Accurate And Reliable PC-MRI Sequence To Investigate Complex Dynamic Of Cerebro-Spinal Fluid in the Brain.
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Purposes: Free circulation of CSF through Pontine Cistern (PC) plays an important rule in cranio spinal compliance and is necessary to expect endoscopic third ventriculostomy success in case of aqueductal stenosis (1). An accurate cerebrospinal fluid (CSF) flow measurement through the PC is technically challenging and might explain the failure of ETV procedure [2]. CSF motion is very slow and PC is infiltrated with the basilar artery that generates blood flow artifacts and surrounding vessels corrupt the signal and make it difficult to segment the CSF flow area of PC using phase contrast MRI (PCMRI) [3]. The aim of this study was to develop reliable new PCMRI sequence to accurately quantify CSF flow free of artifact from blood signal.

Material and Method The study was performed on a 3T scanner (GE Healthcare, Milwaukee, USA) and 8-channel head coil. Imaging parameters are: FOV=140x140 mm², thickness = 5 mm, BW= 62.5 kHz, flip angle=20°, minimum TE and TR, matrix 256x160, 32 cardiac phases, 2 views per segment, and 1 Nex. The slice was positioned perpendicularly through the PC and the Foramen of Magendi (FOM). FOM will be considered as a control compartment because it is not infiltrated with blood vessel. The velocity encoding (Venc) of the conventional sequence was set to the minimum possible value of 50 mm/s. This commercial available sequence was first modified to achieve a lower Venc of 20 mm/s to increase the sensitivity of the acquisition to slower flow. In addition to remove signal of blood flowing into the selected slice, we incorporated a spatial selective pre-saturation pulse. This involves the implementation of a Hadamard pulse (or double sided bands) to achieve a perfect parallelism with the selected slice and reproduce the same sat-band (thickness, gap and orientation) in the other side (Figure 1). The spatial saturation band was 50 mm thick and positioned inferior and adjacent to the prescribed slice with a 10 mm gap. Following the approval of the study by our regional ethical committee, 18 consented adult patients (age 63.5 ± 15.7 years) with suspected hydrocephalus underwent the clinical examination with the conventional and developed PCMRI sequences through the same imaging slice. Delineations of CSF in the PC and FOM were automatically and separately [4] performed to extract ROI area, flow (min and max) and stroke volume. The values obtained by the conventional and the developed sequences were compared using paired Ttest.

Results: The advantage of incorporating sat-band to remove the blood artifact aliasing from basilar artery is clearly demonstrated (figure 1). In addition one can appreciate the other advantage of reducing the Venc to 20mm/s to record CSF flow in PC and FOM. The processing is more reproducible with the developed sequence (intra-observer intra-class correlation coefficient) was always higher for flow, stroke volume and ROI area in both FOM and PC (results not shown). Significantly higher ROI area (p < 0.001) was measured in FOM with the developed sequence compared to the conventional one (Table 1) with no significant effect neither in the flow (min and max) nor the stroke volume. In the PC, as expected the opposite phenomenon was observed: the ROI was not significantly different between the 2 sequences but the stroke volume was significantly lower (p = 0.021) and the flow had significantly lower maximum (p = 0.019) and significantly higher minimum (p=0.031).

Table 1: Paired Ttest to compare the developed and conventional sequences in the foramen of Magendi (FOM) and pontine cistern (PC). The threshold for p was set to 0.05 and NS stands for not significant

Discussion: The modified sequence that uses Hadamard pre-saturation bands with cine PCMRI provides accurate and reproducible CSF flow and stroke volume measurements in the PC. In addition with a lower Venc one can easily extract the CSF pixels even if CSF flow is very low. Theses modifications have no compromise in SNR, temporal and spatial resolution. Such quantification will definitely impact the success of ETV and might also be useful to better diagnose and understand hydrocephalus or others CSF flow alteration as subarachnoid hemorrhages.