CSF dynamic in a population of children with intracranial CSF increase
Florine Dallery¹, Catherine Gondry-Jouet², Cyrille Cape³, Anthony Fichten², Malek Makki¹, Bader Chaarani¹, Roger Bouzerara¹, and Olivier Balédent¹
¹Radiology, Jules Verne University of Picardie and Amiens University Hospital, Amiens, Picardie, France, ²Neurosurgery, Amiens University Hospital, Picardie, France, ³MRI Research Center, University Children Hospital of Zurich, Zurich, Switzerland, ⁴Imaging, Amiens University Hospital, Picardie, France

Target Audience: Pediatric neuroradiology

Purpose: The intracranial cerebrospinal fluid (CSF) volume increase is frequently seen in the ventricles or in the subarachnoid spaces of newborn and children patients. In number of cases, morphological images can’t conclude if it is a passive or active dilatation. Phase contrast MRI (PC-MRI) is the only tool able to measure CSF oscillations in vivo during the cardiac cycle. Some teams¹,²,³ have already studied PC-MRI flow in children to investigate CSF dynamic in pathology. However, none of these studies until 2013 has studied quantitatively CSF oscillations during cardiac cycle. Recently, PC-MRI study⁴ has shown that CSF oscillations increase with growth, but keeping a similar ratio between the CSF oscillation in the aqueduct and the spinal canal. The aim of this work was to see if the CSF hydrodynamic can bring complementary information to study CSF volume increase in pediatric populations.

Methods: Forty three patients, children aged 5 days to 111 months, with an intracranial CSF volume increase (ventricular or/and subarachnoid spaces) were included. They underwent a morphological MRI and a PC-MRI study to quantify CSF oscillations. Kinetic phase contrast sequences were carried out on a 3T MRI Signa HDx GE Healthcare. The parameters used were: a matrix (in mm²) 384 x 256 for the aqueduct and 256 x 256 for CSF cervical; a flip angle of 30 °; slice thickness 5 mm; a repetition time of 10 to 18 ms; an echo time of 4 to 8.5 ms; a field of view of 140 mm x 98 mm; 32 frames per cardiac cycle. From a sagittal T1-weighted sequence, acquisition plane for phase contrast sequences have been placed: one perpendicular to the cervical plane (Figure 1). Encoding speed was 10 cm / second. A CSF volume index (CSF

Results: The entire population was divided in 3 subgroups (Figure 3). The first group with 23 patients presented only ventricular dilatation: CSFDynamic = 20 ± 25; CSFRepartition = 120 ± 151. There was no correlation between CSFDynamic and CSFRepartition. The second group with 16 patients presented both dilatations (ventricular and subarachnoid spaces): CSFDynamic = 18 ± 17; CSFRepartition = 1.67 ± 0.81; There was positive correlation between CSFDynamic and CSFRepartition. And the last group with 4 patients presented only a subarachnoid spaces dilatation: CSFDynamic = 11 ± 6; CSFRepartition = 0.65 ± 0.19. Results were different in each subgroups probably linked to different pathophysiological origins.

Discussion: In the global population and in the first group with only ventricular dilatation, there was no significant correlation between CSFDynamic and CSFRepartition. Some of children had normal CSF Dynamic. Normal CSF Dynamic could be associated with small or high CSFRepartition. In the group with ventricular dilatation, some children presented an abnormal CSF volume dilatation, but among them, some of children had a normal CSFDynamic. Contrariwise, in the group with both dilatations, relationship was underlined between the CSF flow and the size of the CSF compartments. This interesting correlation shows that an increase of the ventricular compartment in front of the subarachnoid spaces size is correlated with an increase of CSF oscillations through the aqueduct. That could help to understand ventricular dilatation’s mechanism in children. We notice that children of this group were very young. We know that at this period, the fontanels are not completely closed. In number of cases, morphological images can’t conclude if it is a passive or active dilatation. CSF oscillations bring complementary information concerning the active aspect of the CSF. Further studies are needed with a larger population and long-term follow-up to evaluate the pertinence of these new morphological parameters.

Conclusion: In pediatric population, the absence of correlation between the dynamic of the CSF and its volume in the global population shows that the CSF oscillations are not only the result of the size of the ventricles or the subarachnoid spaces. The CSF oscillations bring complementary information concerning the active aspect of the CSF. Further studies are needed with a larger population and long-term follow-up to evaluate the pertinence of these new morphological parameters.


Figure 1. Dynamic analysis by phase contrast MRI

Figure 2. Morphological analysis: A: area of the ventricles; B: area of the brain; C: area of the skull

Figure 3. Link between CSFRepartition and CSF Dynamic per subgroup. Pink area represents patients with normal CSF dynamic. Four patients had aqueductal stenosis which were not detected by morphological imaging (snowflake).