

NEUROIMAGING FINDINGS IN CHILDREN WITH CEREBRAL PALSY – RISK ASSESSMENT FOR SYMPTOMATIC EPILEPSY

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Received on June 30, 2021

Presented by L. Traykov, Member of BAS, on September 29, 2021

Abstract

Neuroimaging plays a key role in the diagnosis of cerebral palsy (CP), as it helps to understand the etiology and pathogenesis of neurological impairment.

The aim of the study is to demonstrate the role of neuroimaging in assessing the risk for epilepsy in children with CP with various lesions in CT and MRI with a focus on neuroimaging findings in full-term and premature children and their risk for epilepsy.

The study includes 521 children with CP, diagnosed in the Clinic of Child Neurology, UMHATNP “St. Naum” between 2008 and 2018. Two hundred and twenty children underwent MRI of the brain, 464 of the cases had CT, and 127 had both MRI and CT. Various pathological lesions in MRI (brain malformations, lesions in the white or gray matter, lesions in the basal ganglia, cystic lesions, cortical atrophy, ventriculomegaly) were found in all patients with CP and symptomatic epilepsy, while 5.8% of those children with CP without epilepsy had normal MRI. Normal findings were observed in CT in 7.5% of the children with CP and epilepsy, while this result reached 12.1% when children did not have epilepsy. Among the abnormal findings in MRI with the highest relative risk for symptomatic epilepsy were ventriculomegaly RR – 1.296 (95% CI 1.149–1.463), cortical atrophy RR – 1.235 (95% CI 1.082–1.410) and lesions in the gray matter RR – 1.210 (95% CI 1.056–1.387). When comparing the types of the lesions in MRI in full-term and premature children with CP, we observed that white matter lesions predominated in premature children, while

grey matter lesions in full-term children, which explains the higher incidence of epilepsy in full-term children.

We found a higher incidence of pathological lesions in neuroimaging studies in patients with CP and concomitant epilepsy compared to those without epilepsy, as well as a high relative risk for epilepsy in patients with ventriculomegaly, cortical atrophy, and gray matter lesions.

Key words: cerebral palsy, epilepsy, neuroimaging study

Introduction. The term “cerebral palsy” (CP) combines a group of non-progressive, residual syndromes with motor manifestations (paresis, muscle tone, coordination and postural changes, and involuntary movements), often with symptomatic epilepsy, intellectual deficit and speech problems due to abnormal development or damage to the parts of the brain in prenatal, perinatal and early postnatal period.

In over 80% of the cases with CP neuroimaging shows pathological findings and reveals the etiology and the pathogenesis of CP [1]. Structural changes in the brain occur at different periods of its development. One cause, such as an infectious agent or hypoxic-ischemic event, can cause different pathological lesions depending on the time of the impact that leads to the brain damage. The most common MRI/CT findings in preterm infants are lesions in the white matter (periventricular leukomalacia), while in term infants the lesions in the gray matter and brain malformations predominate. Epilepsy, mental retardation and speech disorders in patients with CP have been found to be more common when cortical and subcortical lesions and malformations are presented [2].

The aim of the study is to assess the risk for epilepsy in various lesions in CT and MRI of the brain in children with CP and to analyze the neuroimaging findings in full-term and premature children and their influence on epilepsy.

Materials and methods. The study included 521 children with CP diagnosed in the Clinic of Child Neurology, UMHATNP “St. Naum” between 2008 and 2018. Two hundred and twenty of the children had MRI, 464 of the children had CT scans, and 127 had both CT and MRI.

The statistical methods used for analysis of the results are: Chi-square test and Relative Risk assessment for quantitative evaluation of the risk of symptomatic epilepsy in various neuroimaging findings. Statistical analysis was performed using SPSS – (Statistical Package for the Social Sciences) version 13.

Results. The study compared the pathological findings in MRI/CT in children with CP with and without epilepsy. Various pathological lesions were found in MRI of the brain in all patients with CP and symptomatic epilepsy, while 5.8% of the children with CP without epilepsy had normal MRI. In patients with symptomatic epilepsy the lesions in the white matter predominated (39.3%), followed by gray matter lesions (35.1%), cystic lesions (33.9%), cortical atrophy (29.2%), brain malformations (27.4%), and ventriculomegaly (25%) (Table 1).

T a b l e 1

MRI findings in children with CP with and without epilepsy. Applying the Chi-square test to search for statistical dependence

MRI findings			Epilepsy		Total	X ²	df	p
			No	Yes				
Brain malformations	No	N	34	122	156	1.01	1	0.316
		%	65.4%	72.6%	70.9%			
	Yes	N	18	46	64			
		%	34.6%	27.4%	29.1%			
White matter lesions (periventricular leukomalacia, gliosis)	No	N	30	102	132	0.15	1	0.697
		%	57.7%	60.7%	60.0%			
	Yes	N	22	66	88			
		%	42.3%	39.3%	40.0%			
Grey matter lesions (gliosis, ulegyria)	No	N	43	109	152	5.90	1	0.015
		%	82.7%	64.9%	69.1%			
	Yes	N	9	59	68			
		%	17.3%	35.1%	30.9%			
Basal ganglion lesions	No	N	49	151	200	0.91	1	0.340
		%	94.2%	89.9%	90.9%			
	Yes	N	3	17	20			
		%	5.8%	10.1%	9.1%			
Cystic lesions	No	N	43	111	154	4.92	1	0.026
		%	82.4%	66.1%	69.9%			
	Yes	N	9	57	66			
		%	17.6%	33.9%	30.1%			
Cortical atrophy	No	N	46	119	165	6.58	1	0.010
		%	88.5%	70.8%	75.0%			
	Yes	N	6	49	55			
		%	11.5%	29.2%	25.0%			
Ventriculomegaly	No	N	49	126	175	9.03	1	0.003
		%	94.2%	75.0%	79.5%			
	Yes	N	3	42	45			
		%	5.8%	25.0%	20.5%			
Normal MRI	No	N	50	167	217			n/a
		%	94.2%	100.0%	98.6%			
	Yes	N	3	0	3			
		%	5.8%	0.0%	1.4%			

We observed a high incidence of cortical atrophy (36.3%), ventriculomegaly (28.3%), and cystic lesions (27.5%) in the CT of the patients with CP and epilepsy. Normal CT scans were found in 7.5% of the children with CP and symptomatic epilepsy, while in patients without epilepsy normal CT scans were observed in 12.1% of them (Table 2).

T a b l e 2

CT findings in children with CP with and without epilepsy. Applying the Chi-square test to search for statistical dependence

CT findings			Epilepsy		Total	X ²	df	p
			No	Yes				
Normal CT	No	N	175	245	420	2.69	1	0.101
		%	87.9%	92.5%	90.5%			
	Yes	N	24	20	44			
		%	12.1%	7.5%	9.5%			
Brain malformations	No	N	185	235	420	2.43	1	0.119
		%	93.0%	88.7%	90.5%			
	Yes	N	14	30	44			
		%	7.0%	11.3%	9.5%			
Ventriculomegaly	No	N	156	190	346	2.69	1	0.101
		%	78.4%	71.7%	74.6%			
	Yes	N	43	75	118			
		%	21.6%	28.3%	25.4%			
Calcifications	No	N	184	244	428	0.02	1	0.877
		%	92.5%	92.1%	92.2%			
	Yes	N	15	21	36			
		%	7.5%	7.9%	7.8%			
Cystic lesions	No	N	163	192	355	5.66	1	0.017
		%	81.9%	72.5%	76.5%			
	Yes	N	36	73	109			
		%	18.1%	27.5%	23.5%			
Periventricular leukomalacia	No	N	171	230	401	0.07	1	0.788
		%	85.9%	86.8%	86.4%			
	Yes	N	28	35	63			
		%	14.1%	13.2%	13.6%			
Grey matter lesions (gliosis lesions)	No	N	170	210	380	2.93	1	0.087
		%	85.4%	79.2%	81.9%			
	Yes	N	29	55	84			
		%	14.6%	20.8%	18.1%			
Basal ganglia lesions	No	N	193	249	442	2.29	1	0.129
		%	97.0%	94.0%	95.3%			
	Yes	N	6	16	22			
		%	3.0%	6.0%	4.7%			
Cortical atrophy	No	N	157	160	317	13.57	1	<0.001
		%	79.7%	63.7%	70.8%			
	Yes	N	40	91	131			
		%	20.3%	36.3%	29.2%			

Among the abnormal lesions in MRI ventriculomegaly had the highest relative risk for symptomatic epilepsy (RR – 1.296 (95% CI 1.149–1.463)), followed by cortical atrophy (RR – 1.235 (95% CI 1.082–1.410)) and grey matter lesions (RR – 1.210 (95% CI 1.056–1.387)) (Table 3).

T a b l e 3

Relative Risk (RR) for epilepsy in different MRI lesions of the brain

MRI abnormal lesions	RR	95% CI	
Brain malformations	0.919	0.772	1.094
White matter lesions	0.971	0.834	1.130
Grey matter lesions	1.210	1.056	1.387
Basal ganglia lesions	1.126	0.922	1.376
Cystic lesions	1.190	1.038	1.365
Cortical atrophy	1.235	1.082	1.410
Ventriculomegaly	1.296	1.149	1.463
Normal MRI	n/a		

When comparing the lesions in MRI of the brain in full-term and premature children with CP, we observed that in premature children white matter lesions and ventriculomegaly predominated, while in full-term children gray matter lesions, cystic lesions, cortical atrophy and lesions in the basal ganglia were the leading findings, suggesting a higher incidence of epilepsy in full-term children (Fig. 1). We found that 31.8% of the premature and 68.2% of the full-term children had epilepsy which supports the above observation.

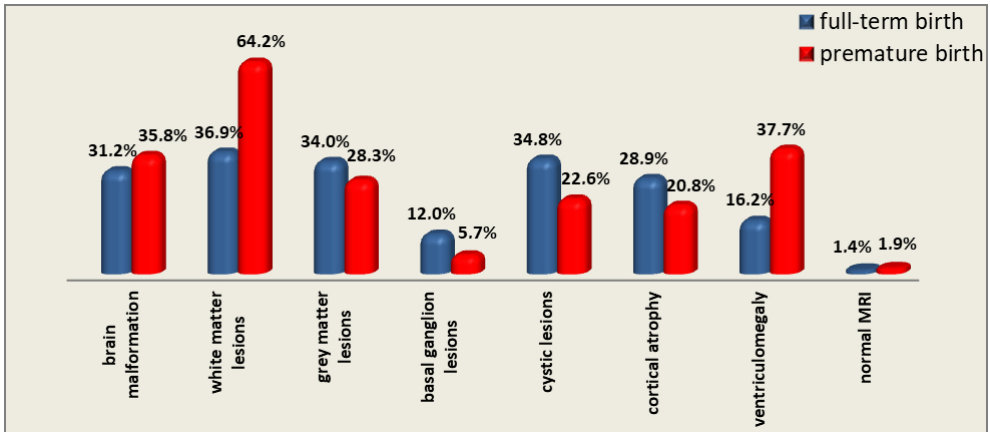


Fig. 1. MRI lesions in the brain in full-term and premature birth children

Discussion. In children with CP a high incidence of abnormal imaging findings, detected by CT and MRI of the brain, was reported, varying between 84% and 87% [3, 4]. GÜRKAN et al. [5] observed that children with CP and epilepsy had a higher incidence of abnormal imaging findings compared to those with CP but without epilepsy. Demonstrating a direct link between epileptic syndrome and a specific structural lesion in neuroimaging is a complex process that depends on the direct matches between the localization of the structural

finding in MRI/CT and the pathological findings in EEG and SPECT (performed during epileptic seizure). In our study we looked only for a general statistical relationship between the presence of lesions in CT/MRI and the incidence of epilepsy in patients with CP. SENBIL et al. [6] found that neuroimaging studies were abnormal in 74.2% of children with epilepsy and CP, while in those with CP without epilepsy pathological findings were observed in 48.8% of the cases. We confirm the observations from previous studies that there is a higher incidence of abnormal findings in MRI/CT in children with CP and epilepsy compared to those without epilepsy. In our study abnormal findings in CT of the brain were observed in 92.5% of the children with CP and epilepsy versus 87.9% of the children without epilepsy. In MRI all children with epilepsy and CP had abnormal findings versus 94.2% of those without epilepsy. The risk for epilepsy depends on the etiology as it reaches 50–94% in children with cortical lesions and malformations and is around 50% when there is a perinatal stroke [7,8]. Other studies have also reported a high risk for epilepsy when gray matter lesions and cerebral atrophy are presented [9,10]. Our observations confirm that in patients with epilepsy and CP cortical atrophy (seen in 36.3% of the patients in CT and in 29.2% in MRI) and gray matter lesions (seen in 20.8% of children in CT and in 35.1% of the cases in MRI) are more common. Our results support those of ZELNIK et al. [11] who reported that cortical atrophy may be a predictor for epilepsy manifestation. Gürkan et al. [5] found that the most common lesion in children with CP was periventricular leukomalacia, regardless of the presence of epilepsy. Our observations are similar to those of Gürkan et al. [5] as in our patients with and without epilepsy the most numerous were the lesions in the white matter. Another observation of the authors was that the incidence of cerebral atrophy, brain malformations and hydrocephalus was higher in the group of children with epilepsy and therefore they calculated a high relative risk for epilepsy when these three lesions were presented in MRI. We also confirm a high relative risk for epilepsy when ventriculomegaly (RR – 1.296 (95% CI 1.149–1.463)), cortical atrophy (RR – 1.235 (95% CI 1.082–1.410)) and gray matter lesions (RR – 1.210 (95% CI 1.056–1.387)) are presented. In a study of COOPER et al. [12] 25% of the children with CP and white matter lesions experienced seizures beyond the neonatal period and 15% of them developed epilepsy. According to the authors the incidence of epilepsy in their study was lower because cortical lesions were not included. We found that in MRI scans of preterm children white matter lesions (periventricular leukomalacia and gliosis) predominated (64.2%), while those lesions were found in (36.9%) of full-term children. We observed less gray matter lesions (28.2%) and less often cortical atrophy (20.8%) in premature children compared to full-term children (grey matter lesions – 34.0%, cortical atrophy – 28.9%), similar to the results of other authors [1,4]. These observations determine the lower incidence of epilepsy in premature children compared to full-term children.

Conclusion. We found a higher incidence of abnormal lesions in neuroimaging studies in patients with CP and concomitant epilepsy compared to those without epilepsy, as well as a high relative risk for epilepsy in patients with ventriculomegaly, cortical atrophy and gray matter lesions. The incidence of epilepsy is higher in full-term children with CP due to the predominance of gray matter lesions and cortical atrophy, while in preterm children white matter lesions of the brain are more common.

Neuroimaging studies contribute to the early diagnosis of CP and initiation of rehabilitation that will support the better development of motor and intellectual abilities in children due to brain plasticity in early childhood.

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