"Trumpet shaped" dilated cerebral aqueduct and cerebrospinal fluid (CSF) flow profiles in patients with highly elevated CSF flow

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Purpose

With ageing of the population the diagnosis of a possible hydrocephalus gains in importance.

Even if the CSF flow measurement in Patients with communicating hydrocephalus (CH) measurement is under discussion, the decision when to perform further MRI examinations and additional MRI CSF flow measurement has to be made.

We wanted to explore the relationship between aqueductal cerebrospinal fluid (CSF) flow measurements and changes of the anatomical configuration of the cerebral aqueduct (AC). To our best knowledge Y. Kurihara [14] was the first to describe a change in morphology of the AC in NHP patients in the year 1995.

We examined 150 Patients (incl. Patients with Shunt) by MRI on our institute. We performed a retrospective evaluation of different anatomical configurations and found enlarged AC diameter in patients with elevated CSF flow.

We could demonstrate that there is extremely statistically significant correlation between highly elevated absolute stroke volume of CSF in the AC and dilated AC conformation. We called this sign "trumpet shaped" AC conformation. To gain further information we calculated 3D surface plots of the CSF velocity over a heart cycle and we could demonstrate that there is even a qualitative difference in CSF velocity plots of patients with normal compared to patients with dilated AC configuration.

We think that an enlarged, even trumped shaped AC is a sign of high value to pick out patients for further MRI examinations, and best treatment of hydrocephalus. This may be of great importance in evaluating patients with suspected CH.

Methods and Materials

From Oct. 2008 till May 2011 we measured 150 Patients (incl. Patients with Shunt) by MRI CSF flow measurements on our institute. All patients had an Evans ratio > 0.3 which indicates that the ventricles are enlarged. Retrospectively we found enlarged AC diameter in patients with elevated CSF flow. We looked at the first examinations of 43 (mean age 67 years) patients without a
shunt with suspected CH. After using the anatomical form of the AC on sagittal MRI images to form two groups of patients: "tubular" AC and "trumpet like" AC. "Tubular" means the diameter of the AC is the same at pars anterior and pars posterior, in "trumpet like" configuration there is an increase in the diameter at the caudal end of the AC. Quantitative PC MRI measurements were performed perpendicular to the AC. The results of the evaluation of the lumen area were correlated with the quantitative MRI CSF flow data. In addition we compared flow velocity profiles in the AC over a heart cycle of these patients.

We evaluated the clinical outcome of 22 Patients by using the mRS before and after treatment.

Statistical analysis:

Descriptive statistics such as means, percentages and ranges were computed for several variables. When the data was gauss distributed we used two-sided, unpaired Student t-tests to compare several variables for both groups. As usual we used confidence lines of 5% and 1%. All analyses were done using GraphPad Software (www.graphpad.com).

Results

3D surface plots over a heart cycle illustrate the amount and velocity of CSF passing trough the AC. With the widening of the AC in "trumpet like" configuration the CSF plot is significant different.

In general, there is a better correlations of our measurements for "tubular" AC. And in "trumpet like" configuration the placement of the measure plane is of importance too.

When looking at the absolute stroke volume, the measured values of the trumpet configuration are elevated: 0,489 ml ± 0,237 ml for "trumpet like" configuration, compared to 0,200 ml ± 0,124 ml measured in patients with tubular configuration. This difference is considered to be extremely statistically significant by t-test.
The measured values of peak velocity in the trumpet configurated AC are elevated - 13,85 cm/s ± 3,98 cm/s, compared to 9,28 cm/s ± 3,66 cm/s measured in patients with tubular configuration. This is considered to be extremely statistically significant by t-test.

The values of the Evans ratio for the "trumpet" configuration are higher than for the tubular configuration - we measured 0,403 ± 0,044 for "trumpet" compared with 0,370 ± 0,073 for tubular.

We used the Modified Rankin Scale (mRS) to evaluate the clinical status of our patients before and after shunting (MEDOS Shunt). We were able to evaluate the mRS in only 22 patients. 60% of patients with tubular AC configuration improved after shunting. Only 8,3% of the patients with "trumpet like" AC configuration improved after treatment.

Images for this section:

Fig. 1: Normal "tubular" AC. From left: T2 CSF Drive image. 3D CSF flow Profile. T1 FFE image saggital und axial.

Fig. 2: Enlarged "trumped shaped" AC. From left: T2 CSF Drive image. 3D CSF flow Profile. T1 FFE image saggital und axial.
**Fig. 3:** 1st row: 3D surface plot of flow velocity measured in a normal AC over a heart cycle. 2nd row: enlarged AC. 3rd row: “trumpet configuration”.

**Fig. 4:** Comparison of "tubular" and "trumpet like" configuration of the AC for: (left) peak velocity, (middle) Evansindex, (right) mRS (showing clinical improvement in patients with tubular configurated AC)
Conclusion

As the range of measured CSF_PCA values differs in literature, we added 3D surface plots in our work to visualize the flow in the AC. We found extremely statistically significant differences between "tubular" and "trumpet like" AC configuration.

1) We think that an enlarged, even trumped shaped aqueduct is a sign of high value to pick out patients for further MRI examinations (CSF flow measurement), even if this is under discussion.

2) The massive dilatation of the AC into a trumpet shape, seems to be related to a worse outcome after shunting - larger numbers of patients have to be evaluated!

References


**Personal Information**

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