MR velocity mapping of 3D cerebrospinal fluid flow in the patients with enlarged ventricular system: preliminary results

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Purpose: Time-resolved 3D MR velocity mapping is an established method for investigation of normal and pathologic blood flow in the vascular system. We thought that this technique is applicable to study flow patterns of CSF in the human ventricular system. We used time-resolved 3D MR velocity mapping in combination with calculation of particle path lines from velocity vector field data to visualize intracranial CSF flow patterns in patients with an enlarged ventricular system.

Materials and Methods: MR imaging data of the brain were collected from nine patients with an enlarged ventricular system (48 ± 15 years; 40 − 83 y) and nine age-matched healthy volunteers. Six patients were suspected to have hydrocephalus internus, two patients were suspected for normal pressure hydrocephalus, and one patient had a ventriculostomy 10 years ago because of hydrocephalus internus. MRI examinations were performed on a 1.5 Tesla whole-body system (Achieva, Philips Medical Systems, Best, The Netherlands) equipped with an eight-channel head coil. Time-resolved 3D MR velocity mapping data were acquired using a 3D TFE phase-contrast (PC) sequence. Retrospective vector-ECG gating was used for covering the entire cardiac cycle. The sequence yielded 12 quantitative flow-encoded 3D data sets per cardiac cycle. The measurement parameters used were: TR/TE = 16/9 ms, SENSE = 2, turbo factor = 3, spatial resolution = $1.38 \times 1.38 \times 1.5$ mm^3. The individually adapted venc ranged between 2 and 4 cm/s. A local phase correction (LPC) filter was applied for eddy currents correction. In order to enable investigation of 3D velocity vectors of CSF flow velocity encoding was performed in A>>P, L>>R, and F>>H direction. For calculation of time-resolved 3D CSF flow patterns, MR velocity mapping data were evaluated using the GTFlow software tool (GyroTools, Zurich, Switzerland). CSF flow in patients was classified as “hypermotile flow” if CSF flow showed increased dynamics and as “hypomotile flow” if CSF flow showed attenuated dynamics compared to healthy volunteers (**Fig. 1A**).

Results: For the six patients who were suspected to have hydrocephalus internus, four showed hypomotile CSF flow (**Fig.1B**) whereas two showed hypermotile CSF flow. For the two patients who were suspected to have normal pressure hydrocephalus, one showed hypomotile and the other showed hypermotile CSF flow (**Fig.1D**). The one patient who had underwent a ventriculostomy 10 years ago because of hydrocephalus internus showed normal CSF flow dynamics and a path of CSF flow through the opening (**Fig.1C**).

Conclusion: The preliminary findings of these feasibility study indicated changes in CSF flow patterns in patients with enlarged ventricular system compared to volunteers. However, correlation with more detailed clinical parameters as well as examinations on clearly defined subgroups of patients with an enlarged ventricular system is necessary to investigate the usefulness of this approach.

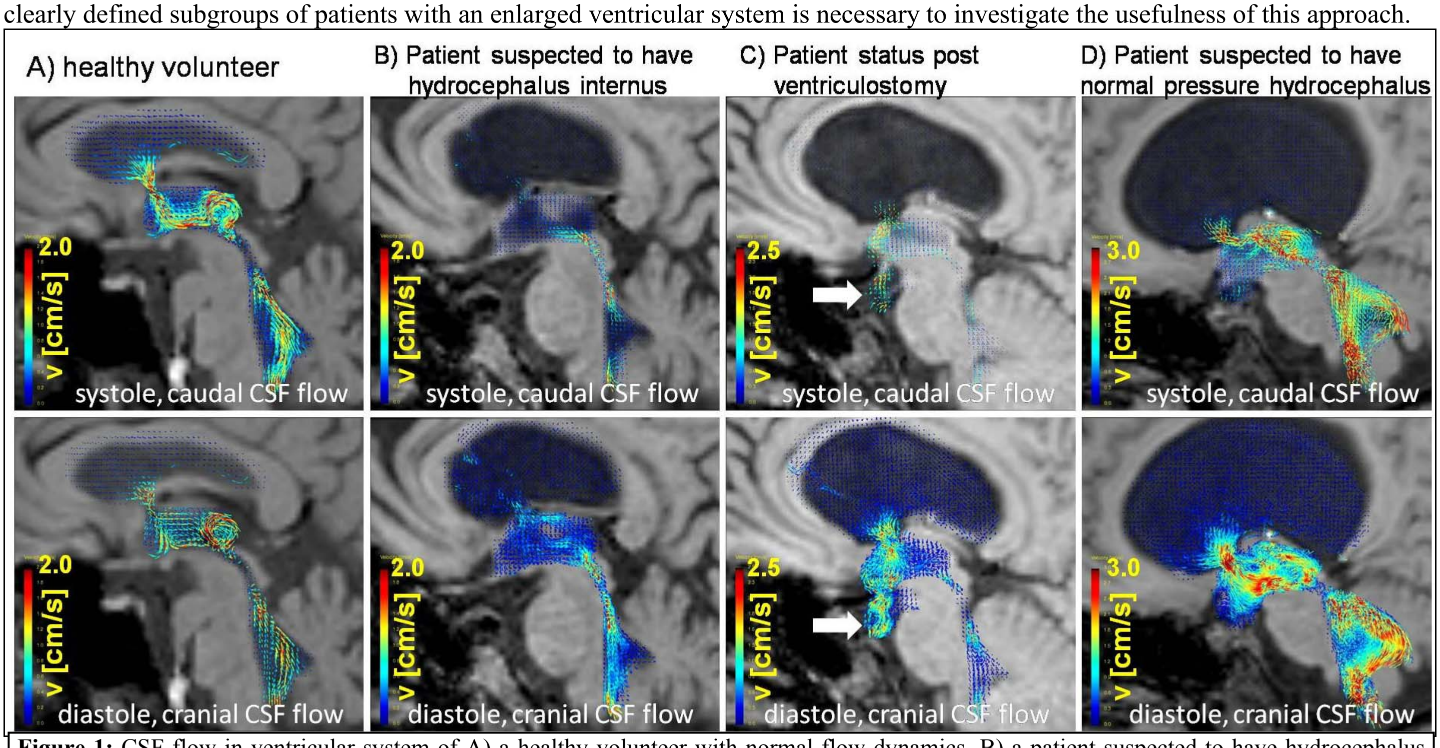

Figure 1: CSF flow in ventricular system of A) a healthy volunteer with normal flow dynamics, B) a patient suspected to have hydrocephalus internus with hypomotile flow dynamics, C) a patient after ventriculostomy 10 yrs ago with normal flow dynamics and a flow path through the opening, and D) a patient with suspected to have normal pressure hydrocephalus with hypermotile flow.