Reduction in CSF Pulsatility with Altered Intracranial Compliance by Craniectomy in Communicating Hydrocephalus

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Introduction  Communicating hydrocephalus (CH) is a neurodegenerative disease characterized by dilated cerebral ventricles and hyperdynamic pulsatile CSF flow in the cerebral aqueduct, evident from MRI (1). Currently, its etiology is poorly understood. Numerous studies have shown that CH is accompanied by reduced intracranial compliance, (2), which has been suggested as a causative factor involved in the development of CH (3). It follows that a procedure such as decompressive craniectomy, which increases intracranial compliance, and may provide a useful technique for studying the effects of compliance on CH characteristics. We hypothesize that increased compliance, produced by craniectomy, will reduce ventricular dilation as well as elevated CSF pulsations in a rat model of CH.

Methods  CH was induced in adult Sprague-Dawley rats by injecting kaolin into the basal cisterns (4). CH was characterized by measuring pulsatile CSF stroke volume (SV) at the aqueduct using a cardiac gated phase contrast MR scan (TE/TR = 6/10, 128x128 matrix, ST = 1 mm, FOV = 3 cm, velocity encoding = 1-2 cm/s). SV was calculated as the net volume of CSF flowing in one direction over a cardiac cycle. CH was also characterized by measuring ventricular volume (VV) using a balanced 3D TrueFISP MR scan (TR/TE = 2/4, 128x128x100 matrix, ST = 3.2 mm, FOV = 3 cm) and a T2 weighted 2D FSE sequence (TR/TE = 36/3074, ETL = 8, 256x256 matrix, 40 slices, ST/gap = 0.6/0.1 mm, FOV= 3 cm). Volume was calculated by segmenting the CSF encompassing the lateral and third ventricles and aqueduct.

Bilateral craniectomies (4x10 mm each) were made over the parietal bone two weeks after induction of CH. VV and SV were measured prior to and immediately after craniectomy. SV and VV were compared before and after craniectomy. The dura was left intact in all animals, although small tears were present in some. All animals were intubated and ventilated on isoflurane/O2 during MRI.

Results  Animals that failed to develop CH were excluded. Fig. 1 shows T2 weighted axial slices of lateral ventricles at the Foramen of Monroe of a control (left) and a CH (right) animal. Dilated ventricles are clearly evident in the CH animal but almost barely visible in the control.

Discussion  This was a novel and preliminary study testing the effect of altered intracranial compliance on pulsatile CSF flow. Our results indicate that CSF pulsatility is closely linked to compliance, and that increased compliance reduces pulsatile CSF flow. The relationship between pulsatility decrease and ventricular dilation also indicates that this effect is more pronounced for more severe forms of CH. So, increased intracranial compliance may help ameliorate functional and behavioral deficits in CH, although this is purely speculative at this point. Further study is needed to draw solid conclusions, and the effect of altering compliance by other techniques (such as CSF infusion and shunting) on pulsatility and ventricular dilation also needs to be investigated.

References
4. J. Li et al., Exp Neurol 211, 351 (Jun, 2008).