Aqueductal stroke volume

MR imaging has been proposed to quantify the flow of CSF in the aqueduct.

Phase contrast magnetic resonance imaging can quantitatively measure stroke volume in selected regions, notably the aqueduct of Sylvius, synchronized to the heartbeat.

By phase-contrast cine MR imaging (PCCMR), the stroke volume (SV), defined as the mean volume passing through the aqueduct during both systole and diastole, can be calculated. A SV greater than or equal to 42 µL serves as a selection criterion for patients with good probabilities of improvement after ventriculoperitoneal shunt (VPS) [1].

Aqueductal stroke volume (ACSV) measured by phase-contrast cine (PCC)-MRI has been proposed with controversy as a tool for the selection of patients with normal pressure hydrocephalus (NPH) as candidates for shunt-surgery.

Case series

2017

Stecco et al. retrospectively reviewed charts and MRI of 38 shunted patients (72,16 ±6,16 years). ACSV measurements were performed 7-30 days before shunt and at the first and sixth months after surgery. Normally distributed variables were compared in the two groups (improved/unimproved) by T-test for baseline values and with repeated measures analysis of variance.

26 patients (68,4 %) improved after VPS (mean time of symptom onset was 8,15 ±7,19 months). Mean preoperative ACSV value was 271,85 ± 143,03, which decreased by 21,6 % (mean 213 ± 125,14) at the first month and 40,3% sixth months after VPS (mean 162,15 ± 91,5). 12 patients (31,6 %) did not improve (mean time of symptom onset was 29 ± 5,62 months). Mean preoperative ACSV value was 79,83 ± 31,24, decreased to 8,7 % (mean 72,83 ±28,66) at first month after VPS, 21,2% (mean 62,83 ± 31,12) after six months. We found statistical difference between preoperative ACSV of improved and unimproved patients ($p<0,01$), onset time of symptoms ($p<0,01$) and the changes in ACSV after one and six months in both groups ($p<0,001$).

ACSV is useful to stratify patients with NPH after surgery (improved /not improved) suggesting to proceed with serial ACSV measurements before deciding treatment [2].

2015

Phase-contrast MR imaging was performed in 21 patients with probable idiopathic normal pressure hydrocephalus. Patients were selected for shunting on the basis of pathologically increased intracranial pressure pulsatility. Patients with shunts were offered a second MR imaging after 12 months. Ventricular volume and transverse aqueductal area were calculated, as well as clinical symptom score.

No correlations between aqueductal stroke volume and preoperative scores of mean intracranial pressure or mean wave amplitudes were observed. Preoperative aqueductal stroke volume was not

different between patients with shunts and conservatively treated patients (P = .69) but was correlated with ventricular volume (R = 0.60, P = .004) and aqueductal area (R = 0.58, P = .006) but not with the severity or duration of clinical symptoms. After shunting, aqueductal stroke volume (P = .006) and ventricular volume (P = .002) were reduced. A clinical improvement was seen in 16 of 17 patients who had shunts (94%).

Aqueductal stroke volume does not reflect intracranial pressure pulsatility or symptom score, but rather aqueduct area and ventricular volume. The results do not support the use of aqueductal stroke volume for selecting patients for shunting [3].

2012

Among 21 patients investigated with both tap test (TT) and phase contrast magnetic resonance imaging (PC-MRI), El Sankari et al identified two groups, with either (1) a positive TT (PTT) or (2) a negative one (NTT), and compared their aqueductal stroke volume (ASV) as measured by PC-MRI. ASV cutoff value was set at 70 µL/cardiac cycle (mean value +2 standard deviations in age-matched healthy subjects).

In the PTT group (n = 9), the mean ASV was 175 ± 71 µL. Among these patients, four were shunted, and improved after surgery. In the NTT group, two patients were finally diagnosed with aqueductal stenosis and excluded. Among the remaining patients (n = 10), the mean ASV was 96 ± 93 µL ($p < 0.05$). However, three of these patients presented with hyperdynamic ASV, and an associated neurodegenerative disorder was diagnosed. Two patients had ventriculoperitoneal shunting despite their NTT, and improved.

In the patient population, the noninvasive measurement of hyperdynamic ASV correlated with PTT, suggesting PC-MRI could be utilized to select those patients who would benefit from shunting. ASV may therefore be an interesting supplemental diagnosis tool [4].

2008

Nine patients who presented with clinical and radiologic evidence of NPH, but refused treatment with VPS, were evaluated every 6 months for up to 2 years for progression in their clinical symptoms and changes in their SV, as measured by phase-contrast cine MR imaging (PCCMR).

SV seems to increase between the onset of the symptoms and the following 18 to 20 months, then seems to plateau, followed in the next 18 to 20 months by a slight decline, and finally to a more precipitous drop in the next 12 months. During this time, however, the patient's clinical symptoms progressively worsen.

Patients with a low SV have not necessarily had brain atrophy and can show, in the following months, a progressive increase in SV, which qualifies them as good candidates for VPS. The progressive reduction of the SV in untreated patients with worsening clinical symptoms may be a sign of a progressive cerebral ischemic injury, which renders the NPH irreversible [5].

2007

Thirty-eight patients with suspected normal pressure hydrocephalus were included. Cerebrospinal

fluid stroke volume (SV) was assessed using cine phase-contrast magnetic resonance imaging, and the results were kept blinded until postoperative follow-up after 7 +/- 5.8 months (mean +/- standard deviation). Selection to surgery was based on a positive lumbar infusion test or cerebrospinal fluid tap test, and outcome was evaluated with objective tests.

Six patients were excluded from SV measurements because of technical difficulties. Eight patients were not operated (negative lumbar infusion test and cerebrospinal fluid tap test). SV in the not operated patients (mean, 66 +/- 53 microl) did not differ from the operated patients (95 +/- 78 microl; P = 0.335). Operated patients showed statistically significant improvements in walk (P = 0.020), reaction time (P = 0.006), and memory (P = 0.001) tests. Patients were divided into three groups according to SV range: low (0-50 microl), middle (51-100 microl), and high (>100 microl). No statistically significant (P > 0.05) improvements in any of the objective tests were found in any of the SV ranges. The numbers of individually improved patients were similar in the different SV ranges: six out of seven in the low, nine out of nine in the middle, and five out of eight in the high range. Weak correlations were found between SV and the initial pulse amplitude (Rs = 0.043; P = 0.014) as well as the plateau pulse amplitude (Rs = 0.043; P = 0.014) as measured with the lumbar infusion test.

The data from this study show no evidence that cine phase-contrast magnetic resonance imaging measurements of SV in the cerebral aqueduct are useful for selecting patients with normal pressure hydrocephalus symptoms to shunt surgery [6].

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