Application of transcranial Doppler ultrasound in pediatric patients: how to verify the indications?

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STRESZCZENIE


ABSTRACT

Aim. The aim of the study is to identify the most important indications for the transcranial Doppler in pediatric patients. Material, method. The study population consisted of 140 children aged 8 months to 18 years (93 girls, 47 boys). The indications for the patients’ admittance were: headache, vertigo, syncope, stroke confirmed by the brain computed tomography. All the patients were examined physically and neurologically; the transcranial Doppler and the head MRI were performed. In the cases were cerebrovascular malformation was suspected, the magnetic resonance angiography was conducted. Results. According to the clinical examination and the neuroimaging we diagnosed: tension headache in 52 children; migraine in 14 children; ischemic stroke in 38 children. The pathological result of the TCD was found in 50 children: in 10 of them the result suggested the hypoplasia of intracranial vessels; in the same group in 4 children the vertebral artery hypoplasia was confirmed. In 38 children with ischemic stroke the evolution of the blood flow, from stenotic signs to partial/ full recanalization, was observed. Conclusions. The TCD is extremely important in the blood flow evolution investigation of the pediatric ischemic stroke patients. In majority of children with headache no TCD pathology was found. Key words: transcranial Doppler, children, headache, stroke, indications

The transcranial Doppler (TCD) is the diagnostic procedure commonly used in ambulatory and hospital practice. As the method does not expose the patients to the X-ray radiation and does not require the anesthesia, it becomes more and more common, especially in children. According to the American Academy of Neurology the value of TCD is well established in sickle cell disease for assessing stroke risk, in monitoring the vasospasm after subarachnoid hemorrhage and in diagnosing right-to-left cardiac shunts (Evidence Type A Class I-II). The usefulness of TCD in intracranial steno-
occlusive disease is less evident but still it is considered as useful for the detection of intracranial stenosis/occlusion or detection of impaired cerebral hemodynamics in patients with extracranial stenosis/occlusion and with cerebral small-artery disease (Evidence Type B, Class II-III) [1].

Although the headaches are not the indication for TCD but in every-day practice the method is being commonly used to provide information about cerebral hemodynamics [2]. The clinical application of TCD remains to be determined. The aim of the study was to identify the most important indications for the transcranial Doppler in pediatric patients.

MATERIAL AND METHODS
The study population consisted of 140 children aged 8 months to 18 years (93 girls, 47 boys). All the patients were hospitalized in the Neuropediatric Department within the period of the last three years, the stroke patients within the last 8 years. The indications for the patient’s admittance were: headache, vertigo, syncope, ischemic stroke. All stroke cases were confirmed with the brain computed tomography and/or magnetic resonance imaging (MRI). The neuroimaging (MRI and/or MRA) was performed with 1.5 Tesla machine and interpreted by an experienced pediatric radiologist. Some of the children required the general anesthesia for the examination. All patients were examined physically and neurologically; the transcranial Doppler and the head MRI were performed in all of them. In the cases were cerebrovascular malformation in TCD was suspected the magnetic resonance angiography was conducted. The TCD in the patients with headache/vertigo and syncope was performed in the interictal period; in the stroke patients- in the acute state of disease.

The neurological state of the majority of examined patients was normal, even of the thirty eight patients with stroke. In the last group hemiparesis and/or facial nerve paresis contralateral to the brain lesion was found.

The TCD examination was performed with single-channel portable unit Pioneer TC 2000 (EME Eden Medizinische Elektronik, Uberlingen, Germany) with a hand-held transducer operated in a range-gated, pulse-waved mode at 2MHz. Intracranial arteries were insonated through the temporal window by use of standardized protocol[3]. Middle cerebral artery (MCA), anterior cerebral artery (ACA), terminal segment of internal carotid artery (ICA) and posterior cerebral artery (PCA) were examined. Arteries were distinguished by the position of the probe, the depth of insonation and the direction of the blood flow. The sample volume size was 8 to 10 mm in the axial and 5 mm in the lateral direction. The examined parameters of the blood flow were: the mean blood flow velocity (MV), the blood flow character (laminar or turbulent). The turbulent blood flow was recognized when spectral broadening was recorded. The features of the vessel stenosis were: increase of the mean blood flow velocity (> 0.8 m/second) or the blood flow velocity difference between the left and right side (> 0.3 m/second) with coexisting turbulent character of the blood flow. The vessel hypoplasia was diagnosed when there was a significant decrease in blood flow velocity with coexisting turbulent character of the blood flow.

RESULTS
The stroke patients were analyzed within the group 1. According to the clinical data stroke patients were classified as PACI (partial anterior circulation infarct, 11 children), LACI (lacunar anterior circulation infarct, 7 children) and TACI (total anterior circulation infarct, 2 children). According to the clinical and additional examinations and the International Headache Classification in most of the examined patients the idiopathic headache was diagnosed (66 patients; 47, 1%); the group was divided into subgroup with tension headache (52 children, 37, 1%, group 2) and migraine (14 patients, 10%, group 3). Secondary headache was found in about 1/3 of the whole group (36 patients, 28,5% - group 4) (Table I). The positive family history (headaches in parents and/or child’s siblings) was found in six children - four with tension headache and two with migraine.

The pathological result of the TCD was found in 39 children (28% of all groups).

Table I. Examined groups of patients according to diagnoses

<table>
<thead>
<tr>
<th>Group</th>
<th>Diagnosis</th>
<th>Number of patients (total n=140)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ischemic stroke</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>Tension headache</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>Migraine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>common</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>classical</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>benign paroxysmal vertigo</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Symptomatic (total number 36 patients)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sinusitis/ tonsillitis</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Arachnoid cyst</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Instability/ hyperlordosis of cervical vertebral column</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Glaucoma</td>
<td>2</td>
</tr>
</tbody>
</table>

Generalized increase of the blood flow velocity was found in 19 patients with stroke and 10 patients with migraine whereas in none in other groups (Table II). Vessel reactivity test was positive in four patients with classical migraine (group 3). Decrease of the segmental blood flow velocity with turbulent blood flow was found in 10
patients with tension headache (group 2). In 4 of them vertebral artery hypoplasia was confirmed in the magnetic resonance angiography. Turbulent blood flow was also found in 15 stroke children (group 1). The localization of the blood vessel pathology was contralateral to the neurological deterioration found in the patient. Segmental blood flow decrease was found in 10 cases only in the group with tension headache (group 2) (Table II).

**DISCUSSION**

In the adult patients with tension headache and the healthy ones no differences in TCD blood flow parameters were found [5]. Moreover, in the adults with common migraine and with classical migraine in the interictal period the TCD parameters of cerebral vessels blood flow were similar to the results in healthy ones [6,7].

In adolescents with migraine and tension headaches the features of cerebral vessels hyperactivity was found only during the headache incident [8]. Arjona et al. have examined the group of patients aged 16-50 years with migraine and tension headache; the cerebral vessels hyperactivity was found only in the patients with migraine [9].

In comparably large group of 133 children with headache examined by Maytal et al. (52% migraine, 21% tension headache, 19% unclassified headache) only 78 (59%) underwent the neuroimaging (head CT and/or MRI). Only in 4 out of the 78 the pathological changes on neuroimaging were found. The authors did not perform the TCD [10,11]. All the results mentioned above indicate that the neuroimaging studies have a very limited value in the evaluating headaches in pediatric patients.

The huge group of 858 children aged from six months to 18 years was examined by Hirsch et al. within the time of seven years. The pathological findings in TCD were found in 0, 4% (headache, orthostatic deregulation group), 5,4% (acute neurological symptoms) and 22% of different reasons. The positive predictive value of finding any abnormality was very low, so the indications for TCD performance in children are very specific, for example the known other vascular examinations of pathological processes of the brain vessels (stenoses) and chronic diseases, like sickle cell disease and angiitis [2]. Our results, however examinations not performed in such large group of patients, are similar to the authors’. Moreover, the Fiermonte et al. found the increase of the blood flow in the migraine patients as useful to differentiate between the diagnosis of migraine and tension headache, which is also consistent with our results [12]. Gergont A, Kozera G et al. results indicate, that there are no specific features in the blood flow parameters between the children with migraine and tension headache, so the last and the largest group of pediatric patients with headache, the tension headache group, still presents the diagnostic problem[13,14]. As the pathophysiology of migraine and tension headache is different, the TCD results in the two groups are different as well. One of the features specific to migraine is the blood vessel hyperactivity, confirmed also in our patients.

Nesterovskij et al. examined 140 children aged 6 – 16 years, with different types of headaches; they found the increase of blood velocity in all types of headaches when compared to the control group [15].

In the very small group (four children) with the suspicion of vessel hypoplasia on TCD examination, the magnetic resonance angiography results confirmed the initial diagnosis. In much larger group of children analyzed by Bojnova V et al. group of 205 children aged 3-15 years with different symptoms - stroke, transient ischemic attacks, focal seizures) the intracranial vessel hypoplasia was found in 63 of them, mainly with the use of MRI [16].

In our group of symptomatic headache (group 4) no specific features of cerebral blood flow were found. It seems to be the cause of headache in the group, as the children with intracranial pressure for hydrocephalus, tumors, head trauma or neuroinfections present the cerebral blood flow disturbances [17-20].

**Table II.** The statistical analysis of the TCD parameters within the examined patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gr. 1 stroke (N=38)</th>
<th>Gr. 2 Tension headache (N=52)</th>
<th>Gr. 3 Migraine (N=13)</th>
<th>Gr. 4 Symptomatic headache (N=36)</th>
<th>Statistical significance between the examined groups of patients (Fisher’s exact test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generalized increase of blood velocity</td>
<td>19 (50,0%)</td>
<td>0 (0,0%)</td>
<td>10 (76,9%)</td>
<td>0 (0,0%)</td>
<td>Gr.1-Gr.2: p&lt;0,00001</td>
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<tr>
<td>Turbulent blood flow</td>
<td>15 (39,5%)</td>
<td>10 (19,2%)</td>
<td>0 (0,0%)</td>
<td>0 (0,0%)</td>
<td>Gr.1-Gr.2: p=0,05, Gr.1-Gr.4: p=0,006</td>
</tr>
<tr>
<td>Segmental blood velocity decrease</td>
<td>0 (0,0%)</td>
<td>10 (19,2%)</td>
<td>0 (0,0%)</td>
<td>0 (0,0%)</td>
<td>Gr.3-Gr.2: p&lt;0,00001</td>
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<td>Gr.1-Gr.2: p&lt;0,00001</td>
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<td></td>
<td></td>
<td>Gr.1-Gr.3: p&lt;0,00001</td>
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<td>Gr.1-Gr.4: p&lt;0,000001</td>
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<td>Gr.2-Gr.4: p=0,005</td>
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</table>
All the patients of the group 1, the stroke patients, admitted to hospital with the symptoms of hemiparesis and/ or facial nerve paresis of the same side of the body; some of them with speech and consciousness disturbances. On the base of the clinical course and the results of neuroimaging we qualified all of them to the one of the three stroke types: PACI, LACI or TACI. At the hospital admittance TCD results presented the stenotic blood flow in the intracranial part of ICA and/or MCA and/ or ACA with the increased mean blood flow velocity in the vessel compared to the opposite, healthy vessel, and the features of the turbulent blood flow spectrum. At the discharge form hospital in 9 patients of the group 1 the normalization of the mentioned parameters was observed, but still in the last 10 of them the stenotic blood flow was present. This is the group of patients requiring special care and the systematic TCD examinations.

It is obvious that the pediatric patients with sickle cell diseases are at risk of ischemic stroke; that risk increases with the increase of blood flow velocity and that is the group of patients which requires the regular blood transfusions [21-25]. Although in the described group of stroke children there are no patients with sickle cell disease, but still the necessity of the TCD follow-up in that group seems to be clear.

We did not find in the Polish literature any article comparing the quality and the prevalence of the cerebral blood flow in pediatric patients with headaches and/ or vertigo and/or autonomic deregulation to the healthy children corresponding for the age and sex. Such project is going to be the authors’ next aim.

Conclusions

The TCD is a valuable non-invasive and ray-free technique. It is extremely important in the blood flow evolution investigation in the ischemic stroke patients, as the change in the blood flow parameters may predict the recurrence of stroke. In majority of children with headache no TCD pathology was found. In relatively small group of pediatric patients the TCD result suggests the intracranial vessel malformation and makes the clinicians perform magnetic resonance angiography. More thorough trial with the group of healthy children is necessary to establish the potential frequency of CNS vessel pathology in pediatric population.

References


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