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Characteristics and distinctiveness of multiple sclerosis in children in magnetic resonance imaging

Monika Wisz[1], Katarzyna Łukaszewska-Stanik[1], Wiesław Guz[1,2], Antoni Samojedny[1], Stanisław Wisz[3], Wojciech Stanik[4]

[1] Clinical Department of Radiology, Provincial Hospital No. 2, Rzeszów, Poland
[2] Institute of Physiotherapy, University of Rzeszów, Rzeszów, Poland
[3] NZOZ Radiologica, Rzeszów, Poland
[4] Clinical Cardiology Department with Acute Coronary Syndrome Department, Provincial Hospital No. 2, Rzeszów, Poland

Author's address: Monika Wisz, Clinical Department of Radiology in Provincial Hospital No. 2 in Rzeszów, Lwowska 60 Str., 35-301 Rzeszów, Poland e-mail: swisz@op.pl

Summary

Background: Multiple sclerosis (MS) in children is a demyelinating disease of a central nervous system (CNS), whose clinical symptoms and results of imagining examinations differ from those found in adults, and therefore requires different criteria of diagnosis. The method of choice in MS imaging in children is magnetic resonance imaging (MRI). The purpose of this study was to present the characteristics of paediatric MS in MRI brain scan.

Material/Methods: MRI brain scans of 20 children aged 11–17 with diagnosed MS were analyzed. The compliance of MRI brain scans with KIDMUS criteria from 2008 was stated along with the location and morphology of plaques of demyelination.

Results: In the examined group all three KIDMUS criteria required for MS diagnosis were met by 45% of children, and two criteria by 50% of children. The average size of the demyelination plaque was 9 mm. Giant foci were not observed. As much as 95% of lesions were located in periventricular white matter, 40% of lesions in brainstem, 25% in cerebellum and 5% in thalamus.

Conclusions: The image of changes in MRI brain scan in children presents a wide range of differences. For a correct diagnosis and implementation of suitable treatment it is necessary to learn them. This is particularly important in this age group due to an early development of disability.

MeSH Keywords: Magnetic Resonance Imaging • Multiple Sclerosis, Relapsing-Remitting • Pediatrics

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Background

Multiple sclerosis (MS) in children is a demyelinating disease of the CNS in which both clinical manifestation and imaging examinations differ from those typical for adults. A significant role in this condition is played by genetic (family incidence equals to 5%, compared to 0.2% for the general population) and environmental factors (most frequently vitamin D deficiency in childhood and place of living). Incidence of MS in children depends on the latitude and in temperate climate in general population it amounts to 4–8/100 000 [1,2]. It is estimated that in 3–5% of people affected by multiple sclerosis the first episode occurs in the childhood [3,4]. Incidence of paediatric SM depends on the age-group and sex – after the age of 12 it more frequently affects girls, which is related to earlier puberty. Between 10 and 12 years of age. the incidence is similar and in children <10 y.o. there is a small male predominance [5]. There are two types of MS distinguished before the age of 18: paediatric – in children under the age of 10 and adolescent in children between 10 and 18 years of age – since 2007 both are named as "paediatric multiple sclerosis" [1].

Diagnosis of multiple sclerosis in children is based on clinical findings, additional tests of which the most important is cerebrospinal fluid analysis with IgG antibody level and the presence of oligoclonal bands [2,6], together with diagnostic imaging [7].

Table 1. Criteria for multiple sclerosis diagnosis in magnetic resonance imaging examination in adults and children.

McDonald criteria, including Barkhof-Tintoré criteria	KIDMUS 2004 criteria	Revised KIDMUS 2008 criteria
At least 9 lesions in T2-weighted images or at least one lesion enhanced upon contrast administration	At least one lesion perpendicular to the longitudinal axis of corpus callosum	Five or more demyelinating lesions
At least 3 lesions in periventricular locations	Presence of well circumscribed lesions	At least 3 lesions in periventricular locations
At least 1 lesion in subcortical location		At least 1 lesion in cerebral trunk
At least 1 lesion in subtentorial or spinal cord location		
At least three of listed features required	Both listed features required	At least two listed features required

Magnetic Resonance (MR) is the imaging examination of choice, determining the diagnosis, and it has to be performed in specific sequences and planes. However, the lack of visible lesions of demyelination in MR does not exclude MS [6].

Commonly used are the McDonald's criteria, which include the Barkhof's and Tintore's criteria, have a high sensitivity (74%) and specificity (86%) in diagnosing MS in adults. Because of the distinctiveness and different developmental level of the nervous system in childhood, higher regeneration potential of CNS, a large group of diseases with similar symptomatology, the above criteria, especially in the group <10 y.o., are not sensitive enough (27%). Therefore, in 2004, new diagnostic criteria for paediatric MS were developed (KIDMUS criteria) and modified in 2008. These criteria have a high sensitivity (85%) and specificity (98%) [1,3,5] (Table 1).

Aim of the study

The aim of the study was to present paediatric multiple sclerosis characteristics in MR imaging.

Material and Methods

A retrospective analysis of MR images of 20 children, in whom MS diagnosis was based on clinical symptoms, laboratory tests and MR imaging. Those children were hospitalised in the years 2009 to 2013 in the Clinical Department of Paediatrics with Subdivision of Paediatric Neurology in Provincial Hospital No. 2 in Rzeszow and were under care of out-patient Neurology Clinic.

In the analysed group there were 17 girls (85%) in the age ranging from 11 to 17 years (mean age 14 years) and 3 boys (15%) in the age ranging from 12 to 16 (mean age 14 years).

Images were acquired using a 1.5T Philips Achieva scanner. T1 – weighted images were obtained in the axial plane, T2-weighted in the axial, coronal and sagittal planes and FLAIR sequence in the axial plane. A contrast agent – Magnevist was used in 18 children in the volume of 0.2 mL/kg. In two cases there was no parental consent for using contrast media. After contrast injection, T1-weighted images were obtained in the axial, coronal and sagittal planes.

MR brain images were analysed for:
- accordance with KIDMUS group criteria from the year 2008;
- size of demyelinating lesions;
- presence of typical changes for paediatric MS – giant lesions, tumour-like lesions;
- location different than typical for MS;
- enhancement of demyelinating lesions after contrast agent injection.

Results

Brain MR images were analysed based on the diagnostic criteria developed by KIDMUS group and amended in 2008.

The first criterion – five or more focal lesions of demyelination in brain was met by 18 of 20 examined children, i.e. 90%.

The second criterion – two or more focal lesions of demyelination located periventricularly was met by 19 analysed children, i.e. 95%).

The third criterion – one or more focal lesion of demyelination located in the brainstem was met by 8 of 20 examined children, i.e. 40%.

To diagnose adolescent MS, at least two of three of the above mentioned criteria must be met. In the analysed group all three criteria were met by 9 children (45%), and two criteria by 10 children (50%).

One child (5%) did not meet the KIDMUS criteria. In the initial brain MRI examination there was a single lesion of demyelination with a diameter of 2–3 mm, located in the corpus callosum (Figure 1A). In the MRI examination of the cervical spinal cord, there was a lesion of 5×6×23 mm in size. It was hyperintense on T2-weighted images, contrast-enhanced and with bulging of the spinal cord (Figure 1B) – the appearance of that lesions was nonspecific, (to be

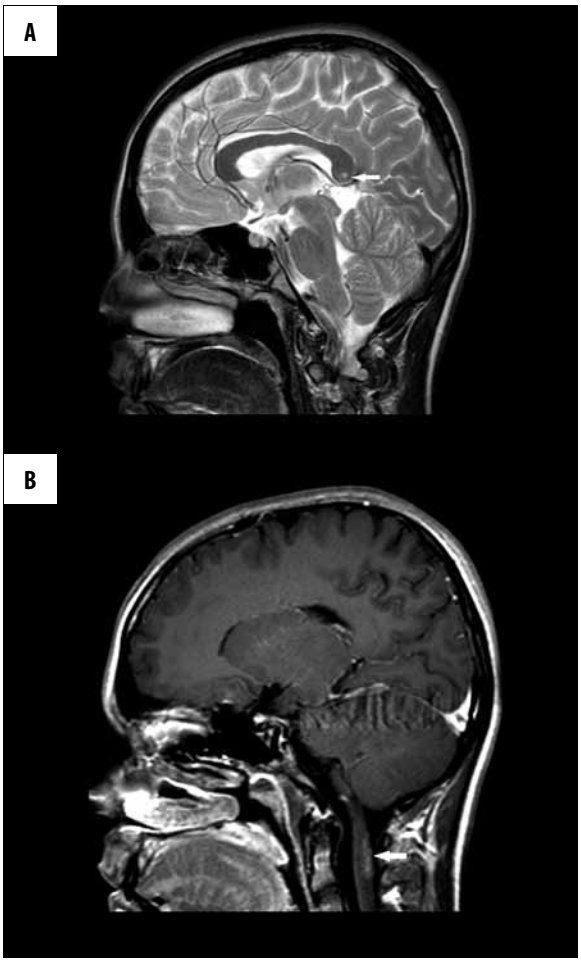

Figure 1. 14-year-old girl, MRI brain scan. (**A**) T2-weighted FSE sequence image, sagittal plane –a single focus in the lobe of colossal commissure (arrow). (**B**) T1-weighted SE sequence image + CM, sagittal plane – a focus of demyelination on C2 level enhanced after the contrast, emphasizing spinal cord contour (arrow).

differentiated between a demyelinating lesion and a proliferating lesion). In a follow-up examination that lesion diminished to about 4×5×16 mm, there was no contrast enhancement, but new foci appeared in the brain. Based on that and additional tests, multiple sclerosis was diagnosed. According to the literature, about 10% of paediatric multiple sclerosis, is of so called "spinal origin" – in such cases, demyelinating lesions are found in the spinal cord and lesions in the brain might not be seen [5].

In our material, the size of demyelinating lesions was from 2 mm to 12 mm, the mean size of the lesions was 9 mm. There was no giant or tumour-like lesions identified.

The most frequent brain location was in the periventricular white matter – 95%, brain stem (Figure 2) – 40%, cerebellum (Figure 3) – 25%, and thalamus in one child, i.e. 5% (Figure 4).

After contrast media injection the lesions enhanced in 6 out of 18 children (Figure 5), which accounted for about 33% of the examined patients, as compared to 50% of contrast-enhanced lesions in adults [1].

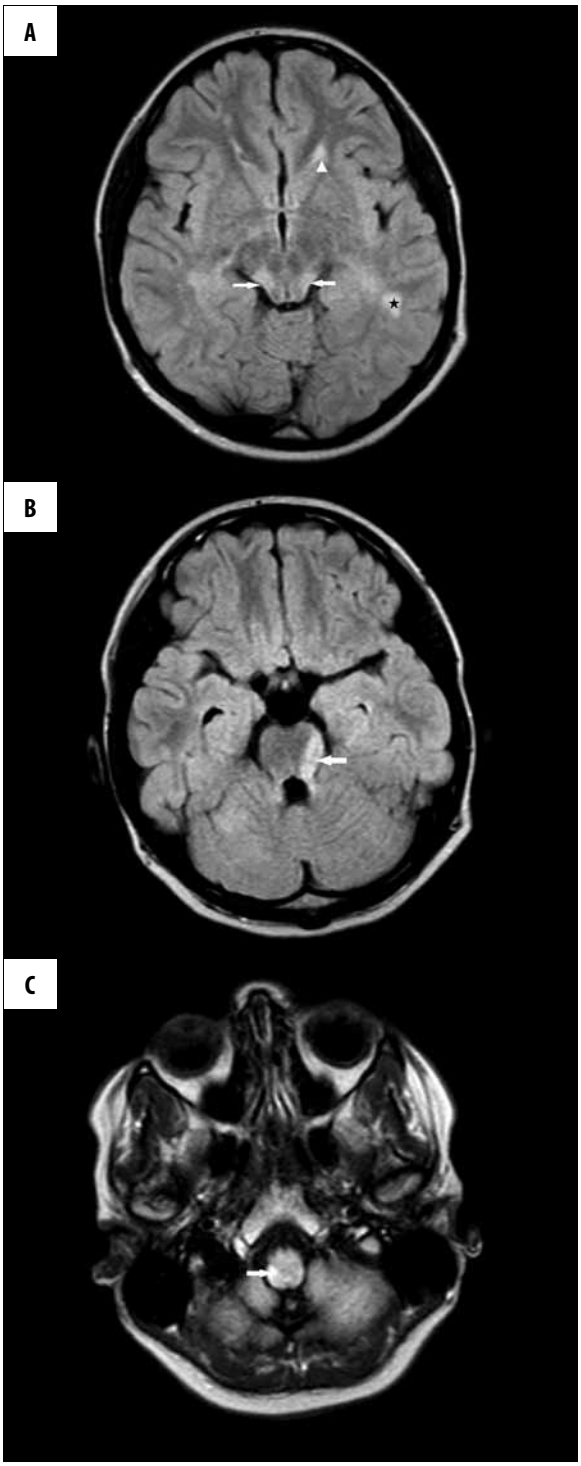

Figure 2. 16-year-old girl, MRI brain scan, FLAIR FSE sequences images, transverse plane. Demyelinating foci in: (**A**) cerebral peduncle (arrows), circumventricular white matter (arrow head) and in subcortical location (star), (**B**) a demyelinating foci in the pons (arrow), (**C**) a demyelinating focus in medulla oblongata (arrow).

Discussion

The reviewed literature concerning paediatric MS showed that demyelinating lesions in magnetic resonance imaging

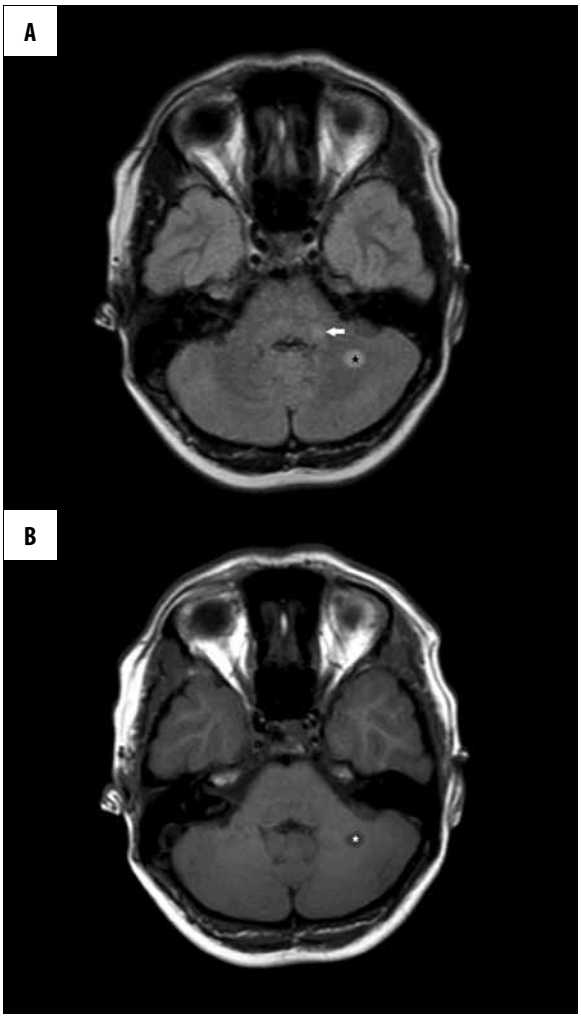

Figure 3. 14-year-old girl, MRI brain scan: (**A**) FLAIR FSE sequence image, transverse plane, (**B**) T1-weighted SE image, transverse plane. Demyelinating foci in the cerebellum left hemisphere (star) and in the left cerebellar peduncle (arrow).

in children frequently reveal a different location and size as compared to those found in MR images of adults.

Lesions of demyelination are clearly separated in T2-wighted and FLAIR images [8], in children before puberty the lesions are less numerous and smaller than in adolescents and adults. In the material presented in this paper, there was no relationship between the size of demyelination and age of a child. However, we should remember that the study group did not include children younger than 10 years of age. In T1-weighted images, pathological hypointense foci are less common than in adults and they frequently regress. They do not always indicate a chronic process, as in adults [1]. The presence of so called black holes – areas of extensive damage of the brain tissue, hypointense in T1-weighted images, may be related to persistent disability [2,9].

According to the reviewed literature, characteristic for the paediatric group are: giant forms of demyelinating lesions, exceeding 20 mm in size. They can be single, and frequently accompanied by oedema. The presence of giant lesions with marked oedema (tumefactive lesions) can be an indicator

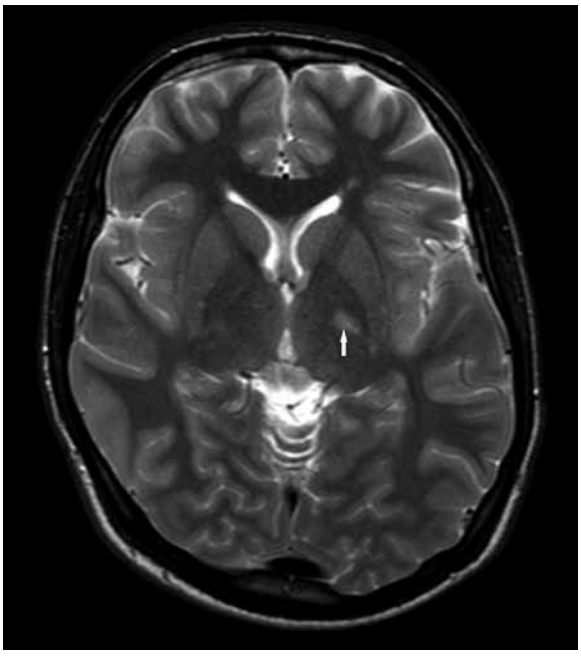

Figure 4. An 11-year-old boy, MRI brain scan, T2-weighted FSE sequence image, transverse plane – a demyelinating lesion in the front left thalamus (arrow).

of an acute phase of demyelination in the paediatric form of MS. There are also lesions imitating proliferative lesions and brain abscesses, which can occupy even an entire brain hemisphere with accompanying mass effect, pseudocysts and necrotic areas within them [1,3,6]. In children younger than 10 years of age, the early phase of the disease in the MRI may suggest leukodystrophy with extensive bilateral involvement of the white matter. In the paediatric group presented by the authors of this study, there were no giant or tumour-like lesions identified. However there were degenerative changes of some demyelinating lesions (Figure 6).

Authors of numerous studies on the paediatric form of MS agreed that in paediatric MS a different location of the lesions is much more common: i.e. in the brainstem, cerebellum, spinal cord, corpus callosum, basal ganglia and thalamus [1,3,6,9]. Results obtained by the authors of this study are in accordance with data presented in the literature – in nearly a half of the children (40%) demyelinating changes were located in the brainstem, in 25% – in the cerebellum, and in one case in the thalamus.

An important component of MS diagnosis is spreading of demyelinating lesions in time and space, shown in MRI [3,10]. "Spread in space" can be defined by the number and location of lesions in a single MRI examination. New lesions in new locations in the following MRI examinations confirm "spread in time". To confirm spread of lesions in time and space in children, it is recommended to perform a follow-up examination 6 weeks after the first demyelination episode, whereas in adults the follow-up scan is performed after 3 months [1].

The clinical manifestations of MS in children are different and include a slower course and shorter bouts of the disease. The duration of clinical symptoms has to be at least 24 hours to meet the criterion of a bout [11].

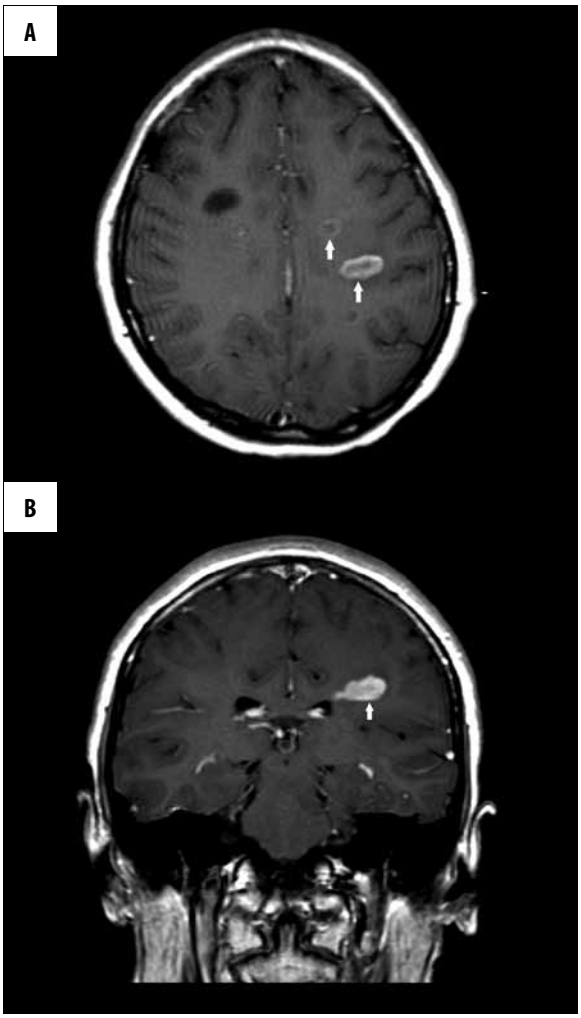

Figure 5. 16-year-old girl, MRI brain scan. T1-weighted SE sequence image + CM: (**A**) transverse plane, (**B**) frontal plane. Foci of ring enhancement demyelinating changes in circumventricular white matter of left parietal lobe (arrows).

In the beginning of the disease there may be one symptom or multiple symptoms. As much as 90% of paediatric MS cases constitute a relapsing-remitting variety. In about 5% of children and nearly always in children older than 13 years, MS is chronic and progressive [5].

The first MS symptoms in the youngest age group i.e. <6 years, are usually ataxia, epilepsy and impairment of cognitive functions. In older children, the disease manifests with paresis, pyramidal dysfunction, optic neuritis, symptoms from the brainstem or as diffuse inflammation of the brain and spinal cord [4].

Paediatric MS has a poor long-term prognosis. Despite longer time to disability in comparison to adults (according to the literature, about 20 years in children, 10 years in adults [4]) and because of early onset, persistent disability occurs at the time of highest life activity. Furthermore, cognitive impairment affects especially children, which makes a proper development more difficult. Due to that, early diagnosis and proper treatment are crucial [3,5,8,12].

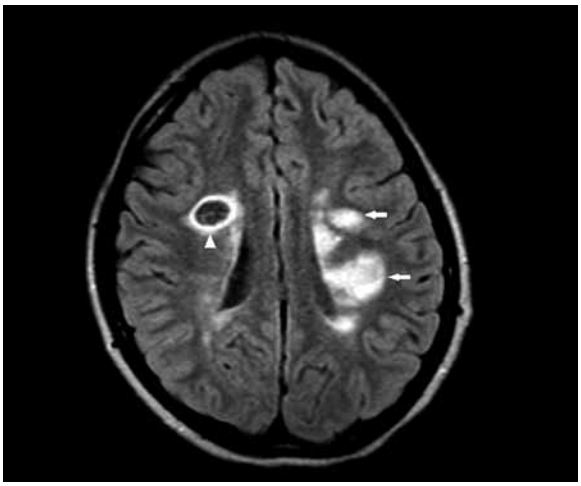

Figure 6. 16-year-old girl, MRI brian scan, FLAIR FSE sequence image. Numerous, overlapping demyelinating foci in circumnentricular white matter (arrows) with degenerative features in the right frontal lobe (arrow head).

A more precise assessment of brain pathologies, especially in the seemingly healthy brain tissue, is possible due to a more common use of high-field MRI scanners (1.5T, 3T). This creates new possibilities for MS diagnostics and differentiation of demyelinating lesions [1].

Proton spectroscopy (HMRS) is becoming a part of a routine MRI examination of people affected by MS. It allows for an analysis of metabolite concentration in the demyelination plaques and in normal-looking brain tissue, and defines relative metabolite proportions in plaques. The most important in MS are N-acetylaspartate (NAA), myo-inositol (mIns), creatine, choline, lipids and lactates. Abnormalities found in patients with MS are related to a decrease of NAA and increase of mIns concentration not only in the areas of abnormal brain structure, but also in the whole brain [1,13].

Diffusion-weighted imaging (DWI) including diffusion tensor imaging (DTI) is particularly useful in detection of pathologies in a normal-looking brain tissue. By using these techniques it was possible to visualise lesions which are not visible in typical MRI examinations, even if performed by high-field scanners. This method has been recognized as useful in assessing cognitive impairments in children with MS [1].

Conclusions

Although paediatric MS is a rare disease, early detection, proper diagnosis and treatment implementation are crucial because of a high risk of early disability and frequent cases of cognitive impairment. Due to different clinical and neuroimaging manifestations, diagnosis and differentiation of paediatric MS causes a lot of difficulties and requires separate criteria. Imaging examination of choice is still an MRI. Owing to new MRI techniques, detection of malfunctioning of the seemingly unchanged brain tissue becomes possible which shortens time to diagnosis and leads to faster implementation of proper treatment in case of a suspected demyelinating disease.

References:

1. Wilczek A: Stwardnienie rozsiane u dzieci: objawy kliniczne, diagnostyka, różnicowanie i leczenie, Neurologia dziecięca, 2010; 19(37): 75–82 [in Polish]
2. Poser CM, Brinar VV: Disseminated encephalomyelitis and multiple sclerosis: two different diseases – a critical review. Acta Neurol Scand, 2007; 116: 201–6
3. Jurkiewicz E, Kotulska K: Rola badań obrazowych układu nerwowego w diagnostyce stwardnienia rozsianego u dzieci. Neurologia i Neurochirurgia Polska, 201; 45(2): 152–60 [in Polish]
4. Bigi S, Banwell B: Pediatric multiple sclerosis. J Child Neurol, 2012; 27(11): 1378–83
5. Zgorzalewicz M: Stwardnienie rozsiane u dzieci i młodzieży. Aktualności neurologiczne, 2003; 2(2): 137–44 [in Polish]
6. Gergont A, Nowak A, Piotrowska A, Kaciński M: Typy zajęcia układu nerwowego w stwardnieniu rozsianym. Przegląd Lekarski, 2008; 65(11): 789–92 [in Polish]
7. Gołąbek V, Woźniakowska-Gęsicka T, Sokołowska D: Ostre rozsiane zapalenie mózgu i rdzenia kręgowego u dzieci jako następstwo jałowego zapalenia opon mózgowo-rdzeniowych – opis dwóch przypadków. Neurologia i Neurochirurgia Polska, 2011; 45(2): 180–87 [in Polish]
8. Miller DH, Wienshenker BG, Filippi M et al: Differential diagnosis of suspected multiple sclerosis: a consensus approach. Neurologia Praktyczna, 2011; 6: 15–33
9. Chitnis T, Tardieu M, Amata MP: International pediatric MS study group clinical trials summit. Neurology, 2013; 80(12): 1161–68
10. Absoud M, Wasser E: Childhood CNS inflammatory demyelinating disease. Paediatrics and Child Health, 2010; 20(9): 404-10
11. Szafirska M, Urbanik A, Róg T: Zmiany metaboliczne w obrębie blaszek u chorych na stwardnienie rozsiane – ocena w technice protonowej spektroskopii MR (HMRS). Przegląd Lekarski, 2013; 70(5): 328–34 [in Polish]
12. Callen DJA, Shroff MM, Branson HM et al: MRI in the diagnosis of pediatric multiple sclerosis. Neurology, 2004; 72: 961–67
13. Ketelslegers IA, Neuteboon RF, Boon M et al: A comparison of MRI criteria for diagnosis pediatric ADEM and MS. Neurology, 2010; 74(18): 1412–15