CSF dynamics, hydrocephalus investigations and shunt testing in vivo

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Abstract

Cerebrospinal fluid (CSF) fills specific cavities surrounding brain and spine. It flows with the slow rate around 0.3 ml/min from lateral and third ventricle, from where it outflows ventricles, through cisterna magna to cerebral subarachnoid space where it is absorbed to venous blood flowing through sagittal sinus. Despite slow flow, any obstacle in pathway of CSF circulation may produce dilatation of brain ventricles and specific clinical symptoms (Hakim Triad), known as hydrocephalus. The model of CSF circulation and pressure-volume compensation was formulated in 1978 by Prof. Anthony Marmarou and is still useful in understanding the nature of disturbances of CSF dynamics in clinical practice. Presented as electric circuit, it includes source of CSF production, uni-directional resistance to CSF outflow and non-linear compliance. Parameters of the model may be identified in clinical practice using infusion test. The test is minimally invasive; infusion of mock CSF may be performed into lumbar CSF space, through pre-implanted reservoir connected with ventricles or pre-chamber of implanted hydrocephalus shunt. External fluid is infused with a constant rate 1 or 1.5 ml/min, and through the same needle, CSF pressure is recorded. Resistance to CSF outflow is probably most important index describing health of CSF dynamics. If it is increased (>13 mmHg/(ml/min)), CSF flow is considered as disturbed, and implantation of shunt system should be considered. The meaning of compliance of CSF space is less obvious. Decreased compliance denotes that internal changes of brain volume (mainly blood) may produce excessive increases in ICP which per-se may produce responses specific for hydrocephalus. Also, recently, specific distortion of ICP pulse waveform has been proposed as useful index of disturbed CSF dynamics, by Prof. M. Kasprowicz and her research group in Wrocław. Investigation on CSF dynamics rarely can be substituted by non-invasive measurements. MRI imaging, transcranial Doppler investigation are not sensitive and specific enough. The role of hydrocephalus shunt is to improve poor CSF circulation. Problem is that shunts may not drain CSF in a way which is 100% beneficial for the patient. It may be blocked, may underdrain or overdrain CSF. Infusion test through the shunt prechamber is a very useful technique, which may detect blockage, overdrainage and, very importantly, avoid unnecessary revision when the shunt works properly.

About the lecturer

She graduated in 1980 from the Warsaw University of Technology, Faculty of Electronics, earning an MSc degree with distinction for her thesis *The Design of a Microwave Generator with the Gunn Diode*. In 1992, she completed a postgraduate study (DESS: Computerisation of Companies) at the University of Paris-Dauphine in France. In 2001, she obtained her PhD with distinction from the Warsaw University of Technology, Poland for her thesis *Hydrodynamic Properties of Hydrocephalus Shunts*.

Since 1993, she has been working at the University of Cambridge, Department of Clinical Neurosciences, Division of Neurosurgery, where she holds a position as Senior Research Associate. Her scientific specializations include CSF dynamics in hydrocephalus and idiopathic intracranial hypertension, hydrocephalus shunt technology, cerebral blood flow in hydrocephalus, computer-supported monitoring and analysis of intracranial pressure, and in vivo testing of hydrocephalus shunts. She has published 162 papers listed on Medline and is ranked as the 12th highest expert on *hydrocephalus* worldwide on the Expertscape.com website.