrocephalus patient, a catheter is inserted in one of the brain ventricles, and then connected to a valve. This so-called ventricular catheter is a standard-size, flexible tubing with a number of holes placed symmetrically around several transversal sections or "drainage segments". Three-dimensional computational dynamics shows that most of the fluid volume flows through the drainage segment closest to the valve. This fact raises the likelihood that those holes and then the lumen get clogged by the cells and macromolecules present in the cerebrospinal fluid, provoking malfunction of the whole system.

Methods

Objective: To better understand the flow pattern, we have carried out a parametric study via numerical models of ventricular catheters. The parameters chosen are the number of drainage segments, the distances between them, the number and diameter of the holes on each segment, as well as their relative angular position.

Results

Results: These parameters were found to have a direct consequence on the flow distribution and shear stress of the catheter. As a consequence we formulate general principles for ventricular catheter design.

Learning Objectives

Design and development of ventricular catheters

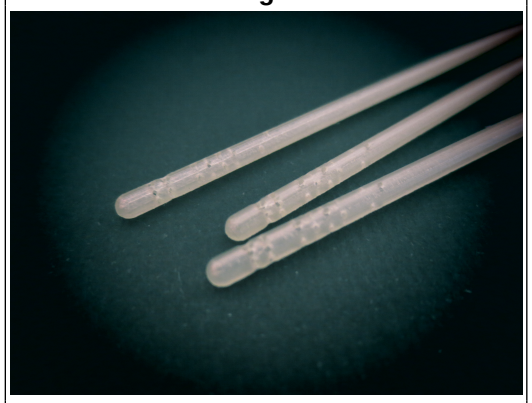
References

1. Galarza, M., Giménez, A., Pellicer, O., Valero, J. & Amigó, J.M. (2016). Parametric study of ventricular catheters for hydrocephalus. Acta Neurochirurgica 158(1):109-15
2. Galarza M., Giménez A., Valero J., Pellicer O.P., Amigó J.M. (2014) Computational fluid dynamics of ventricular catheters used for the treatment of hydrocephalus: a 3D analysis. Childs Nerv. Syst. 30(1):105-116
3. Galarza M., Giménez A., Pellicer O., Valero J., Amigó J.M. (2015) New designs of ventricular catheters for hydrocephalus by 3-D computational fluid dynamics. Childs Nerv. Syst. 31 (1):41-47
4. Galarza M., Giménez A., Valero J., Pellicer O., Martínez-Lage, J.F., Amigó J.M. (2015) Basic cerebrospinal fluid flow patterns in ventricular catheters prototypes Childs Nerv. Syst. 31(6):873–884
5. Giménez, A., Galarza, M., Pellicer, O., Valero, J. & Amigó, J.M. (2015). Influence of hole geometry on the flow distribution in ventricular catheters. Biomedical Engineering. OnLine201615(Suppl 1):71

Conclusions

These principles can help develop new catheters with homogeneous flow patterns thus possibly extending their lifetime.

Fig 1



Prototype catheters with homogeneous flow patterns based on parametric designs

Fig 2

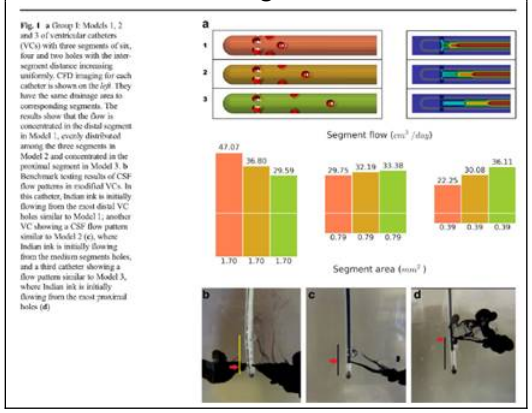


Fig 3

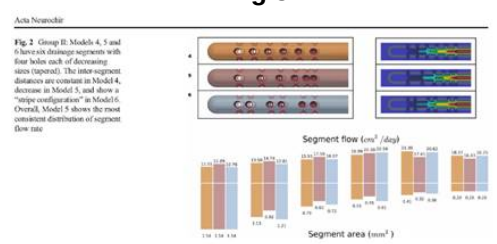


Fig 4

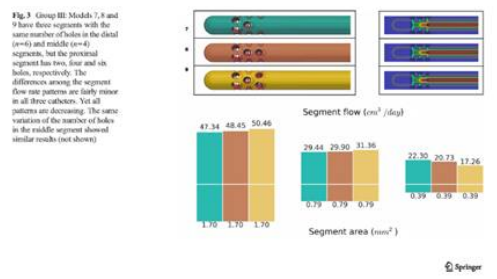


Fig 5