

Hydrocephalus

From nature to pathology

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Abstract

Hydrocephalus is the buildup of too much cerebrospinal fluid (CSF) inside the ventricular system with the deleterious consequence for the brain locked inside the rigid adult skull. Normal Pressure Hydrocephalus (NPH) is a misunderstood, under diagnosed and potentially treatable cerebral pathology, with large clinical interest. (1)

The generalized concept cause of hydrocephalus is an obstacle to the drainage of the CSF. The obstacle can be visible inside the ventricular system for what is called an intraventricular obstructive hydrocephaly or being visible outside the ventricular system in the extra-ventricular obstructive hydrocephaly. If no visible obstacle is observed in images the hydrocephaly is called communicant. But even in this subgroup the concept is that of an obstacle in the subarachnoid space, which we are unable to see but still represent a mechanical problem to the CSF system. (2) This easy intellectual algorithm, “the plumber view” was sustained by the development of the ventricular drainage systems with a very high rate of success. For these reasons, hydrocephalic diseases are very neglected by the neurosurgery community based on a linear concept and a straight forward surgery treatment to be done by residents. Besides that, the majority of the scientific studies and the general medical knowledge of the CFS ventricular system used to consider it as an isolate hydrodynamic system. Recent clinical and scientific data like the possible therapeutic effect of the third ventriculostomy in communicant hydrocephaly (3) (4) and the partial response of patients with some cerebrovascular diseases to the ventricular drainage (5) has demanded a new perspective different from the “the plumber view”. The interaction between the high pressure pulsatile cerebrovascular system and the ventricular system has to be looked act. The intra-cranial CSF can act as a pressure buffer providing a physical bypass to the pulse waves created by the heart beat and so protecting the delicate cerebral microcirculation from that continuous stress. The notion of Normal Pressure Hydrocephalus as a problem of compliance is recent and provides a new way to look at the CSF pathology. (6)

Communicant hydrocephaly can actually not be a disease from the start but actually a way of the system try to maintain homeostasis and deal with a loss of the normal

compliance. The dilation of the ventricular system could provide the system with a better way to dissipate the deleterious arterial pulse waves. Of course, being the cranial system rigid in its adult form, this advantage is quickly overcome by a compartmental space problem.

The mathematical modelling and simulation of CSF dynamics can be used as a non-invasive tool using fluid-structure interaction (FSI) in order to properly capture the compliance and pressure absorption that is believed to be a key role of the CSF fluid and related to the appearance of NPH.

The understanding of the physiologic relations between the cerebrum-vascular and the CSF systems can help physicians optimize the therapeutic approaches for “helping” nature trying to deal with a dysfunction of this delicate inter-play.

Keywords: Normal Pressure Hydrocephalus, Compliance, Mathematical modelling.

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