Epilepsi 2021;27(1):23-31 DOI: 10.14744/epilepsi.2020.63644

ORIGINAL ARTICLE

The Evaluation of Brain Volume in Children with Epilepsy on Magnetic Resonance Imaging by Stereological Method

Saliha Seda ADANIR,[1] Ömer Faruk CİHAN,[1] Ayşe Aysima ÖZÇELİK[2]

[1]Department of Anatomy, Gaziantep University Faculty of Medicine, Gaziantep, Turkey
[2]Department of Pediatric Neurology, Gaziantep University Faculty of Medicine, Gaziantep, Turkey

Summary

Objectives: Brain volume is important in many diseases for both children and adults. Studies examining brain volume in terms of seizure types are less although several studies examining brain volume on healthy and epileptic children are available. Thus, this study aims to examine the cerebral cortex, cerebral white matter, cerebral, cerebellar, and total brain volumes in terms of epilepsy-related factors in children diagnosed with idiopathic epilepsy.

Methods: Cranial magnetic resonance images of 100 children (girls, 50; boys, 50), aged 3–16 years old, who had idiopathic epilepsy with generalized and partial seizures were retrospectively evaluated. The volumetric measurements of the cerebral cortex, cerebral white matter, cerebrum, cerebellum, and total brain were performed using the Cavalieri principle, which is one of the methods for volume calculation with stereology techniques.

Results: No significant difference was noted in the brain volumes between partial and generalized seizure groups. However, asymmetry on cerebral cortex volume in both seizure groups was determined. Similarly, no correlation was found between epilepsy duration, seizure frequency, use of antiepileptic drugs, and brain volumes.

Conclusion: Studies comparing two different seizure types are relatively less among the studies examining brain volume in childhood epilepsy. Thus, the study of brain volume in children with partial and generalized seizures diagnosed with idiopathic epilepsy will contribute to the studies conducted in this area, and the results obtained are essential for understanding the impact of epilepsy and epilepsy-related factors on brain volume.

Keywords: Brain volume; generalized seizures; epilepsy; magnetic resonance imaging; partial seizures; stereology.

Cite this article as: Adanır SS, Cihan ÖF, Özçelik AA. The Evaluation of Brain Volume in Children with Epilepsy on Magnetic Resonance Imaging by Stereological Method. Epilepsi 2021;27:23-31.

Introduction

Brain volume is significant in many diseases for both children and adults. Several studies exist investigating changes in the brain volume in diseases such as autism, attention-deficit/hyperactivity disorder, schizophrenia, multiple sclerosis, epilepsy, and Alzheimer's disease.[1–5] Some volumetric studies on childhood epilepsies stated that epileptic children had significantly smaller brain volumes compared with healthy children.[2,6] Consequently, volumetric changes were observed not only in the TBV but also in the gray matter and subdivision parts of the brain such as the cerebrum and cerebellum.[2,6–8]

Epilepsy is a common neurological disease in childhood. Epilepsy seizures are generally classified into three groups: partial (focal), generalized, and idiopathic onset. Generalized and partial (focal) seizures are defined as seizures involving the entire brain cortex and seizures originating from a specific location of the cortex, respectively.[9,10] Although many studies have been done examining epileptic children, only very few studies indicate whether any effect exists on the brain volume of seizure groups.[8] The detailed literature review observed a few studies comparing seizure types and examining symmetry in the brain hemispheres.[11] Moreover, studies also exist reporting the age of epilepsy onset, seizure frequency, and the use of antiepileptic drugs as being effective in brain volume.[2,8,12–14] The Cavalieri principle, which is one of the methods for volume calculation with stereology techniques, is a frequently used method

Dr. Saliha Seda ADANIR

Corresponding author
Saliha Seda ADANIR, M.D.
e-mail seda.adnr93@gmail.com

Received 10.05.2020
Accepted 26.10.2020
Online date 21.01.2021

Epilepsili Çocuklarda Beyin Hacminin Manyetik Rezonans Görüntüleri Üzerinde Stereolojik Yöntemle Değerlendirilmesi

Özet

Amaç: Beyin hacmi birçok hastalıkta hem çocuklar hem de yetişkinler için önemlidir. Epileptik ve sağlıklı çocuklarda beyin hacminin incelendiği birçok çalışma olmasına rağmen, beyin hacminin nöbet tipleri açısından incelendiği çalışmaların daha az olduğu görülmektedir. Bu çalışmanın amacı, idiyopatik epilepsi tanılı çocuklarda serebral korteks, hemisferik beyaz cevher, serebrum, serebellum ve toplam beyin hacminin epilepsi ile ilişkili faktörler açısından incelenmesidir.

Gereç ve Yöntem: Çalışmada, idiyopatik epilepsi tanılı parsiyel ve jeneralize nöbetleri olan 3-16 yaş arası 50'si kız, 50'si erkek toplam 100 çocuğun kraniyal manyetik rezonans görüntüleri retrospektif olarak incelenmiştir. Serebral korteks, hemisferik beyaz cevher, serebrum, serebellum ve toplam beyin hacim ölçümleri, stereoloji teknikleri ile hacim hesaplama yöntemlerinden biri olan Cavalieri prensibiyle hesaplanmıştır.

Bulgular: Parsiyel ve jeneralize nöbet grupları arasında beyin hacimlerinde anlamlı bir fark olmadığı saptanmıştır ($p>0.05$). Ancak her iki nöbet grubunda serebral korteks asimetrisi tespit edilmiştir. Epilepsi süresi, nöbet sıklığı, antiepileptik ilaç kullanımı ve beyin hacimleri arasında anlamlı bir ilişki olmadığı görülmüştür ($p>0.05$).

Sonuç: Çocukluk çağı epilepsilerinde beyin hacmini inceleyen çalışmalar arasında, iki farklı nöbet tipini karşılaştıran çalışmaların daha az olduğu bilinmektedir. Bu çalışmada, idiyopatik epilepsi tanısı alan parsiyel ve jeneralize nöbetleri olan çocuklarda beyin hacminin incelenmesinin bu alanda yapılan çalışmalara katkıda bulunacağı ve elde edilen sonuçların epilepsi ve epilepsi ile ilişkili faktörlerin beyin hacmi üzerine etkisini anlamak adına önemli olduğu düşünülmektedir.

Anahtar sözcükler: Beyin hacmi; jeneralize nöbet; epilepsi; manyetik rezonans görüntüleme; parsiyel nöbet; stereoloji.

for calculating the volumes of structures and organs which have irregular borders.[15] In addition, the Cavalieri principle provides precise numerical data. Thus, reliable and unbiased results are obtained.[16] It is accepted as the gold standard in volumetric studies.[17]

This study aims to investigate the cerebral cortex volume (CCV), cerebral white matter volume (WMV), cerebral volume (CV), cerebellar volume (CRV), and total brain volume (TBV) in terms of seizure type, gender, antiepileptic drug usage, seizure frequency, and epilepsy duration in children with partial and generalized seizures and to evaluate the symmetry of the hemispheres in the cerebrum and cerebellum.

Materials and Methods

This study was retrospectively conducted on cranial magnetic resonance (MR) images of 50 girls (mean age, 8.06±3.83 years) and 50 boys (mean age, 9.32±3.68 years) with epilepsy who were admitted to and monitored at Department of Pediatric Neurology, Faculty of Medicine, Gaziantep University, between 2016 and 2018. Of the children, 24 and 26 of the girls and 29 and 21 of the boys had generalized and partial seizures, respectively.

The approval of the Clinical Trials Ethical Committee of Gaziantep University was obtained before the study commenced (Decision no: 2018/29).

Inclusion and exclusion criteria– The study included cases of children 3–16 years old who were diagnosed with idiopathic epilepsy by a pediatric neurologist (AAÖ; according to the International League Against Epilepsy 2017 epilepsy classification), had no pathology in the cranial MR images, and had a normal neurological examination. Cases with a diagnosis of symptomatic epilepsy associated with cerebral palsy, encephalitis, tumor mass, and so on; those with a diagnosis of cryptogenic epilepsy; and those with a history of preterm birth were excluded from the study. Images with artifacts that could cause any missing or false results related to any of the measured parameters or prevent the identification of reference points were not included in the study.

Imaging protocol– MR imaging examinations were performed with a Philips Ingenia 1.5-T MR scanner (Philips, Andover, MA, USA). Moreover, continuous 5-mm-thick sections of axial, coronal, and sagittal slices (512×512 matrices) were obtained.

Converting digital imaging and communications in medicine (DICOM) images to JPEG format– All DICOM images were transferred to RadiAnt DICOM Viewer program and converted to JPEG format for volumetric measurement. Consequently, images in JPEG format were separately recorded for each patient. An average of 25 axial, 25 sagittal, and 25 coronal section images were obtained for each patient.

Volumetric measurement– The measurements were performed with a computer-assisted stereological analysis system (Stereo Investigator Version 8.0, MicroBrightField, Williston, VT, USA) at the Stereology Laboratory of the Department of Anatomy, Faculty of Medicine, Gaziantep University.

CCV and WMV were measured in T1-weighted axial sections (Fig. 1a). Moreover, the CV was measured in T1-weighted coronal sections (Fig. 1b). Both cerebral hemispheres were separated from the cerebral falx. The tentorium cerebelli was accepted as the border between the cerebrum and cerebellum. A line through the superior colliculus and below the mammillary body was accepted as the border on the images of the sagittal sections of the cerebrum and the brainstem. Moreover, the CRV was measured in T1-weighted sagittal sections (Fig. 1c). Consequently, the right and left cerebellar hemispheres were separated by identifying the midsagittal section. The cerebellum was separated from the cerebrum through the tentorium cerebelli. The fourth ventricle was accepted as the border between the brainstem and the cerebellum. TBV was measured in T1-weighted sagittal sections (Fig. 1d). CCV, WMV, CV, and CRV were separately measured in two hemispheres.

Statistical analysis– The Shapiro–Wilk test was used to test the compliance of the data toward normal distribution, and the independent samples t-test and the paired samples t-test were used to compare normally distributed variables in two independent and two dependent groups, respectively. Moreover, Spearman's rank correlation coefficient test was used for testing the relationship between the numerical variables while the chi-square test was used to test the relationship between the categorical variables. The Statistical Package for the Social Sciences for Windows, version 22.0, was used for statistical analysis. A value of $p<0.05$ was accepted as statistically significant.

Results

The CCV, WMC, CV, CRV, and TBV of 50 girls and 50 boys with epilepsy in this study who were aged 3–16 years were measured using their cranial MR images. No statistically significant difference was noticed between age and gender ($p=0.097$). In addition, the epilepsy-related features of the patients are shown in Table 1.

Differences in volumetric measurements between gender– CCV, WMV, CV, CRV, and particularly TBV were found to be significantly larger in boys than girls ($p=0.017$, $p=0.012$, $p=0.008$, $p=0.008$, $p=0.002$, respectively; Table 2).

Differences in volumetric measurements between epilepsy groups– No significant difference exists in the structures measured between the partial and generalized epilepsy groups ($p>0.05$; Table 3).

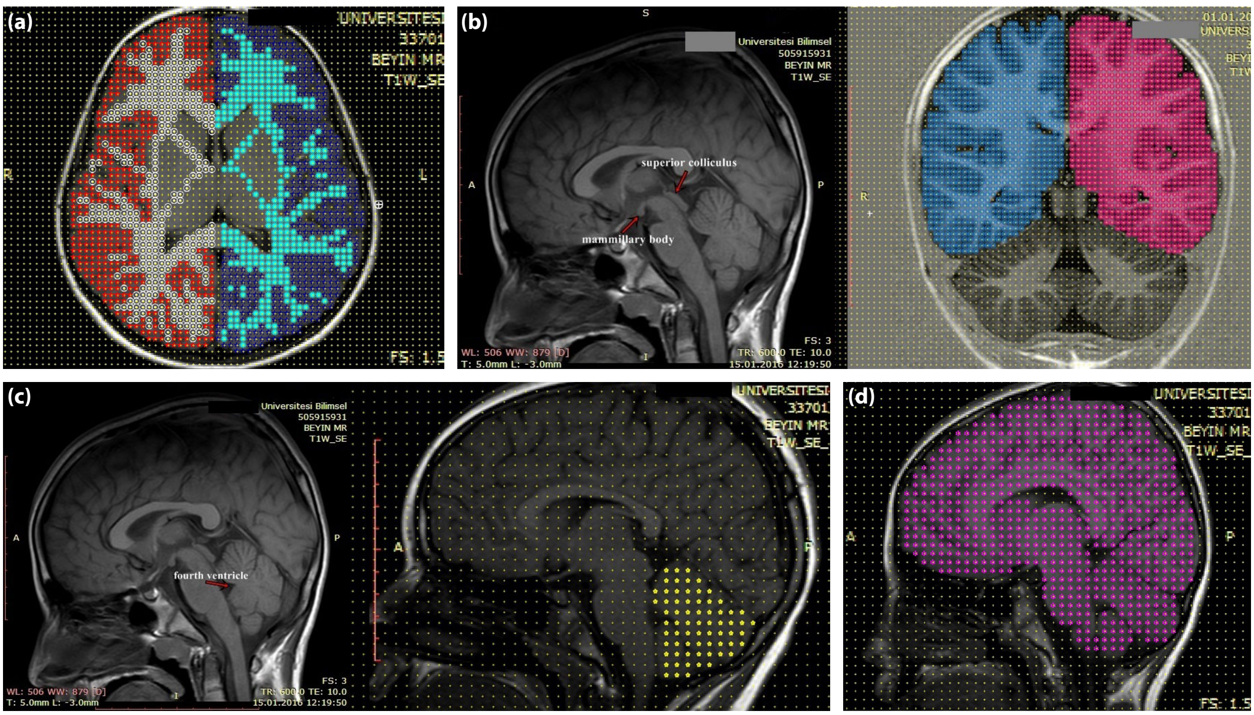

Fig. 1. **(a)** Measurement of cerebral cortex and cerebral white matter volume. **(b, c)**, Measurement of cerebral volume. **(d)** Measurement of total brain volume.

Table 1. Epilepsy-related features of the patients

Epilepsy-related features		Girl	Boy
Seizure type	Partial group	26	21
	Generalized group	24	29
Seizure frequency	≤1 per year	35	32
	>1 per year	15	18
Antiepileptic drugs usage	One drug	35	33
	Two or more drugs	15	17

Table 2. Comparison of brain volumes between gender

Volume (cm^3)	Boy (mean±SD)	Girl (mean±SD)	p
CCV	311.38±110.34	261.95±92.89	0.017*
WMV	155.53±63.71	122.95±62.89	0.012*
CV	873.21±237.9	724.01±310.19	0.008*
CRV	114.05±38.84	89.52±39.00	0.008*
TBV	1021.95±245.41	831.11±337.8	0.002*

SD: Standard deviation; cm^3: cubic centimeter; CCV: Cerebral cortex volume; CV: Cerebrum volume; CRV: Cerebellum volume; TBV: Total brain volume; WMV: White matter volume. *Statistically significant difference.

Table 3. Comparison of brain volumes between epilepsy group

Volume (cm^3)	Partial (mean±SD)	Generalized (mean±SD)	p
CCV	280.73±104.65	291.93±105.03	0.595
WMV	133.29±60.83	144.53±68.76	0.391
CV	806.72±251.11	791.42±314.34	0.790
CRV	101.13±41.28	102.36±40.44	0.595
TBV	938.34±279.78	916.05±335.11	0.721

SD: Standard deviation; cm^3: cubic centimeter; CCV: Cerebral cortex volume; CV: Cerebrum volume; CRV: Cerebellum volume; TBV: Total brain volume; WMV: White matter volume.

Asymmetry between the two hemispheres– The CCV was larger in the right hemisphere in both generalized and partial epilepsy groups (p=0.001). In addition, no asymmetry between the right and left hemispheres was detected in WMV, CV, and CRV (p>0.05).

Correlation between volumetric measurements and age– The relationship between volumetric measurements and age was separately analyzed between epilepsy groups and gender. While the CCV increased with age in girls in the generalized epilepsy group (p=0.001, r=0.661), no significant correlation was found between CCV and age in other groups (p>0.05). However, WMV, CV, CRV, and TBV significantly increased with age in boys and girls in both the generalized and partial epilepsy groups (Table 4).

The relationship between volumetric measurements and seizure frequency, epilepsy duration, and antiepileptic drugs– No significant difference in terms of volumetric measurements was found between the patients in both genders who had a seizure frequency of <1 and >1 per year (p>0.05). Consequently, epilepsy duration did not have a significant correlation with brain volumes in both girls and boys (p>0.05). No significant difference in terms of volume was found between those using only one antiepileptic drug and those using two or more antiepileptic drugs (p>0.05).

Discussion

Several studies exist in the literature examining brain volume in epileptic and healthy children. The majority of these studies compared healthy and epileptic children, and a few studies compared seizure types in epilepsy. In contrast with other studies, the brain volumes of epileptic children with partial and generalized seizures were compared in this study. Similar to the comparison of the seizure types, a few studies exist examining the hemisphere asymmetry in epileptic children. However, unlike many other studies,

Table 4. Correlation of brain volume between age

Parameters		Generalized group		Partial group	
		Boy (29)	Girl (24)	Boy (21)	Girl (26)
Cerebral cortex volume	p	0.455	0.001	0.216	0.590
	r	0.144	0.661**	-0.281	0.111
White matter volume	p	0.002	0.001	0.049	0.002
	r	0.548**	0.716**	0.390*	0.570**
Cerebrum volume	p	0.001	0.001	0.001	0.001
	r	0.882**	0.939**	0.772**	0.782**
Cerebellum volume	p	0.001	0.001	0.005	0.001
	r	0.783**	0.818**	0.735**	0.706**
Total brain volume	p	0.001	0.001	0.001	0.001
	r	0.909**	0.944**	0.842**	0.814**

*Statistical correlation, **Statistically high correlation.

the asymmetry between the brain hemispheres of epileptic children was evaluated and both types of seizures were compared in this respect. A comparison of the results of the present study with the literature is shown in Table 5.

The measurement method is important for the reliability and impartiality of the study in volumetric studies. Stereology is a gold standard method that provides unbiased and reliable measurements. However, a stereological study in epileptic children has not been found although it is frequently used in volumetric studies. The Cavalieri principle, which is one of the stereology techniques, was preferred in this study because of its reliability.

Cerebral cortex– The cerebral cortex and gray matter volume in healthy children/adults and those with epilepsy have been investigated in many studies.[7,13,14,18–23] Some of these studies investigated total gray matter volume[13,14,19–21,23] and the CCV.[7,18,22]

Epilepsy is a disease that directly affects the cerebral cortex. The relationship between chronic partial epilepsy and brain atrophy was attributed to cortical thickness changes in epilepsy.[22] Caplan et al.[13] found that healthy children had a significantly larger total gray matter volume than epileptic children. However, two different studies investigating the gray matter volume found no difference between healthy and epileptic children.[14,19] Conversely, another study significantly detected larger CCV in epileptic children compared with healthy children.[7]

Gogtay et al.[20] reported that the gray matter volume increased at early ages and started to decrease with adolescence in healthy children. On the other hand, Caviness et al.[18] reported that the cerebral cortex did not have a significant correlation with age in healthy children aged 7–11 years. Moreover, Hermann et al.[21] found that the gray matter volume decreased with age in both healthy and epileptic children aged 8–18 years old. No significant correlation exists between the CCV and age in this study. Throughout its development, the CCV reaches its maximum in different lobes at different times and then decreases.[24] This difference in the results may be due to the different age groups in the studies.

The studies reported that the early onset of seizures and long duration of epilepsy was associated with a lower volume of gray matter.[13,14] Conversely, Caplan et al.[23] reported that they did not find any correlation between the duration of seizure, age of seizure onset, and gray matter volumes in epileptic children. Similarly, this study found no significant relationship between seizure frequency, epilepsy duration, usage of antiepileptic drugs, and CCV. Caviness et al.[18] found that the cerebral cortex is symmetrical in both hemispheres in healthy girls and boys. On the contrary, the CCV was found to be significantly larger than the left compared with the right hemisphere in both generalized and partial groups in the present study. These results suggest that epilepsy may affect cortex symmetry.

Cerebral white matter

No significant difference was observed between the two groups regarding the WMV in healthy and epileptic children.[13,14,19] Hermann et al.[21] examined the development of white matter and reported that WMV increased between 8 and 14 years old in healthy and epileptic children. A study examining the white matter found a significant increase with age in healthy children.[25] However, another study did not find

Epilepsi 2021;27(1):23-31

Table 5. Comparison of the results with some volumetric studies with epileptic children

Study	Case	Number of cases			CCV-GMV	WMV	CV	CRV	TBV
		Child		Adult					
Caplan et al.[a][23]	Healthy	M		M					
		F		F					
		T	37	T	810.22 ±70.86	484.13 ±67.98			1408.15±143.06
	Epilepsy	M		M					
		F		F					
		T	26	T	763.49± 74.38	470.64± 66.51			1351.22±122.46
Caplan et al.[a][19]	Healthy	M		M					
		F		F					
		T	34	T	810.22±70.86	484.13±67.98			1408.15±143.06
	Epilepsy	M		M					
		F		F					
		T	69	T	779.35±68.97	479.66 ± 72.96			1373.26 ±117.74
Daley et al.[a][14]	Healthy	M		M					
		F		F					
		T	38	T	798.39±71.25	483.36 ±67.46			1395.35 ±141. 07
	Epilepsy	M		M					
		F		F					
		T	44	T	789.45±68.73	487.70 ±76.43			1388.94 ±19.06
Lawson et al.[b][6]	Healthy	M	23	M					
		F	19	F					
		T	42	T			1235[c]	144	1405[c]
	Frontal lobe epilepsy	M		M					
		F		F					
		T	20	T			1134	143	1302
	Mesial temporal lobe epilepsy		12				1131	134	1278
Lawson et al.[b][2]	Healthy	M		M					
		F		F					
		T	44	T			1235[c]	144[c]	1389[c]
	Epilepsy	M	129	M					
		F	102	F					
		T	231	T			1104	133	1237

Table 5. Comparison of the results with some volumetric studies with epileptic children *(continue)*

Study	Case	Number of cases				CCV-GMV	WMV	CV	CRV	TBV
		Child		Adult						
Lawson et al.*[8]	Healthy	M	23	M						
		F	21	F						
		T	44	T					1236[c]	145
	Epilepsy	M	61	M						
		F	51	F						
		T	112	T					1081	133
Zelko et al.[a,d][7]	Healthy	M		M						
		F		F						
		T	36	T			510.009	487.670		
	Epilepsy	M		M						
		F		F						
		T	108	T			527.129[c]	481.488		
This study[b,d]	Epilepsy	M	50	M		311.38±110.34	155.53±63.71	873.21±237.9	114.05±38.84	1021.95±245.41
		F	50	F		261.95±92.89	122.95±62.89	724.01±310.19	89.52±39.00	831.11±337.8
		T	100	T		286.67±104.47	139.24±65.07	798.61±285.06	101.78±40.64	926.53±309.00

CCV: Cerebral cortex volume; CV: Cerebrum volume; CRV: Cerebellum volume; F: Female; GMV: Gray matter volume; M: Male; T: Total; TBV: Total brain volume; WMV: White matter volume. [a]Measurements are given as cubic millimeter; [b]Measurements are given as cubic centimeter; [c]Significant difference between epilepsy and control group; [d]Cerebral cortex in the studies, and the volume of the gray matter was measured in the others.

any significant correlation between WMV and age.[18] This study observed an increase in the WMV with age in partial and generalize groups. Consequently, myelination encompasses a duration starting in the fetal period until the third decade in normal development.[24] Although the absence of a difference in terms of cerebral white matter between epileptic and healthy children and its increase with age in epileptic children suggest that epilepsy does not affect the myelination process. However, some studies contradict these results.[21]

Two studies have reported a negative relationship between the long duration of epilepsy and WMV.[13,14] This study observed that seizure frequency, epilepsy duration, and antiepileptic drugs did not affect WMV. Similarly, seizure type did not affect WMV. Studies evaluating the asymmetry of hemispheric white matter are very few. Consequently, this study found no statistically significant difference in WMV in the right and left hemispheres in both partial and generalized groups.

Cerebrum– Significantly smaller CVs were observed in the studies conducted in epileptic children than the control group.[2,6,8,26] This decrease may be attributed to seizures, traumas, and congenital anomalies.[2,6,8,26]

Hagemann et al.[27] reported that the cerebrum volume in adults with partial and generalized epilepsy did not show any significant difference between the two epilepsy groups. Consequently, this study did not observe any significant difference in the CVs of children with partial and generalized seizures.

Giedd et al.[11] found that the right cerebral hemisphere was significantly larger than the left cerebral hemisphere in healthy children. Two different studies reported that cerebral hemispheres were symmetrical in both healthy and epileptic children.[2,8] Similarly, this study found that the hemispheres were symmetrical in epileptic children. In addition, the impact of seizure types, seizure frequency, epilepsy duration, and usage of antiepileptic drugs on the cerebral volume was not observed in this study. Consequently, Lawson et al.[2] reported a negative correlation between cerebral volume and seizure years in epileptic children. These differences in the results of the studies may be due to factors such as epilepsy species (whether or not an additional pathology to epilepsy exists).

Cerebellum– The cerebellar volume was found to be significantly larger in healthy than in epileptic children.[2,6,8,26] Botez et al.[12] found that the decrease in cerebellar volume was correlated with epilepsy duration and the use of antiepileptic drugs. However, the relationship of the cerebellar volume decreases with the duration of epilepsy, and the use of antiepileptic drugs is debated. Contrarily, this study found no relationship between seizure frequency, epilepsy duration, antiepileptic drugs, and cerebellar volume. Similarly, seizure type did not affect cerebellar volume. Also, cerebellar asymmetry in epileptic children was not determined.

Total brain– Some studies reported that the TBV did not show a significant difference between epileptic and healthy children.[14,19,23] On the contrary, other studies exist in which smaller TBVs were observed in epileptic than in healthy children.[2,6] Thus, brain atrophy in chronic partial epilepsy may be associated with a decrease in cortical thickness.[22]

The brain volume development is very fast in the first years but it slows down toward the end of the first decade of life.[18] Approximately 90% of brain volume development is completed by 5 years old.[24] Consequently, Courchesne et al.[28] found that TBV increased by approximately 25% in the early childhood and adolescence period. Caviness et al.[18] reported no significant correlation between TBV in healthy children aged 7–11 years old. This study observed a significant increase in TBV with age in epileptic children. These differences may be the result of the difference in age groups.

This study found that seizure type did not affect TBV as in other measured parameters. In addition, no significant relationship exists between epilepsy-related factors (seizure frequency, duration of epilepsy, and antiepileptic drugs) and total brain volume.

The relationship between gender and brain volumes– Many studies compare brain volumes between gender in healthy and epileptic children. In these studies, larger brain volumes were detected in boys than in girls.[8,11,18,24,25,28,29] In the current study, all measured structures were found to be significantly larger in boys than in girls following the literature. Although the large brain volume is not known to be an advantage or disadvantage, gender has been reported to have a significant effect on brain volume.[24]

Study limitatitons– This retrospective study has no control group. Therefore, brain volumes could not be normalized. A comparison with a control group would be useful in future studies. Additionally, thalamus and nuclei basales could not be examined due to due to the 5-mm thick sections on MR images. The researchers believe that examining these structures in future studies would be useful.

Conclusion– Studies comparing two different seizure types (partial and generalized seizures) are relatively less among the studies examining brain volume in childhood epilepsy. The findings showed that seizure type did not affect the volume of the total brain, cerebrum, cerebellum, cerebral cortex, and cerebral white matter in epileptic children. In addition, cerebral cortex, cerebral white matter, cerebrum, and cerebellum symmetry were examined in this study, and asymmetry was detected only in the cerebral cortex. Many studies are available comparing brain volume between gender in epileptic children. Thus, the present study compared the brain volumes between gender in partial and generalized epileptic groups. The results of the present study support the idea that gender is significantly effective in brain volume. It is controversial whether epilepsy-related factors (e.g., antiepileptic drug use, epilepsy duration, and seizure frequency) are effective on brain volumes. According to the findings of this study, these factors may have no significant effect on CCV, WMV, CV, CRV, and TBV. In conclusion, the investigation of the relationship between the volumes of the brain and the subdivisions of the brain and seizure types and the evaluation of hemispheric asymmetry in epileptic children will contribute to the studies conducted in this field. Thus, studies with different types of seizures and larger populations may be useful.

Acknowledgment– The authors are thankful to Professor Dr. Piraye KERVANCIOĞLU, Department of Anatomy, School of Medicine, Gaziantep University, for the support.

Ethics Committee Approval– Ethics committee approved.

Peer-review– Externally peer-reviewed.

Conflict of interest– The authors declare that they have no conflict of interest.

Authorship Contributions– Concept: Ö.F.C., S.S.A., A.A.Ö.; Design: Ö.F.C., S.S.A., A.A.Ö.; Supervision: Ö.F.C., S.S.A., A.A.Ö.; Fundings: Ö.F.C., S.S.A., A.A.Ö.; Data collection &/or processing: Ö.F.C., S.S.A., A.A.Ö.; Analysis and/or interpretation: Ö.F.C., S.S.A., A.A.Ö.; Literature search: Ö.F.C., S.S.A., A.A.Ö.; Writing: Ö.F.C., S.S.A., A.A.Ö.; Critical review: Ö.F.C., S.S.A., A.A.Ö.

References

1. Karacan K, Kosar MI, Cimen M, Solak O, Sahin B. Determination of Lateral Ventricle and Brain Volume in Children with Stereological Method Using MRI. Int J Morphol 2013;31(1):211–6.
2. Lawson JA, Vogrin S, Bleasel AF, Cook MJ, Burns L, McAnally L, et al. Predictors of hippocampal, cerebral, and cerebellar volume reduction in childhood epilepsy. Epilepsia 2000;41(12):1540–5.
3. Castellanos FX, Lee PP, Sharp W, Jeffries NO, Greenstein DK, Clasen LS, et al. Developmental trajectories of brain volume abnormalities in children and adolescents with attention-deficit/hyperactivity disorder. JAMA 2002;288(14):1740–8. [CrossRef]
4. Steen RG, Mull C, McClure R, Hamer RM, Lieberman JA. Brain volume in first-episode schizophrenia: systematic review and meta-analysis of magnetic resonance imaging studies. Br J Psychiatry 2006;188:510–8. [CrossRef]
5. Kalkers NF, Ameziane N, Bot JC, Minneboo A, Polman CH, Barkhof F. Longitudinal brain volume measurement in multiple sclerosis: rate of brain atrophy is independent of the disease subtype. Arch Neurol 2002;59(10):1572–6. [CrossRef]
6. Lawson JA, Cook MJ, Vogrin S, Litewka L, Strong D, Bleasel AF, et al. Clinical, EEG, and quantitative MRI differences in pediatric frontal and temporal lobe epilepsy. Neurology 2002;58(5):723–9. [CrossRef]
7. Zelko FA, Pardoe HR, Blackstone SR, Jackson GD, Berg AT. Regional brain volumes and cognition in childhood epilepsy: does size really matter? Epilepsy Res 2014;108(4):692–700.
8. Lawson JA, Vogrin S, Bleasel AF, Cook MJ, Bye AM. Cerebral and cerebellar volume reduction in children with intractable epilepsy. Epilepsia 2000;41(11):1456–62. [CrossRef]
9. Chuang NA, Otsubo H, Chuang SH. Magnetic resonance imaging in pediatric epilepsy. Top Magn Reson Imaging 2002;13(1):39–60. [CrossRef]
10. Bourgeois BF, Dodson E. Pediatric epilepsy: diagnosis and therapy. Demos Medical Publishing; 2007.
11. Giedd JN, Snell JW, Lange N, Rajapakse JC, Casey BJ, Kozuch PL, et al. Quantitative magnetic resonance imaging of human brain development: ages 4-18. Cereb Cortex 1996;6(4):551–60.
12. Botez MI, Attig E, Vézina JL. Cerebellar atrophy in epileptic patients. Can J Neurol Sci 1988;15(3):299–303. [CrossRef]
13. Caplan R, Levitt J, Siddarth P, Taylor J, Daley M, Wu KN, et al. Thought disorder and frontotemporal volumes in pediatric epilepsy. Epilepsy Behav 2008;13(4):593–9. [CrossRef]
14. Daley M, Levitt J, Siddarth P, Mormino E, Hojatkashani C, Gurbani S, et al. Frontal and temporal volumes in children with epilepsy. Epilepsy Behav 2007;10(3):470–6. [CrossRef]
15. Canan S, Şahin B, Odacı E, Ünal B, Aslan H, Bilgiç S, et al. Toplam hacim, hacim yoğunluğu ve hacim oranlarının hesaplanmasında kullanılan bir stereolojik yöntem: Cavalieri prensibi. T Klin J Med Sci 2002;22:7–14.
16. Odacı E, Bahadır A, Yıldırım Ş, Şahin B, Canan S, Baş O, et al. Cavalieri Prensibi Kullanılarak Bilgisayarlı Tomografi ve Manyetik Rezonans Görüntüleri Üzerinden Hacim Hesaplanması ve Klinik Kullanımı. T Klin J Med Sci 2005;25(3):421–8.
17. Sahin B, Ergur H. Assessment of the optimum section thickness for the estimation of liver volume using magnetic resonance images: a stereological gold standard study. Eur J Radiol 2006;57(1):96–101. [CrossRef]
18. Caviness VS Jr, Kennedy DN, Richelme C, Rademacher J, Filipek PA. The human brain age 7-11 years: a volumetric analysis based on magnetic resonance images. Cereb Cortex 1996;6(5):726–36. [CrossRef]
19. Caplan R, Levitt J, Siddarth P, Wu KN, Gurbani S, Shields WD, et al. Language and brain volumes in children with epilepsy. Epilepsy Behav 2010;17(3):402–7. [CrossRef]
20. Gogtay N, Giedd JN, Lusk L, Hayashi KM, Greenstein D, Vaituzis AC, et al. Dynamic mapping of human cortical development during childhood through early adulthood. Proc Natl Acad Sci U S A 2004;101(21):8174–9. [CrossRef]
21. Hermann BP, Dabbs K, Becker T, Jones JE, Myers y Gutierrez A, et al. Brain development in children with new onset epilepsy: a prospective controlled cohort investigation. Epilepsia 2010;51(10):2038–46. [CrossRef]
22. Pardoe HR, Cole JH, Blackmon K, Thesen T, Kuzniecky R; Human Epilepsy Project Investigators. Structural brain changes in medically refractory focal epilepsy resemble premature brain aging. Epilepsy Res 2017;133:28–32. [CrossRef]
23. Caplan R, Levitt J, Siddarth P, Wu KN, Gurbani S, Sankar R, et al. Frontal and temporal volumes in Childhood Absence Epilepsy. Epilepsia 2009;50(11):2466–72. [CrossRef]
24. Lenroot RK, Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. Neurosci Biobehav Rev 2006;30(6):718–29. [CrossRef]
25. Giedd JN, Blumenthal J, Jeffries NO, Castellanos FX, Liu H, Zijdenbos A, et al. Brain development during childhood and adolescence: a longitudinal MRI study. Nat Neurosci 1999;2(10):861–3. [CrossRef]
26. Millichap J. Brain Volume Reduction with Intractable Epilepsy. Pediatr Neurol Briefs 2000;14:85–7. [CrossRef]
27. Hagemann G, Lemieux L, Free SL, Krakow K, Everitt AD, Kendall BE, et al. Cerebellar volumes in newly diagnosed and chronic epilepsy. J Neurol 2002;249(12):1651–8. [CrossRef]
28. Courchesne E, Chisum HJ, Townsend J, Cowles A, Covington J, Egaas B, et al. Normal brain development and aging: quantitative analysis at in vivo MR imaging in healthy volunteers. Radiology 2000;216(3):672–82. [CrossRef]
29. Blanton RE, Levitt JG, Peterson JR, Fadale D, Sporty ML, Lee M, et al. Gender differences in the left inferior frontal gyrus in normal children. Neuroimage 2004;22(2):626–36. [CrossRef]