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Spinal cord lesions in children and adolescents with multiple sclerosis – Magnetic resonance imaging

Joanna Dębska [a,*], Katarzyna Kotulska-Józwiak [b], Piotr Pawliszak [a], Małgorzata Bilska [b], Dariusz Chmielewski [b], Iwona Puzio [b], Elżbieta Jurkiewicz [a]

[a] Department of Diagnostic Imaging, The Children's Health Memorial Institute, Warsaw, Poland
[b] Department of Neurology and Epileptology, The Children's Memorial Health Institute, Warsaw, Poland

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ABSTRACT

Purpose: The purpose of our study was to determine the prevalence of spinal cord lesions revealed by magnetic resonance (MR) imaging in children and adolescents with clinically definite multiple sclerosis (MS).

Material and methods: We retrospectively evaluated the spinal cord magnetic resonance examinations in a group of MS patients consisting of 58 children (37 girls and 21 boys) aged from 7 to 17.8 years (mean 13.7 years). All children met the criteria of clinically definite MS and had typical MS lesions revealed in the brain imaging.

Results: Spinal cord lesions, regardless of localization, were identified in 36 (62%) patients. In 22 of 58 patients (38%) no lesions were observed. The plaques were found in the cervical spinal cord and the thoracic spinal cord in 30 out of 36 (86.1%) and in 31 out of 36 (88.6%) patients, respectively. Contrast enhancement was noticed in 10 out of 36 patients (27.7%) and was not correlated with the number of lesions present.

We noticed a tendency to higher EDSS score in patients with lesions in more than 1 spinal cord region.

Our study showed that spinal cord lesions are more frequently present in patients with complex neurological disability.

Conclusion: The prevalence of spinal cord lesions in children and adolescents with MS is high. Therefore, spinal cord MRI should be included in diagnostic program of MS.

1. Introduction

Multiple sclerosis (MS) is a chronic inflammatory, demyelinating, neurodegenerative disease of the central nervous system. The disorder is most commonly diagnosed between ages 20 and 40, but can be seen at any age, including children and adolescents.

The term ''pediatric MS'' is applied to children with MS (<10 years of age) and adolescents (<18 years of age) [1]. About 2.2–

* *Corresponding author at*: Department of Diagnostic Imaging, The Children's Health Memorial Institute, Al. Dzieci Polskich 20, 04-730 Warsaw, Poland. Tel.: +48 22 8152284; fax: +48 22 81512 76.
E-mail address: joanna.ewa.debska@gmail.com (J. Dębska).

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4.4% (3–5%) of all MS cases have an onset of disease before the age of 16, less than 1% before 11 years of age [1–5]. The diagnosis is based primarily on clinical findings; however, laboratory tests and magnetic resonance imaging (MRI) play an important role in the diagnostic process [1,6–8]. Magnetic resonance imaging is a method of choice for demonstrating abnormalities of the brain and spinal cord tissue, as well as lesions dissemination in space and time [2,8,9].

Following the recommendation of the International Pediatric MS Study Group the MR examination should include a cranial and a spinal MRI with and without gadolinium [2]. However, although brain MRI is performed routinely in MS children, only few articles relating to lesions in the spinal cord [10] with the use of contrast media in children with MS have been published [11].

In Poland, limited use of spinal cord MRI in MS patients is related also to the requirements of the national program of MS therapy reimbursement, which include brain MRI only as an outcome measure (www.nfz.gov.pl).

The aim of our study was to describe the MR features and to determine the prevalence of spinal cord lesions revealed by magnetic resonance (MR) imaging in children and adolescents with clinically definite multiple sclerosis, based on the diagnostic criteria proposed by the International Pediatric MS Study Group.

2. Material and methods

Our series included 58 children who fulfilled the criteria for relapsing–remitting MS and were treated in the Department of Neurology and Epileptology at out hospital between 2010 and 2013. The group of patients consisted of 37 girls (63.7%), aged from 8.2 to 17.8 years, mean age 14.4 and 21 boys (36.2%) aged from 7 to 16.7, mean age 13.4 years.

We retrospectively evaluated the first spinal cord magnetic resonance examinations which were the part of routine radiological investigations of each MS patients. Both cranial and spinal exams were performed.

MRI of the spinal cord was performed on 1.5T scanner using a spinal phased array coil.

The MRI protocol consisted of T1-, T2-weighted sagittal and axial images visualizing the entire length of the spinal cord. The contrast medium is given for patients in whom lesions were found in the spinal cord; T1-weighted images in two planes following gadolinium administration in dose of 0.1 mmol/kg were obtained.

The parameters used for the sagittal T1-weighted sequence were as follows: repetition time/echo time: TR/TE = 486/10 ms, acquisition matrix = 269 × 384, field of view FOV = 340 × 340 mm, slice thickness 3 mm, gap 10%, averages 4; for T2-weighted: TR/TE = 3400/103 ms, acquisition matrix = 358 × 512, FOV = 340 × 340, thickness 3 mm, gap 10%. The parameters used for axial T1-weighted: TR/TE = 751/12 ms, FOV = 250 × 250, matrix = 185 × 384, thickness 4 mm; for axial T2-weighted: 3910/107 ms, FOV = 250 × 250, matrix = 245 × 384, thickness 4 mm. Acquisition time for spinal cord imaging was approximately 30 min.

The following features of MR images were analyzed: the presence of focal or diffuse lesions seen on T2-weighted images on both planes, lesion location, total lesions count and the number of enhancing lesions.

The spinal cord involvement is described as the presence of high intensity lesions on T2 weighted images, single, multiple or diffuse, with or without enhancement after contrast injection. The presence and number of enhancing lesions was scored in the spinal cord on T1-weighted images after contrast injection.

All spinal cord MRI scans were reviewed by consensus by two experienced neuroradiologists with minimum 15 years of experience in neuroradiology.

All patients underwent thorough clinical workout, including EDSS score. Clinical symptoms associated with spinal cord lesions were determined in five domains: motor, sensory, bowel or urinary disturbances and abnormal reflexes. Abnormal spinal reflexes included any disturbances in superficial abdominal or cremasteric (in males only) reflexes. Neurological status of the patients at the time point when spinal cord MRI was performed was taken into account.

3. Results

First spinal cord MRI was performed during first relapse of the disease in 36 (62%) of the disease, up to 3 months after first relapse in 10 (17.2%) patients, during second relapse in 5 patients (8.6%), and later on the course of the disease in 7 cases (12%).

Spinal cord lesions were disclosed in 22 patients out of 36 with spinal cord MRI performed during first MS relapse (61%), in 7 out of 10 with MRI performed up 3 months after first relapse in (70%) patients, in 4 out of 5 with MRI performed during second relapse (90%), and in 3 out of 7 with MRI performed later on the course of the disease (42.8%).

Spinal cord lesions, regardless of localization, were identified in 36 (62%) patients. In 22 of 58 patients (37.9%) no lesions were observed. The plaques were found in the cervical spinal cord and the thoracic spinal cord in 30 (52%) and in 31 (53%) patients, respectively. The number of lesions differed according to spinal cord segments. In the cervical spinal cord there were 67 lesions while in the thoracic region we observed 63 lesions (Fig. 1).

The lesions were found in only in the cervical spine in 5 children, only in the thoracic spine in 6 patients. Both segments were affected in 25 patients. 4 of 31 patients (11.1%) had uncountable, diffuse lesions.

Contrast enhancement was noticed in 10 out of 36 patients (27.7%). In 3 patients their only one lesion in the cervical spinal cord showed enhancement. One patient had one lesion in the thoracic spine which showed gadolinium enhancement. In 5 patients lesions in both evaluated segments enhanced.

MRI data are summarized in Table 1.

4. Clinical presentation of spinal cord lesions in MS children and adolescents

Mean EDSS score in MS children and adolescents at the time spinal MRI was performed was 1.6 (median EDSS – 1) and ranged from 0.5 to 5. Clinical signs and symptoms associated

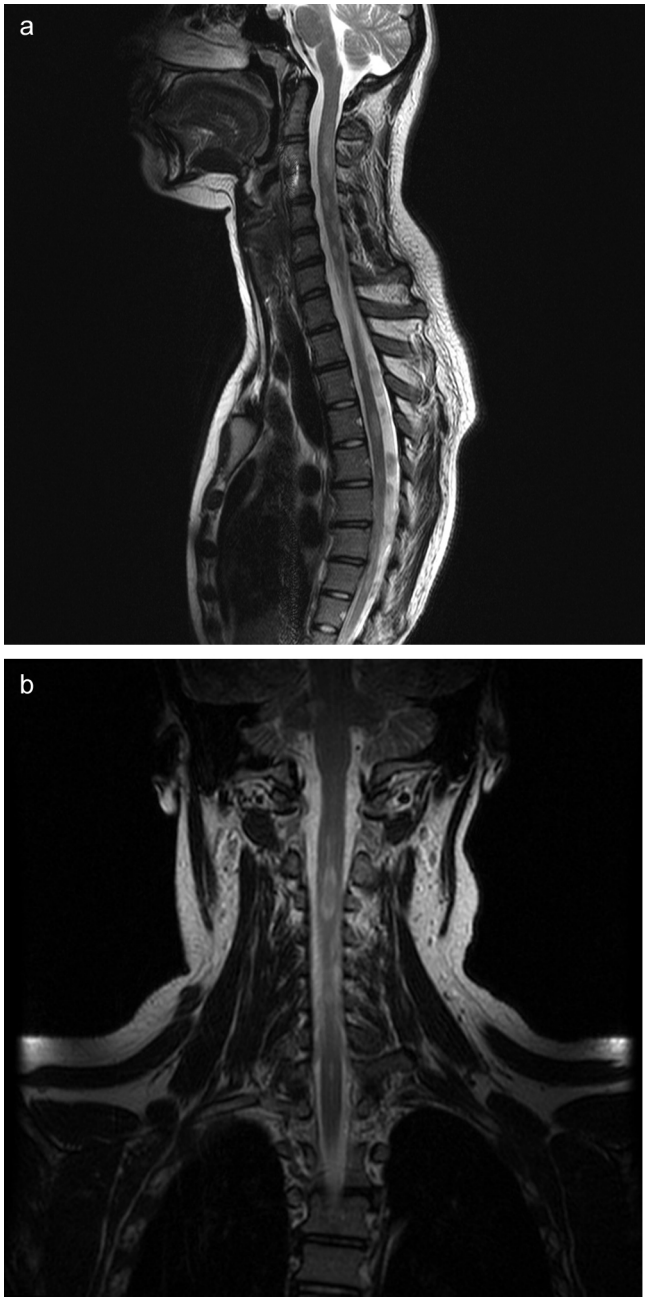

Fig. 1 – Coronal (a) and sagittal (b) T2WI shows multiple hyperintensive lesions in the cervical (a and b) and thoracic (a) spinal cord.

with spinal cord lesions were present in 37 (63.8%) patients. Twenty- seven patients (46.6%) presented with both clinical symptoms and concordant spinal cord lesions on MRI. In 9 (15.5%) patients spinal cord lesions disclosed on MRI were clinically silent. Eight (13.8%) patients presented with clinical symptoms despite no lesions on spinal cord MRI.

Most common clinical symptoms included abnormal superficial reflexes (in 37 patients, 100% of symptomatic cases), motor loss (13 patients, 35.1% of symptomatic cases), sensory loss (6 patients, 16.2% of symptomatic cases), urinary incontinence (6 patients, 16.2% of symptomatic cases), and constipation (4 patients, 10.8% of symptomatic cases).

In the group of patients whose MRI examination showed spinal lesions, the most common symptom were abnormal reflexes – 27 of 36 (75%) patients presented with them. In this subgroup, other clinical symptoms included motor loss (11 patients out of 36 in this group, 30.6%), sensory loss (4 patients out of 36 in this group, 11.1%), urinary incontinence (4 patients out of 36 in this group, 11.1%), and constipation (3 patients out of 36 in this group, 8.3%).

In patients with normal spinal MRI, clinical symptoms included abnormal superficial reflexes (10 patients out of 22 in this group, 45.5%), motor loss (2 patients out of 22 in this group, 9%), sensory loss (2 patients out of 22 in this group, 9%), urinary incontinence (2 patients out of 22 in this group, 9%), and constipation (1 patients out of 22 in this group, 4.5%).

Complex neurological symptoms, affecting more than 1 clinical domain was present in 21 (34.4%) patients and was more common in patients with MRI lesions in spinal cord (16 out of 36 patients; 44.4%) than in patients with normal MRI (5 out of 22 patents; 22.7%).

Only one patient presented with contrast enhancing lesions (1 out of 10; 10%) and no clinical symptoms. In patients with contrast enhancing lesions, five (50%) presented with complex neurological symptoms, affecting more than 1 clinical domain.

Diffuse uncountable MRI lesions were seen only in symptomatic patients. Patients with both C and Th/L regions affected were more frequently symptomatic (21 out of 25 patients; 84%) than asymptomatic (4 out of 25 patients; 16%). EDSS score in this subgroup of patients was up to 2 in 16 cases (64%) and above 2 in 9 cases (36%).

5. Discussion

MRI is nowadays one of the basic tools in diagnosing MS and in monitoring progress of the disease [1,4,5,12]. Most studies until now have focused on cranial MR examinations in adult patients. Recently, spinal cord involvement has been studied more closely [13–15]. It is estimated that about 80% of patients may present spinal cord symptoms during onset of the disease [2]. It is generally thought that in pediatric MS lesions in the spine do not significantly differ from those found in adults in terms of localization, length or number [5,8].

In our study, we have taken into consideration 58 spinal cord examinations, the most numerous group evaluated so far when it comes to pediatric population. The only other study concerning exclusively spinal cord lesions in ped-MS assessed 36 patients [11].

Spinal cord lesions were found in 36 out of 58 patients (62%), which proved to be far less than previously described-Verhey et al. reported lesions in 29 out of 38 patients (81%).

In our patients, spinal cord lesions were present with high frequency from the onset of clinical activity of the disease, clinical symptoms of spinal cord involvement during the first MS relapse were limited to the patients with spinal cord lesions disclosed on MRI examination, and presence of spinal cord MRI lesions was not seen in symptomatic cases only,

Table 1

No.	Sex	Years at investigation	Cervical region		Thoracic region		Clinical symptoms					EDSS
			No. of lesions	Gad	No. of lesions	Gad	Motor loss	Sensory disturbances	Abnormal reflexes	Constipation	Urinary incontinence	
1	F	12	d.u.	No	3	No	–	+	+	–	–	1.5
2	F	16.8	0	–	1	No	–	–	–	–	–	1
3	M	14.9	1	Yes	0	No	+	–	+	–	–	1
4	M	12	5	Yes	5	Yes	–	–	–	–	–	3.5
5	F	8.5	3	No	5	No	+	–	+	–	–	2
6	M	8	d.u.	Yes	d.u.	Yes	+	–	+	–	–	3
7	M	14.3	5	No	1	No	–	–	+	–	–	1
8	F	15.5	6	Yes	4	Yes	+	–	+	+	+	2.5
9	F	12.8	1	No	0	–	–	–	–	–	–	1
10	F	9.3	1	NO	3	No	–	–	–	–	–	1
11	F	11.3	0	–	1	No	–	–	+	–	–	2
12	F	17	1	No	1	No	–	–	–	–	–	1
13	M	7	1	Yes	0	–	+	+	+	–	–	5
14	M	15	0	–	1	No	–	–	–	–	–	1
15	M	15.8	3	No	4	No	+	–	+	–	–	2
16	F	14.4	1	No	3	No	+	–	+	+	–	2
17	M	17	0	–	1	No	+	–	+	–	–	3
18	F	10.8	2	No	1	No	+	–	+	–	–	2
19	M	16.3	4	No	3	No	+	–	+	–	–	2.5
20	F	16.8	1	No	0	–	–	–	+	–	–	1.5
21	F	13.4	3	No	0	–	–	–	–	–	–	1.5
22	F	17.8	3	No	1	No	–	–	–	–	–	1.5
23	F	12.8	1	No	2	Yes	–	–	+	–	–	1.5
24	F	11.6	3	No	3	No	–	–	+	–	–	3
25	F	16.8	5	No	2	No	–	–	+	–	–	1
26	M	15.9	2	No	1	No	–	–	+	–	–	2
27	F	17.3	3	No	6	No	–	–	+	–	+	2
28	F	15.7	d.u.	No	d.u.	No	+	+	+	–	–	4.5
29	F	15.3	1	Yes	1	Yes	–	–	–	–	–	1.5
30	F	16.8	6	No	6	Yes	–	–	+	–	–	2.5
31	M	16.7	2	Yes	1	–	+	–	+	–	–	2.5
32	M	13.4	0	–	1	No	–	–	+	–	–	3
33	M	16.2	1	No	1	No	+	–	+	–		1
34	M	11.5	0	–	1	No	+	–	+	+	+	3
35	M	13.3	d.u.	No	2	No	–	–	+	–	–	2.5
36	F	15.4	2	Yes	1	Yes	–	–	+	–	–	2

d.u. – diffuse uncountable.

suggesting that spinal cord lesions may evolve from the beginning of the disease, even before its clinical activity.

We report that lesions in the spinal cord were more commonly situated in the thoracic regions, however the difference between the occurrence of the lesions in the thoracic vs the cervical segments did not vary significantly (53% vs 52%). This is not consistent with previous studies, as it is generally thought that in pediatric MS lesions in the spine are observed predominantly in the cervical region [2,10,11], in which they do not differ from those in adults [5,8]. In particular, Verhey et al. found lesions in the cervical region in 11 patients (31%), while lesions in the thoracic region were observed in 9 (25%) children and both regions were involved in 9 patients (25%).

The number of detected lesions varied according to spinal region; in our population of 58 patients in the cervical region there were 67 plaques (1.86 per patient) and in the thoracic region 63 plaques were observed (1.75 per patient). Four patients had diffuse uncountable lesions in the cervical and two of them also in the thoracic segment. Once again, our data do not correspond with the previously published study. Verhey et al. reported 30 lesions in the cervical spinal cord and 27 in the thoracic region, which constituted, respectively, 50% and 45% of the number of lesions.

As for the enhancement after the administration of gadolinium contrast, we observed the enhancement in 8 patients (14%) in the cervical spinal cord and in 7 (12%) patients in the thoracic spinal cord, but in five patients lesions in both segments showed enhancement. In general, these patients constituted 28% of our population. Verhey analyzed only 16 examinations after contrast injection, as some of the patients refused the procedure or had previous allergic reaction and 5 children had gadolinium enhancing lesions (31%), which is not a dramatic difference in comparison to what we report.

In terms of clinical disability, the authors found no correlation between the EDSS of patients and the lesion load [18]. In our study we noticed a tendency to higher EDSS score in patients with lesions in more than 1 spinal cord region.

Our study showed that spinal cord lesions are more frequently present in patients with complex neurological

disability. Abnormal superficial reflexes as a sole sign of spinal cord involvement are seen both in patients with normal and abnormal spinal cord MRI. Other neurological signs and symptoms, including urinary incontinence and spinal sensory or motor loss are more frequent among patients with abnormal MRI, although may be seen also in patients with normal MRI.

In the attempt to increase diagnostic value of MRI examination, new imaging techniques have been investigated. The use of MR elastography, magnetization transfer imaging, diffusion transfer imaging and spectroscopy have recently been studied [16–19]. They offer unprecedented insight into tissue microstructure and mechanical properties, showing pathological lesions earlier than traditional MR sequences. Their place in diagnosing MS has not yet been established, but it is thought that, in time, they may become valuable tools in diagnosing MS.

6. Conclusion

Spinal cord lesions in MS children and adolescents are frequently seen and can be clinically silent. Numerous MRI spinal cord plaques are more common in patients with complex neurological disability. Spinal cord MRI examination facilitates making a prompt and accurate diagnosis, helping to prove e.g. dissemination in space. Therefore, spinal cord MRI should be included in diagnostic program as one of the basic examinations.

Conflict of interest

None declared.

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None declared.

Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

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