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Editorial

Transcranial Doppler for middle cerebral artery stenosis assessment: how to grasp the tool?

In this issue of Clinical Neurology and Neurosurgery, Lee et al published an article entitled "A comparison of transcranial Doppler and magnetic resonance imaging for long term changes in middle cerebral artery stenosis" [1]. This study aimed to quantify the arterial narrowing or dilation associated with intracranial middle cerebral artery (MCA) stenosis through the correlation between Transcranial Doppler (TCD) and magnetic resonance angiography (MRA) findings. The follow-up was ensured for a period of about 18 months. Using an incremental approach, a cutoff of 20 cm/s for delta mean flow velocity (MFV) correlated with MRA-assessed changes in the MCA stenosis category (i.e. mild, moderate, severe, or occlusion). This association was significant for stenosis progression, but not for regression. The authors concluded that this criterion could be of interest in the clinical research field and real-world practice.

Other studies evaluating MCA stenosis progression with serial TCD tests predefined a threshold value (i.e. relative variation of 20 cm/s or 30 cm/s for MFV to the initial value [2,3]), or a score of three ranges based on peak systolic velocities (PSV) [4]. Of note, these thresholds were never validated.

The present results are interesting, as they provide additional support for TCD use in MCA stenosis long-term follow-up. Still, the threshold of 20 cm/s increase cannot be regarded as definitely validated by this study alone, and several limits need to be addressed.

First, the number of patients is small. In fact, due to insufficient prospective cohort enrollment, authors added patients from a retrospective cohort, and then aggregated the data for statistical analysis.

Second, the gold standard was a semi-quantitative MRA method for MCA stenosis evaluation. MRA is interesting, as it is non-invasive, doesn't use X-rays nor contrast agent, but remains less reliable and precise when compared to a CT-angiogram.

Third, the TCD technique may also be discussed. The authors measured only mean velocities. However, for any pulsed Doppler exam, systolic and diastolic velocities provide also important information, roughly reflecting the upstream load conditions and downstream flow at the measured focus point, respectively. Thus, a hemodynamically arterial symptomatic stenosis is expected to reduce PSV downstream, leading to a decrease pulsatility index. The diastolic value reflects the effective distal blood flow available for the cerebral parenchyma. This blunt pattern of the velocity spectrum, above all when asymmetric, is a strong argument for the presence of an upstream stenosis.

In addition, a one-dimensional Doppler device was used in this study, which did not allow to correct the angle of insonation, unlike a system coupled with a 2D ultrasound. The angle of insonation depends mainly on the patient's morphology. Irrespectively of the technician's experience, it is not possible to make sure that the angular error was low. This may have influenced the results. Indeed, the found MFV rise cut off was 20 cm/s, with a basal value of 122 cm/s, or an increase of 16.4 %. Knowing that the velocity real value is the measured one divided by the cosine of the insonation angle (i.e. angular correction), it can be calculated that a velocity increase of 16.4% corresponds to an angular correction of 31°, which is quite common in practice.

Arterial stenosis is also likely to alter the blood flow profile, which takes an ogival form (i.e. erythrocytes in the center of arterial lumen accelerate while those along the walls slow down). The difference between the maximum velocity at each moment and the mean velocity is then accentuated. Therefore, it has been proposed to consider the mean velocity curve of the spectrum, which would better reflect the flow in the artery than the maximal contour curve. Thus, unlike neurologists and neuro-intensivists, hematology-pediatricians who monitor vascular diseases related to sickle cell disease most often use mean velocity contours-based indices [5]. The latter observed values are therefore not comparable to those of neurological patients.

Last but not least, it is interesting to compare the condition of MCA chronic stenosis with vasospasm consecutive to subarachnoid hemorrhage (SAH). The famous Lindegaard index [6], defined as the ratio MCA MFV / ipsilateral internal carotid artery MFV, may reveal vasospasm occurrence. If the ratio is less than 3, the spasm is unlikely, whereas if it is more than 6 the spasm is probable, and between 3 and 6 the spasm is possible. Then Vora et al. [7] showed that a MFV between 120 and 200 cm/s indicated a possible, but not certain vasospasm, whereas vasospasm was unlikely if MFV was less than 120 cm/s; and was highly probable when the MFV was greater than 200 cm/s. Grosset et al also described a dynamic index including a rise of more than 50 cm/s within 24 hours, which was correlated to delayed ischemic neurological deficit [8]. These three criteria remain the most used to date by neuro-intensivists. Despite these facts, the increase in velocities usually does not allow to quantify arterial narrowing. For this reason, TCD is considered a qualitative tool for vasospasm detection, which must be confirmed by a radiological examination, including CT angiogram or digital subtraction angiography.

To sum-up, the diagnostic criteria appear to be quite different between these three clinical conditions, and a direct transposition may be hazardous. In addition, systemic conditions (e.g. arterial blood pressure, volemia, capnia, vigilance, etc.) are likely to impact more TCD findings in the setting of severe SAH, than in MCA atherothrombotic stenosis rated at rest.

In conclusion, TCD is a very useful tool for non-invasive examination of brain arteries, both for ambulatory and ICU patients. The parallel is interesting to exert, and illustrates the fact that although TCD itself is quite simple to perform, its interpretation greatly depends on the context and measurement conditions. Larger prospective studies are needed to determine more accurately the most relevant stenosis criteria considering the context.

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