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The diffusion weighted magnetic resonance imaging in diagnostics of symptomatic epilepsy in children

Abstract: In this article the possibilities of MR diffusion weighted imaging in symptomatic epilepsy patients have been presented. We determined the quantitative standards of numerical values of diffusion of white matter in children with symptomatic epilepsy of various etiology. The regions with abnormal white matter FA and ADC values not only matched to limbic circle zones, but also to areas of intra- and interhemispheric connections uniting the frontal, temporal, parietal and occipital lobes of the brain. Determining the specific clusters of brain tracts in symptomatic epilepsy, regardless of etiology, is important to predict the prognosis of the disease and the likely possibility of cognitive impairment. The study proved that symptomatic epilepsy is characterized by a variety of changes in the white matter of the brain tracts that lead to the dissociation of certain regions of the brain, interrupting connections between cortical and subcortical regions and inhibiting transfer of information. It can be concluded, that diffusion-weighted imaging are much more sensitive to the structural and metabolic changes occurring in the brain, in comparison with conventional MRI images.

Keywords: Symptomatic epilepsy, MR diffusion, Fractional anisotropy, Average diffusion capacity.

Introduction

In vivo visualization of structural morphological changes of the brain in patients with epilepsy and epileptic syndromes, has been made possible due to the introduction into daily medical practice of neuroradiologist diagnostic methods of research aspects such as: computed tomography and magnetic resonance imaging (CT and MRI) that are classified as "structural" neuroimaging techniques [1, 21–26]. The introduction of MRI in clinical practice has greatly expanded the identification of various structural changes in the brain tissue underlying the formation of the epileptic focus, which usually leads to the subsequent development of epilepsy. MRI allows radiologists to identify of malformations such as licencephaly, periventricular heterotopy, shizencephaly, a focal cortical dysplasia and other brain anomalies [2, 33–39]. But epilepsy do not always manifest on the background of congenital abnormalities of the brain, particularly if they are not localized in the cortical regions of brain. Congenital disorders of brain has a major part in epilepsy origin, which manifest themselves in early periods of childhood [10, 353–361].

However, in practical medicine, it is not always possible to determine what is the basis of locally-induced epilepsy. Conventional MRI provides information about structural changes not in all cases [5, 95–97]. In this regard, at modern neuroradiology, it became necessary to use functional neuroimaging techniques that allow not only in vivo study the pathological changes of different brain structures, but also capable to clarify some of the mechanisms of epileptogenesis. These methods include diffusion tensor MRI tractography, which is the technology of the future to obtain morphological images of brain.

Diffusion imaging is an MRI method that produces in vivo magnetic resonance images of biological tissues sensitized with the local characteristics of molecular diffusion, generally water (but other molecules can also be investigated using MR spectroscopic approaches) [8, 719]. Diffusion-weighted images are much more sensitive to the structural and metabolic

changes occurring in the brain, in comparison with conventional MRI images. The most important parameter of DT MRI, characterized by the integration of the white matter is fractional anisotropy (FA), which is defined as the magnitude of the direction of water diffusion in three-dimensional-space. Tightly arranged bundles of white matter provide structural coherence, whereby the diffusion of water has a definite direction, and FA is a high enough. In case the structural organization of the white matter decreasing and diffusion of water is less orderly manner, the values of FA subsequently diminishes [6, 401–407]. Average diffusion capacity (ADC) is used as indicator to evaluate the results of diffusion tensor MRI. When the values of ADC are increasing it can be associated with a defect in neurogenesis or cell loss of brain with a consequent increase of the extracellular space of brain [4].

The aim of this study was to determine the quantitative standards of numerical values of diffusion-weighted imaging of white matter in children with symptomatic epilepsy of various etiology.

Materials and methods

MRI studies were performed in 31 children with symptomatic epilepsy. Their age ranged from 2 to 12 years. Debut of epileptic seizures was observed from birth to 13 years, mean age debut 4,2 ± 0,96 years. Disease duration averaged 3,2 ± 0,47 years. The patients were examined and treated at the Department of Paediatric Neurology of Tashkent Paediatric Medical Institute and underwent diagnostic procedures in «MDS» diagnostic centre from 2012 to 2014 and StarMed diagnostic centre in Tashkent. Among the etiological factors of symptomatic epilepsy 11 children had cerebral palsy, 10 children had outcomes of meningoencephalites and 10 children had anomalies of brain. MRI studies were performed on a GE tomography with a magnetic field of 1.5 T using a head radio frequency coil consisting of 18 elements. The study protocol included a standardized program of MRI of the brain, as well as aiming neuroimaging the mediobasal temporal lobe with thin sections with the possibility of post processing and imaging in different planes. Among the special programs used fast spin-echo T2-weighted, perpendicular to the longitudinal axis of the hippocampus slice thickness of 2 mm, and 3D T1 SP6R — pulse sequences with the reform and obtaining images mediobasal temporal lobe perpendicular and parallel to the longitudinal axis of the hippocampus. Measurement of anisotropy and diffusivity. Nowadays in clinical neurology, various brain pathologies may be best detected by studying at particular measures of anisotropy and diffusivity. The underlying physical process of diffusion (by Brownian motion) causes a group of water molecules to move out from a central point, and gradually reach the surface of an ellipsoid if the medium is anisotropic (it would be the surface of a sphere for an isotropic medium). The ellipsoid formalism functions also as a mathematical method of organizing tensor data. Measurement of an ellipsoid tensor further permits a retrospective analysis, to gather information about the process of diffusion in each voxel of the tissue [7]. In an isotropic medium such as cerebrospinal fluid, water molecules are moving due to diffusion and they move at equal rates in all directions. When various barriers and restricting factors such as cell membranes and microtubules interfere with the free diffusion, we are measuring an "apparent diffusion coefficient" or ADC because the measurement misses all the local effects and treats it as if all the movement rates were solely due to Brownian motion [1, 259–267]. The ADC in anisotropic tissue varies depending on the direction in which it is measured. Diffusion is fast along the length of (parallel to) an axon, and slower perpendicularly across it. Once we have measured the voxel from six or more directions and corrected for attenuations due to T2 and T1 effects, we can use information from our calculated ellipsoid tensor to describe what is happening in the voxel. If you consider an ellipsoid sitting at an angle in a Cartesian grid then you can consider the projection of that ellipse onto the three axes. The three projections can give you the ADC along each of the three axes ADC_x, ADC_y, ADC_z. This leads to the idea of describing the average diffusivity in the voxel which will simply be $(ADC_x+ADC_y+ADC_z)/3=ADC_i$.

We use the *i* subscript to signify that this is what the isotropic diffusion coefficient would be with the effects of anisotropy averaged out. All three of these are perpendicular to each other and cross at the centre point of the ellipsoid. We call the axes in this setting eigenvectors and the measures of their lengths eigenvalues. The lengths are symbolized by the Greek letter λ. The long one pointing along the axon direction will be λ_1 and the two small axes will have lengths λ_2 and λ_3. In the setting of the DTI tensor ellipsoid, we can consider each of these as a measure of the diffusivity along each of the three primary axes of the ellipsoid. This is a little different from the ADC since that was a projection on the axis, while λ is an actual measurement of the ellipsoid we have calculated. The diffusivity along the principal axis, λ_1 is also called the longitudinal diffusivity or the axial diffusivity or even the parallel diffusivity $\lambda_{\parallel}$. Historically, this is closest to what Richards originally measured with the vector length in 1991 [9]. The diffusivities in the two minor axes are often averaged to produce a measure of radial diffusivity $\lambda \perp = (\lambda_2 + \lambda_3)/2$.

This quantity is an assessment of the degree of restriction due to membranes and other effects and proves to be a sensitive measure of degenerative pathology in some neurological conditions [12]. It can also be called the perpendicular diffusivity $(\lambda \perp)$. Another commonly used measure that summarizes the total diffusivity is the Trace — which is the sum of the three eigenvalues, $tr(\Lambda) = \lambda_1 + \lambda_2 + \lambda_3 \ldots$ where Λ is a diagonal matrix with eigenvalues λ_1, λ_2 and λ_3 on its diagonal. If we divide this sum by three we have the mean diffusivity, $MD = (\lambda_1 + \lambda_2 + \lambda_3)/3$.

The values of FA and ADC were calculated on the same sections for all the resulting images. The data obtained were subjected to statistical processing on a PC Pentium-4 program, developed in the package EXCEL using a library of statistical functions with the calculation of the arithmetic mean (M), standard deviation (SD), standard error (SE), relative values

(frequency,%), Student's t test (t) with the computation of error probability (P). Differences were considered significant mean values at a significance level of P <0.05.

Results of the study

In a study of 11 children with epilepsy on the background of symptomatic epilepsy with cerebral palsy diffusion tensor MRI tractography allowed to determine the micro structural changes in 9 children. The most important indicator of the integration of the white matter of the brain is the value of the FA [4]. This indicator is in group of children with cerebral palsy was 0,40 ± 0,011 for the front quadrants and 0,41 ± 0,013 for the rear quadrants. Hemispheric asymmetry in this parameter revealed only for the rear quadrant, the main area which represented the temporal lobes, with preferential reduction of FA was determined in the hemisphere with epileptic focus (p <0.01) (Table. 1).

Table 1. – Indicators of FA and ADC on MRI diffusion in children with symptomatic epilepsy with various etiology

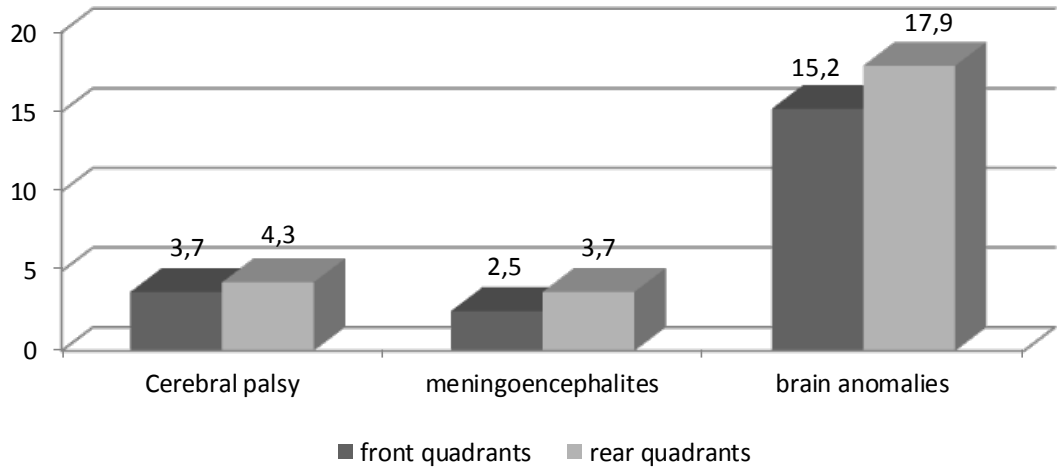
Etiology of symptomatic epilepsy	Indicators of FA		Indicators of ADC	
	Front quadrants	Rear quadrants	Front quadrants	Rear quadrants
Normal brain	0,50±0.004	0,51±0.004	1,2±0,03	1,25±0,04
Cerebral Palsy	0,40±0,011*	0,41±0,013*	1,57±0,02*	1,62±0,02*
After meningoencephalites	0,41±0,009*	0,41±0,01*	1,55±0,02	1,63±0,009
Brain anomalies	0,38±0,02*	0,37±0,03*	1,50±0,06	1,59±0,06

Note: * — the accuracy of the data compared with the norm (* — P <0.01)

Source: Author.

At the same time 10 children had the lowest level of FA for the front quadrants, with deviation of 3.7%. In 8 children observed deviations of FA in rear quadrants with 4.3%. The values of ADC have been counted to study the mechanisms of micro structural changes in brain. ADC values in 54.5% of children with symptomatic epilepsy on the background of cerebral palsy differed from normal values for the front quadrant of the hemisphere with the epileptic focus and posterior regions of the cerebral hemispheres (P <0.01). While observing 11 children with symptomatic epilepsy in 6 children ADC value for front quadrant of the hemisphere was increased by an average of 1.53% then normal values, and for the rear quadrant of the hemisphere on average by 1.1% of normal values (Fig.1).

Figure 1: The percentage of abnormalities in FA values in children with symptomatic epilepsy, depending on the etiology (%)



Source: Author (2014).

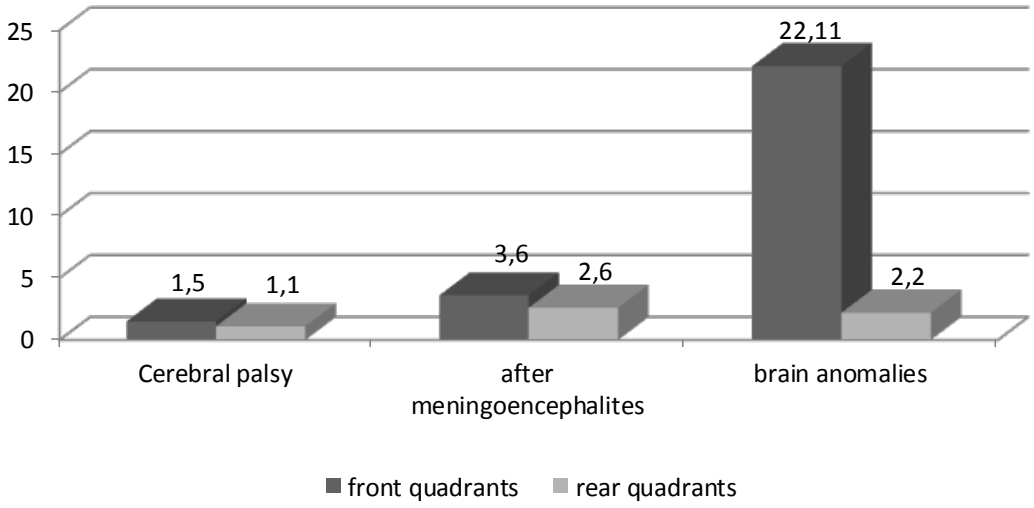
Thus, in children with symptomatic epilepsy on a background of cerebral palsy in most cases there was a decrease of FA for both front and rear quadrant on the background of increasing ADC.

Among the 10 children with symptomatic epilepsy after meningoencephalitis FA values was different, because the average number of FA values were 0,41 ± 0,009 for the front quadrants and 0,41 ± 0,01 for the rear ones. Indicators of ADC for front quadrants were 1,55 ± 0,0 and for the rear ones were 1,63 ± 0,009. Deviations from normal values to down on average in FA was 2.5% for front quadrants, for the rear was 3.7%. When analyzing ADC values different pattern was revealed, so the mean deviation from the normal values to upwards in front quadrants was 3.6%, for the rear ones was 2.6% (Fig.2)

Analyzing the data of MR diffusion in children with symptomatic epilepsy on the background abnormalities of brain development we have identified low levels of FA for both front and rear quadrants (0,38 ± 0,02 and 0,37 ± 0,02, respectively; P <0.01) as compared with the normal values. A deviation from the normal FA had 15.2% for the front quadrants and 17.9% for the rear. Indicators of ADC in children with symptomatic epilepsy on a background of developmental abnormalities of the brain underwent the following changes: the front quadrants figures were 1,50 ± 0,06 (p <0.01) for the rear — 1,59 ± 0,06

(P <0.01). There was a significant deviation of ADC from normal values, 22.11% for the front quadrants and 2.2% for the rear. Thus, in children with symptomatic epilepsy on a background of developmental abnormalities of the brain there was a sharp decline of the FA for front and rear quadrants and a huge increase of the ADC for the front quadrants.

Figure 2: The percentage of abnormalities of ADC in children with symptomatic epilepsy depending on the etiology (%)



Source: Author (2014)

In children with symptomatic epilepsy on the background of cerebral palsy in most cases first, second, third clusters were detected (7, 10 and 6 children, respectively). The combination of these clusters observed in 8 cases (72.7%). In children with symptomatic epilepsy on the background of meningoencephalites in most cases, there was a first and second cluster (7 and 10 children, respectively). The combination of all four clusters were recorded in 90% of children. Changes in the state of integrity of the corpus callosum was observed among 54.5% of children with cerebral palsy, and 50% of children with developmental abnormalities of the brain appeared as a hypoplasia or hypogenesia. According to other authors state integrity of the corpus callosum provides stability of cognitive and emotional status of the children. Thus, the presence of these clusters to some extent indicates the "interest" of the various regions of the brain in promoting epileptic seizures, and is being as predictor of the developing of the disease.

Conclusion. We revealed that in children with symptomatic epilepsy, regardless of its etiology, the presence of discrete regions of the abnormal changes of the white matter of the brain was discovered, while the pathological changes of white matter were localized not only in the epileptogenic, but also in the opposite hemisphere. The regions with abnormal white matter FA and ADC values not only matched to zones of limbic circle, but also to areas of intra- and interhemispheric connections uniting the frontal, temporal, parietal and occipital lobes of the brain. Determining of specific clusters of lesions of the brain tracts in symptomatic epilepsy in children, regardless of etiology, is important to predict the prognosis of the disease and the likely possibility of cognitive impairment. Status integrity of the corpus callosum provides stability of cognitive and emotional status of children [11, 1267]. Thus, this study showed that symptomatic epilepsy in children is characterized by a variety of changes in the white matter of the brain tracts that lead to the dissociation of certain regions of the brain, which subsequently causes further breaking connections between cortical and subcortical regions and interrupting transfer of information. MRI tractography allows to extend the representation of micro structural changes in integrity of gray and white matter of brain in symptomatic epilepsy and clarify the structural and metabolic etiologic subtype of the disease according to the recommendations of the International League Against Epilepsy.

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Peculiarities of cardiac hemodynamic in pregnant women with mild preeclampsia

Abstract: Study the characteristics of cardiac hemodynamic in pregnant women with mild preeclampsia. Inadequate marker of cardiovascular adjustment in PE is to develop disproportionately LVM, the formation of isolated diastolic left ventricular dysfunction and the development of circulatory system in all organs and tissues. Thus, a disproportionately high rate of LVM, in patients with mild preeclampsia is as a predictor of severe preeclampsia before its clinical manifestation, and the indication for revision of the tactics of pregnancy.

Keywords: Doppler, pre-eclampsia, left ventricular, cardiohemodynamics.

The problem of preeclampsia — one of the most urgent in modern obstetrics [1; 2; 4; 8; 9]. Preeclampsia is a progressive disease, forms, manifestations of which may be very different, as well as the pace of growth of its manifestations [4; 5; 6; 7].

Analyzing the numerous studies on preeclampsia (PE) and eclampsia (E), it can be concluded that a very significant role in the pathogenesis of this complication of pregnancy and childbirth plays violations in the circulatory system of mother and fetus. All of the above, and strongly suggests a more in-depth study of the state of different parts of the circulatory system in the dynamics of the development of PE, and E. And, of course the very heart (myocardium) can not participate in the changes taking place throughout the circulatory system [5; 6; 7; 8].

It is still unclear what are the real changes in the parameters in different types of preeclampsia, and whether there is a possibility of restoring LVM after birth, which is extremely important for judging questions about early detection of developing complications from the heart, and the prevention of targeted therapy.

Objective: study the characteristics of cardiac hemodynamic in pregnant women with mild preeclampsia.

Materials and methods

The basis of this paper on the results of a survey of 60 women in the III trimester of pregnancy. I made -group 30beremennye with physiological pregnancy, 30 pregnant women with mild PE (II group). From instrumental methods were applied Doppler echocardiography. The study was conducted at 30–34 weeks of gestation. Echocardiography was performed on the machine. The company Sono Scape models SSI-5000 (China). The method of tissue doppleroehokardiografii (TMDEhoKG) were determined left ventricular myocardial mass.

LVM was calculated in the one mode — the formula Devereux R.B and Riechek N in accordance with the Penn-convention:

LVMi (r)= 1,04 x [(PW d, mm + IVS d, mm + EDD, mm)^3 – (EDD, mm^3)] –13,6

The criterion for LVH takes a value and LVM> 110g/m^2

Statistical processing of the results was performed using