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Comparative Analysis of Epileptogenic Changes Detected on the PET/CT, EEG and MRI Scans and Their Correlation with Post-Surgery Outcomes

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Abstract. We attempted to determine the most common localizations of epileptogenic foci by using common functional (EEG and PET/CT) and structural (MRI) imaging methods. Also, we compared the number of epileptogenic foci detected with all diagnostic methods and determined the success rate of surgery in the operated patients when the epileptogenic foci coincided on all three imaging methods. 35 patients (including children) with clinically proven refractory epilepsy were included into the study. All patients underwent an MRI scan with epilepsy protocol, Fluorodeoxyglucose-18-PET/CT scan, and an EEG prior to a PET study. 14 patients underwent neurosurgery for removal of epileptogenic foci. We found a statistically significant difference between the number of epileptogenic foci which were found in PET/CT and EEG studies but there was no significant difference between MRI and PET/CT lesion numbers. The most common localization of epileptogenic activity on EEG was right temporal lobe (54.3%); the most common lobe with structural changes on MRI was right temporal lobe (42.9%); the most common hypometabolism zone on PET/CT was in right temporal lobe (45.7%). 10 out of 14 patients who underwent surgery demonstrated excellent post-surgical outcomes, with no epileptic seizures one year or more after the operation; 3/14 patients had 1–2 seizures after surgery and one patient had the same count or more epileptic seizures in duration of one year or more. The measure of Agreement Kappa between PET/CT and EEG value was 0.613 ($p < 0.05$). Between PET/CT and MRI the value was 0.035 ($p > 0.05$). Surgical treatment may offer hope for patients with intractable epileptic seizures. PET/CT was an extremely useful imaging method to assist in the localization of epileptogenic zones. The dynamic functional information that brain PET/CT provides is complementary to anatomical imaging of MRI and functional information of EEG.

Key words: epilepsy, MRI, PET-CT, concordance, electroencephalography, surgery outcomes.

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1. Introduction

Epilepsy is a chronic neurological disorder characterized by repeated seizures (>24 h apart), by one seizure with a strong potential for recurrence (at least 60%) or diagnosis of an epilepsy syndrome (Fisher *et al*., 2014). An epileptic seizure can be defined as a sudden, non-volatile, temporary behavioural change involving changes in consciousness, movement, sensation and autonomic nervous system, accompanied by abnormal brain electrical screws. According to World Health Organization report (Epilepsy, 2008), epilepsy is a common neurological disorder affecting about 1.0–2.0% of the population. Similar trends are observed in Lithuania. It affects people of all ages and results in social, behavioural, health and economic consequences to the patients and their families. In trough, the vast majority of the patients with epilepsy are able to live a normal life with adequate medicament treatment. However, a lot of patients using psychotics have serious comorbidities such as psychiatric disorders and mental retardation. Also, some of them have social and working limitations. Epilepsy is responsible for 0.3% of all deaths worldwide according to the Global Burden of Disease Study, by the World Health Organization, the World Bank and the Harvard School of Public Health supported by the Bill and Melinda Gates Foundation (Murray *et al*., 2012).

In case of intractable epilepsy, surgical ablation of epileptogenic foci can result in near-complete elimination of seizures in up to three-quarters of patients. Though some patients do not experience a complete elimination of seizures, surgical ablation often results in a decrease in seizure frequency and intensity. In majority of cases, anti-epileptic drugs can be completely eliminated or the doses can be significantly reduced (Brook, 1990; Engel, 1993; Hemb *et al*., 2010).

Effectiveness and success of the surgical ablation directly depends on accurate localization of the epileptogenic cortex. This is important both to ensure a complete resection of the epileptogenic focus and to reduce the resection volume as much as possible, limiting any potential neurocognitive deficits. Consequently, all patients mostly undergo an intensive and extensive preoperative evaluation and ideally it could be a combination with anatomical and functional imaging methods (Treves *et al*., 2016).

Electroencephalography (EEG) is considered the most important tool for evaluating a patient with epilepsy. Determined as abnormal, it may contribute to the seizure classification, either focal or generalized and it also may characterize the epilepsy syndrome presented by the patient. This possibility allows a prognostic view in most cases in relation to seizure control and also may lead to better treatment choices (Maganti and Rutecki, 2013).

Computer tomography (CT) scans can be useful only in emergent conditions: focal lesions mostly are detected in only 30% of patients (Bronen *et al*., 1996). That's why we didn't include CT results into our study.

The use of magnetic resonance imaging (MRI) in the investigation of focal epilepsies requires special protocols based on the anatomical region of onset in clinical and EEG findings. So, the first reason to use MRI investigation should be to find or qualify the etiology of epilepsy, and the second – to allow precise presurgical evaluation to optimize surgery and outcomes (Cendes, 2013).

Positron emission tomography (PET) is a new way to study the functional anatomy of the brain. PET-CT with 2-[18F]fluoro-2-deoxy-D-glucose (18FDG) as a tracer recently is used for drug-refractory partial epilepsy evaluation, especially when antiepileptic surgery is being considered. The epileptic focus appears hypometabolic interictally (Kuhl *et al*., 1980; Theodore *et al*., 1983). The cause of hypometabolism is not well understood. Possible mechanism may include neuronal loss as part of the epileptogenic lesion or secondary to seizures; deafferentation or decreased synaptic activity and functional changes reflecting postictal depression of metabolic activity (Theodore *et al*., 2001).

The PET examination should be interpreted in conjunction with high-resolution anatomical MRI imaging. The spatial resolution of PET is lower than that of MRI, increasing the susceptibility of PET partial volume effect. This may result in an apparent increase in the size and reduction in degree of hypometabolic zone (Salamon *et al*., 2008).

FDG PET may add useful information when no structural abnormality is seen during the initial MRI examination; when there is a discordance in electroclinical and neuroimaging findings; when there is a suspicion of multiple foci or in the evaluation of a patient with temporal lobe epilepsy, bitemporally.

We compared results from standard diagnostic studies with the FDG PET/CT scan results to see whether FDG PET/CT provided comparable, conflicting or additional information.

In our study we tried to determine and compare the most common localizations of epileptogenic foci by using both functional (EEG and PET/CT) and structural (MRI) imaging methods and show the correlation between all studies. The second aim was to determine the success rate of surgery when epileptogenic foci coincided using all three imaging methods separately or in combination.

We used extensive statistical methods to compare these imaging methods. Most of the statistical data was analysed using the IBM SPSS 23.0 software. Assessment of normality was carried out with the *Kolmogorov–Smirnov* test. In statistics, the *Kolmogorov–Smirnov* test (K–S test or KS test) is a nonparametric test of the equality of continuous, one-dimensional probability distributions that can be used to compare a sample with a reference probability distribution (one-sample K–S test), or to compare two samples (two-sample K–S test). It is named after Andrey Kolmogorov and Nikolai Smirnov.

We also used *Shapiro–Wilk* test which is a test for normality designed to detect all deviations from normality. It is comparable in power to the other two tests. The test rejects the hypothesis of normality when the p-value is less than or equal to 0.05. Failing the normality test allows you to state with 95% confidence that the data does not fit the normal distribution. Passing the normality test only allows you to state that no significant deviation from normality was found.

The *Wilcoxon Signal Criteria* were used to compare the three dependent samples which did not match the normal distribution. The *Wilcoxon Signed-Rank* test is a nonparametric statistical hypothesis test used to compare two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ (i.e. it is a paired difference test). It can be used as an alternative to the paired *Student's* t-test, t-test for matched pairs, or the t-test for dependent samples when

Table 1
Descriptive statistics.

	Number of patients	Range	Min	Max	Mean error	Standard deviation	Standard	Variance
Patient age	35	61	2	63	28.31	2.550	15.088	227.634

the population cannot be assumed to be normally distributed. A *Wilcoxon Signed-Rank* test is a nonparametric test that can be used to determine whether two dependent samples were selected from populations having the same distribution.

Concordance was evaluated by using *Cohen's Kappa* (κ), a statistic method which measures inter-rater agreement for qualitative (categorical) items. It is generally thought to be a more robust measure than simple percent agreement calculation, as κ takes into account the possibility of the agreement occurring by chance. There is a controversy surrounding *Cohen's Kappa* due to the difficulty in interpreting indices of agreement. Some researchers have suggested that it is conceptually simpler to evaluate a disagreement between items.

2. Methodology

2.1. *Patient Characteristics*

Cases comprised 35 patients with clinically proven refractory epilepsy. Gender of the patients was distributed almost equally: 17 men and 18 women patients. There were 27 adult patients and 8 children included in the study. Mean age of all patients was approximately 28.31 (Table 1). The youngest patient was two years old and the oldest 63 years old. We had 32 cases with structural epilepsy which means that patients had distinct structural brain abnormality. Three patients had epilepsy of an unknown etiology. 14 out of 35 underwent surgery.

2.2. *Imaging Methods*

All patients had been admitted for a comprehensive assessment including EEG monitoring, MRI scan with epilepsy protocol and a Fluorodeoxyglucose-18-PET/CT scan. 1.5T MRI (*Siemens Magnetom Avanto*) scan following epilepsy protocol was used and scans were evaluated (blind method) by two independent radiologists with more than 15 years of clinical experience; Fluorodeoxyglucose-18-PET/CT scan (*GE HealthCare Discovery VCT*) following EANM procedure guidelines for PET-CT brain imaging was analysed by experienced radiologists; an EEG at least one hour prior to a PET-CT study and minimum 60 min in duration was evaluated by an experienced clinical neurologist specializing in epilepsy studies. The MRI was performed not earlier than six months before the PET-CT scan to reject errors in occurrence of new structural lesions. 14 patients underwent neurosurgical operation with removal of epileptogenic foci zone. The surgery was rejected for other patients due to the lack of data for exact foci localization.

2.3. *Statistical Data*

Statistical data was analysed using the SPSS 23.0 program. Assessment of normality was carried out with the *Kolmogorov–Smirnov* and *Shapiro–Wilk* tests. The *Wilcoxon Signal Criteria* were used to compare the three dependent samples which did not match the normal distribution. The concordance was evaluated by using κ.

2.4. *Variables, Data Types and Coding*

2.4.1. *Quantitative Variables*

- Amount of epilepsy activity zones on EEG.
- Amount of structural changes on MRI which may result in epilepsy seizures.
- Amount of hypometabolism zones on PET/CT.

2.4.2. *Qualitative Variables*

- Localization of epileptic focus (none is encoded by 0, localization on the right frontal lobe is encoded by 1, localization on the left frontal lobe is encoded by 2, localization on the right parietal lobe is encoded by 3, localization on the left parietal lobe is encoded by 4, localization on the right temporal lobe is encoded by 5, localization on the left temporal lobe is encoded by 6, localization on the right occipital lobe is encoded by 7, localization on the left occipital lobe is encoded by 8.
- Post-surgical outcomes (no epileptic seizures after operation are encoded by T, 1–2 epileptic seizures after operation are encoded by V, 3 or more epileptic seizures after operation is encoded by N).

2.4.3. *Scanning Protocols Used in Imaging*

- **T2W/FLAIR (axial plane).** T2-FLAIR stands for T2-Weighted-Fluid-Attenuated Inversion Recovery.
- **T1W (sagittal plane).** T1 weighted image (also referred to as T1WI or the "spin-lattice" relaxation time) is one of the basic pulse sequences in MRI and demonstrates differences in the T1 relaxation times of tissues. A T1WI relies upon the longitudinal relaxation of a tissue's net magnetization vector (NMV).
- **DW, ADC (axial plane).** Diffusion-weighted magnetic resonance imaging (DWI or DW-MRI) is based on the use of specific MRI sequences as well as software that generates images from the resulting data that uses the diffusion of water molecules to generate contrast in MR images. Apparent diffusion coefficient (ADC) is a measure of the magnitude of diffusion (of water molecules) within tissue, and is commonly clinically calculated using MRI with diffusion weighted imaging (DWI).
- **T2W/GRE (axial plane).** The sequence of a multi-echo gradient recalled echo (GRE) T2-weighted imaging (T2 WI) is a relatively new magnetic resonance imaging (MRI) technique. In contrast to T2 relaxation, which acquires a spin echo signal, T2 relaxation acquires a gradient echo signal.
- **T2W (coronal plane).** T2 weighted image (T2WI) is one of the basic pulse sequences in MRI. The sequence weighting highlights differences in the T2 relaxation time of tissues.

- **T1W with contrast matter** (if radiologist decides to do scan with intravenous contrast).
- **T1W/mpr/iso/p2** (multiplannar reformatting).
- **T2W thin scanning slices** (when hippocampus pathology is suspected).
- **T2W/FLAIR** (perpendicular to long axis of hippocampus lobe).

2.4.4. *Basic PET-CT (FDG) Protocol (Patient Pre-Arrival).*
Patient should fast for at least 4 hours before the procedure, because glucose might interfere with radiopharmaceuticals. Blood glucose levels should be checked prior to FDG administration. When hyperglycemia is present (>160 mg/dl), there is an increased competition between elevated plasma glucose and FDG. Before the scanning procedure, patients should void the bladder. Patients should be positioned comfortably in a quiet, dimly lit room several minutes before FDG administration and during the uptake phase of FDG (at least 20 min). Room with bright and/or blinking lights might induce seizures. In order to ensure that FDG is not administered in a postictal situation continuous EEG recording is required 1–2 h before the procedure. Typical adult dose was ∼370 MBq in 2-D scanning mode and ∼150 MBq in 3-D mode. Typical children dose was ∼26 MBq in 2-D scanning mode and ∼14 MBq in 3-D mode.

2.4.5. *Seizure Outcome Evaluation*
Seizure outcome was evaluated at a 1–2 year post-operative interval by criteria presented below:

1) No epileptic seizures after operation;
2) 1–2 epileptic seizures after operation;
3) 3 or more epileptic seizures after operation.

3. Results

3.1. *Localizations by Using Various Detection Methods*

The most common localization for epileptogenic activity on EEG was right temporal lobe with 54.3%. The second most common localization was left temporal lobe, followed by right frontal and left frontal lobes. An example of seizure specific changes is shown in Figs. 1 and 2. The most common lobe with structural changes on MRI was right temporal lobe with 42.9%. The second one was the left temporal lobe. In Figs. 3–6 we can see the structural changes which might be associated with epileptic seizures. The most common hypometabolism zone on PET/CT again was in the right temporal lobe with 45.7%, followed by left temporal lobe. PET changes representing possible epileptogenic zone are shown in Fig. 7.

All average ranks of the three diagnostic methods were evaluated. MRI lesion amount mean rank was 1.66, EEG lesion was 2.50 and PET lesion was 1.84. Friedman Test statistics show the statistical significance (Chi-Square = 21.00), degrees of freedom $df = 2$, and p value <0,05. The conclusion would be that there is a statistically significant difference in lesion amount between the different diagnostic methods (Tables 2–4).

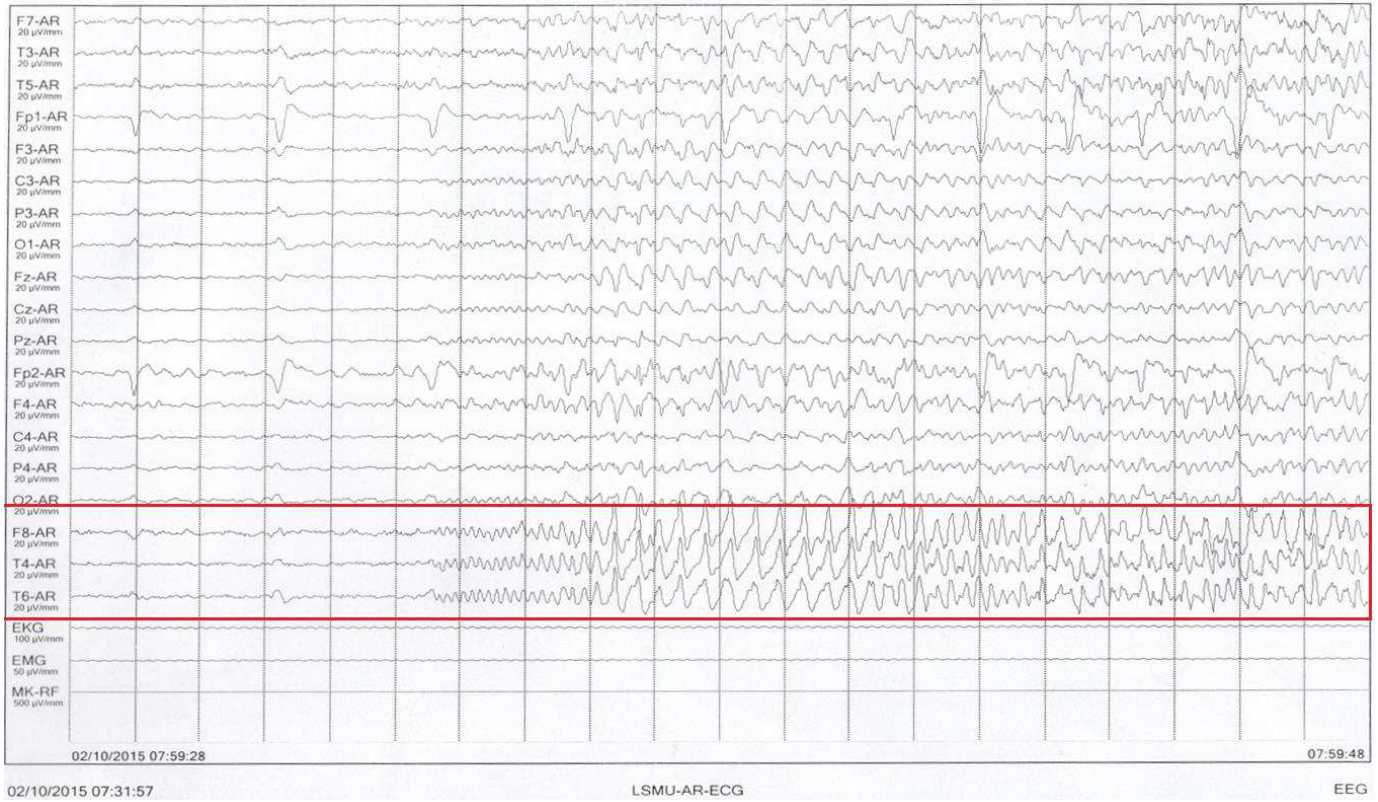

Fig. 1. On the F8-AR, T4-AR and T6-AR derivations we can see seizure specific changes which are characteristic of focal epilepsy. They represent changes in right temporal lobe mostly.
Image courtesy: Lithuanian University of Health Sciences Clinical Hospital (Basevičius *et al.*, 2012).

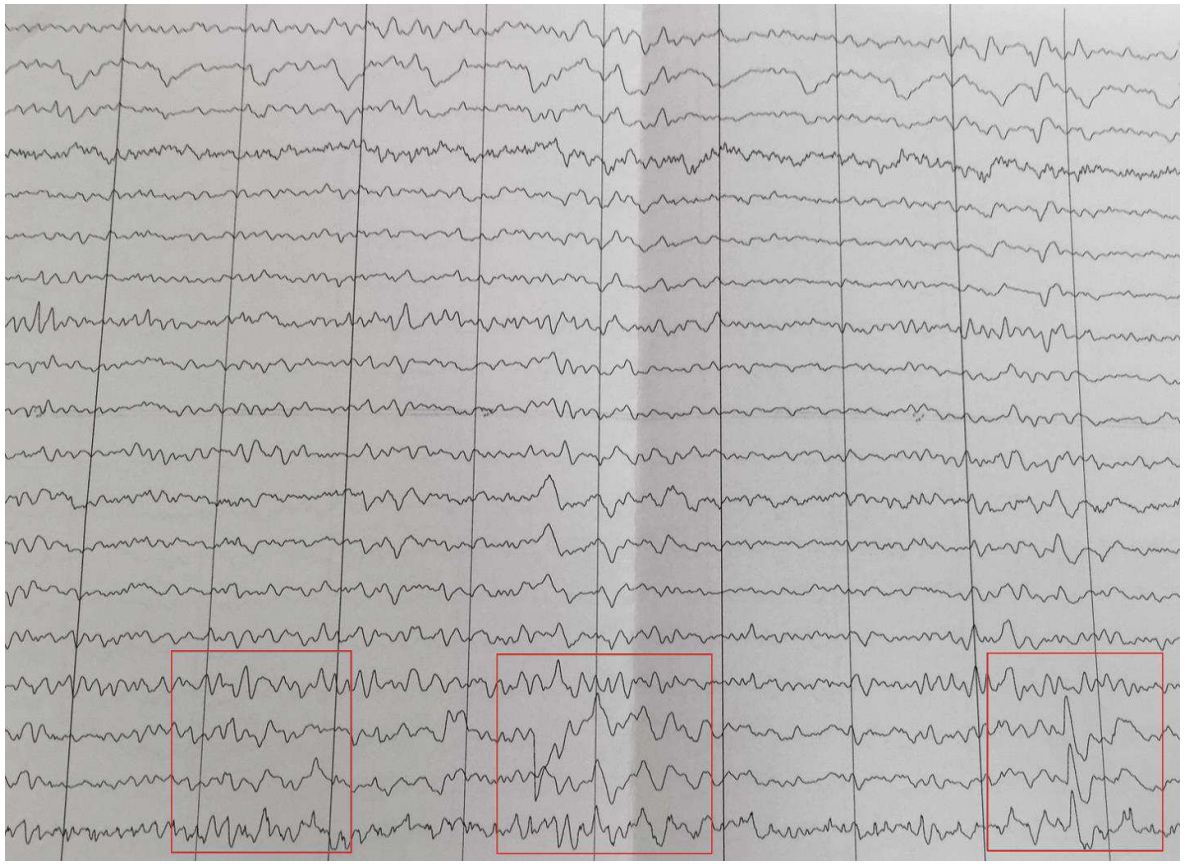

Fig. 2. Localized epilepsy activity was registered on right fronto-temporal regions in the background changes of bioelectrical activity. Generalized alterations are not detected. *Image courtesy: Lithuanian University of Health Sciences Clinical Hospital* (Basevičius *et al*., 2012).

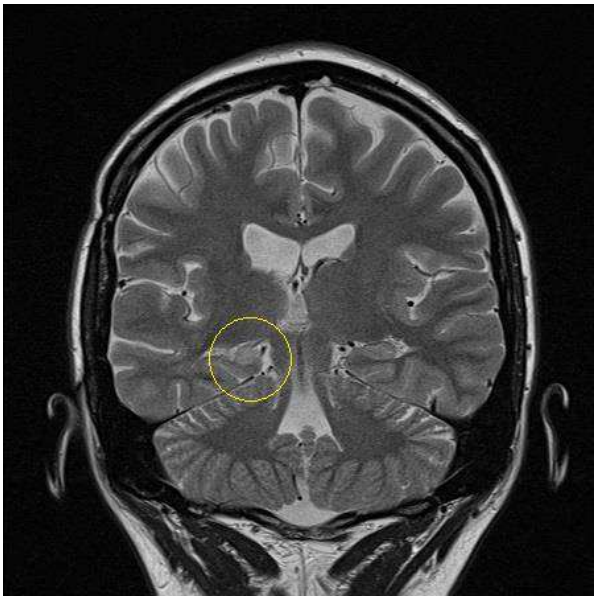

Fig. 3. MRI T2 sequence. Coronal plane. Right hippocampal sclerosis.
Image courtesy: Lithuanian University of Health Sciences Clinical Hospital (Basevičius *et al*., 2012).

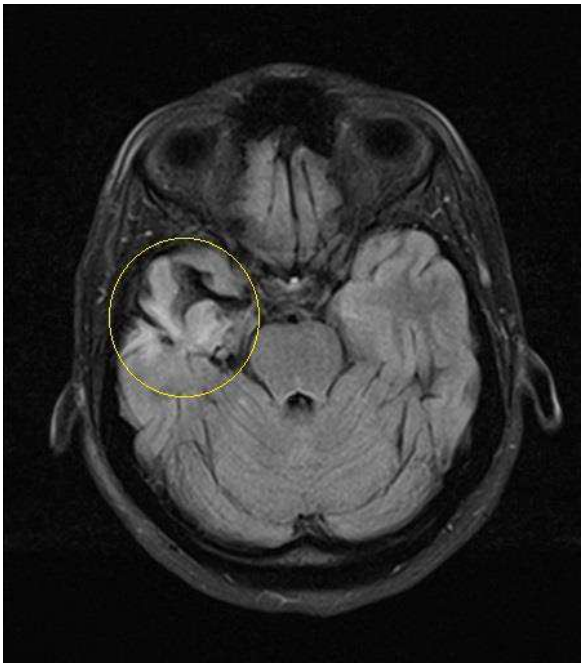

Fig. 4. MRI flair sequence. Axial view. Right temporal lobe atrophy. Gliosis.
Image courtesy: Lithuanian University of Health Sciences Clinical Hospital (Basevičius *et al*., 2012).

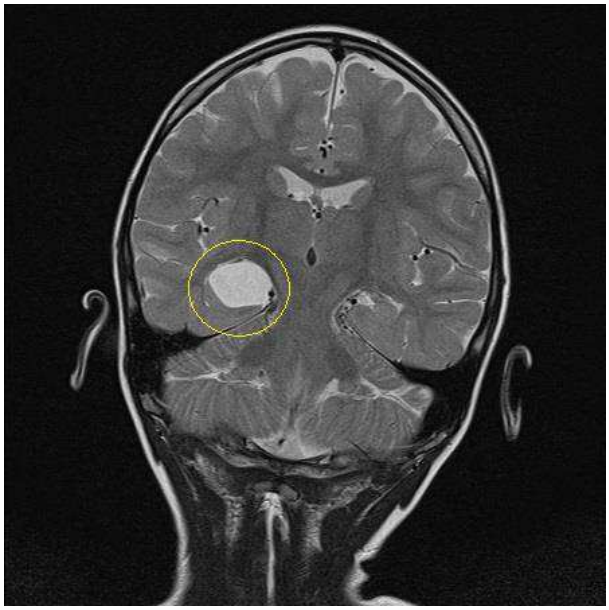

Fig. 5. MRI T2 sequence. Coronal plane. Large cyst in the right temporal area. Might be an epileptogenic source.
Image courtesy: Lithuanian University of Health Sciences Clinical Hospital (Basevičius *et al*., 2012).

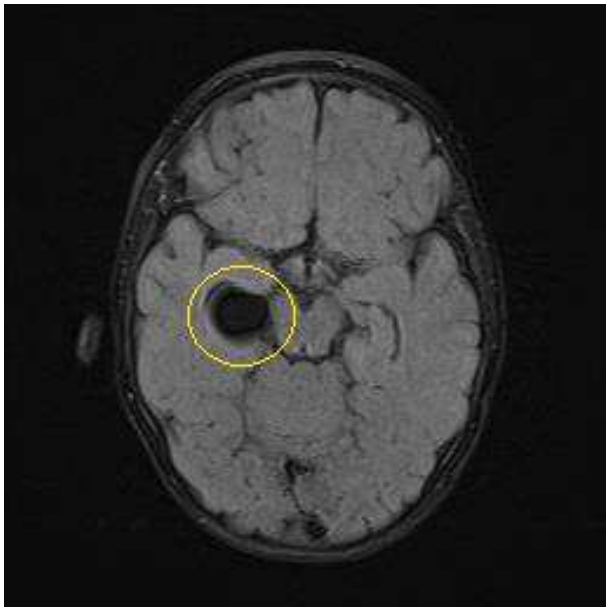

Fig. 6. MRI T1 sequence. Axial view. Same cyst in right temporal part.
Image courtesy: Lithuanian University of Health Sciences Clinical Hospital (Basevičius *et al*., 2012).

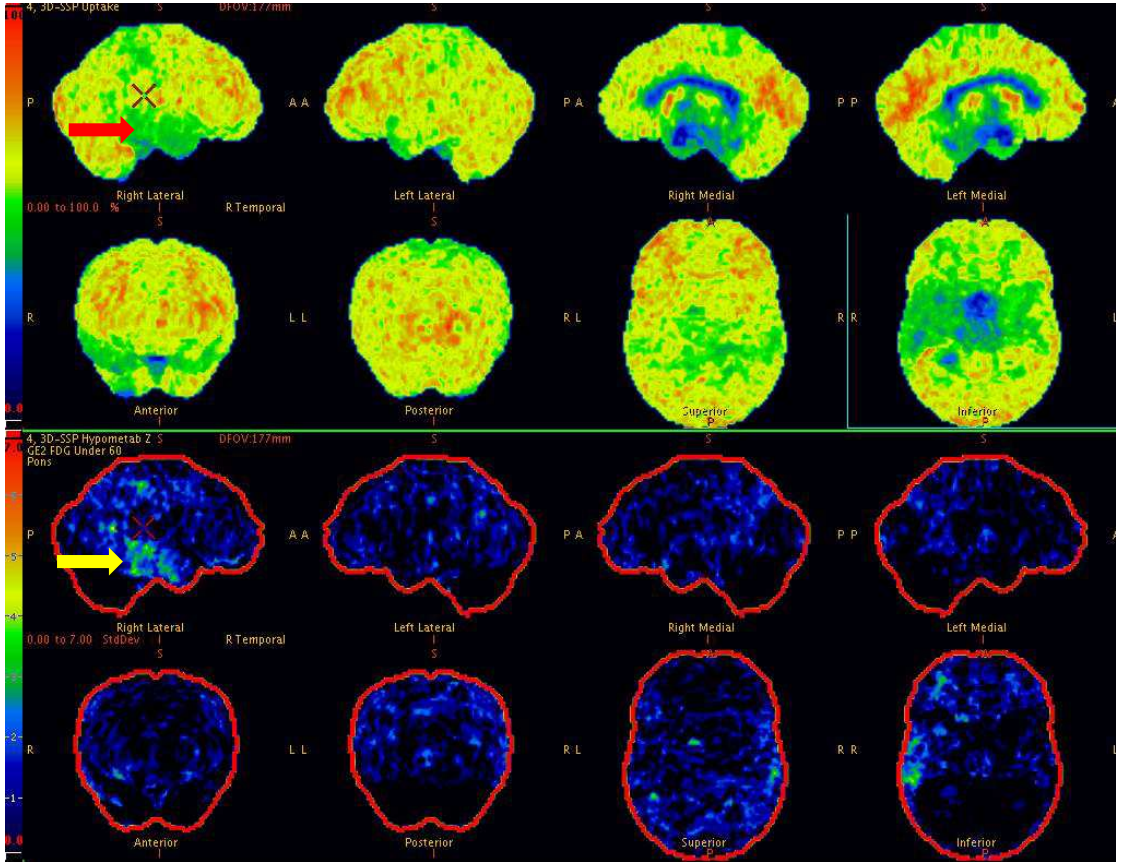

Fig. 7. PET images. Wide hypometabolism zone in right temporal lobe which might have correlation with structural changes found on MRI (marked with arrows). *Image courtesy: Lithuanian University of Health Sciences Clinical Hospital* (Basevičius *et al*., 2012).

Table 2
Descriptives.

	Statistic	Std. Error		
mri_lesion_amount	Mean		0.94	0.072
	95% Confidence	Lower Bound	0.79	
	Interval for Mean	Upper Bound	1.09	
eeg_lesion_amount	Mean		1.76	0.127
	95% Confidence	Lower Bound	1.51	
	Interval for Mean	Upper Bound	2.02	
3pt] pet_lesion_amount	Mean		1.32	0.222
	95% Confidence	Lower Bound	0.87	
	Interval for Mean	Upper Bound	1.78	

Table 3
Ranks.

		N	Mean rank	Sum of ranks
eeg_lesion_amount vs. mri_lesion_amount	Negative Ranks	3	13.50	40.50
	Positive Ranks	22	12.93	284.50
	Ties	10		
	Total	35		
mri_lesion_amount vs. pet_lesion_amount	Negative Ranks	8	8.25	66.00
	Positive Ranks	5	5.00	25.00
	Ties	21		
	Total	34		
pet_lesion_amount vs. eeg_lesion_amount	Negative Ranks	18	11.33	204.00
	Positive Ranks	4	12.25	49.00
	Ties	12		
	Total	34		

Table 4
Test statistics.

	eeg_lesion_amount vs. mri_lesion_amount	mri_lesion_amount vs. pet_lesion_amount	pet_lesion_amount vs. eeg_lesion_amount
Z	−3.443	−1.460	−2.665
Asymp. sig. (2-tailed)	0.001	0.144	0.008

3.2. *Wilcoxon Signed Ranks Test Results*

3.2.1. *Correlation of EEG Violations with MRI Abnormalities*

There were 3 cases when numbers of epileptogenic foci found on EEG were lower than the ones established on MRI. The sum of the rankings was 40.50; the average rank was 13.50. Similar information was provided in 22 cases where the number of epileptogenic foci detected by the EEG method was higher than the ones established on MRI. Table 4 shows the Z-value (-3.443) and the p value (Asymp. sig. (2-tailed) $= 0.001$). Since $p < 0.05$, there was a statistically significant difference between the number of epileptogenic focal points detected on EEG and MRI.

Table 5
Surgery Outcomes.

	Frequency	Percent	Valid percent
Positive	10	71.4	71.4
Moderate	3	21.4	21.4
Negative	1	7.1	7.1
Total	14	100.0	100.0

Table 6
Case processing summary.

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
PET localization vs. EEG localization	35	100.0%	0	0.0%	35	100.0%

3.2.2. *MRI Correlation with PET/CT Lesions*
There were 8 cases where number of epileptogenic foci detected on MRI was lower than those found on PET/CT. These tests correspond to rank = 66.00; average rank = 8.25. In 5 cases, epileptogenic foci number detected on MRI was higher than that identified on PET/CT. Z-value was -1.460, $p = 0.144$. Since $p > 0.05$, there was no statistically significant difference between the number of epileptogenic foci detected on MRI and PET/CT.

3.2.3. *PET/CT Correlation with EEG Lesions*
In 18 cases the number of epileptogenic foci detected on PET/CT was lower than that on EEG. Corresponding ranking was 204.00; the average rank was 11.33. In 4 cases, the number of epileptogenic foci detected on MRI was higher than that established on PET/CT. Z-value was -2.665, $p = 0.008$. As $p < 0.05$, there was a statistically significant difference between epileptogenic foci found on PET/CT and EEG.

3.2.4. *Surgery Outcomes*
14 patients were operated. 10 out of 14 patients (71.4%) had excellent postsurgical outcomes, with no epileptic seizures in one or more years post operation duration. Three patients out of 14 (21.4%) had 1–2 seizures after surgery in 1–2 years post operation and only one patient (7.1%) had the same amount or more epileptic seizures than before (Table 5).

Kappa agreement between PET/CT and EEG value is 0.613 which shows moderate level of agreement. Asymptotic Standardized Error is 0.093; Approximate T is 6.130; Approximate Significance <0.05 (Tables 6–8).

Kappa agreement between PET/CT and MRI value is 0.035, which shows that there was no level of agreement. Asymptotic Standardized Error is 0.031; Approximate T is 1.594; Approximate Significance >0.05 (Tables 9–11).

Table 7
Crosstabulation between PET_localization and EEG_localization.

		eeg_localization				Total
		right_frontal	left_frontal	right_temporal	left_temporal	
pet_localization	not found	1	1	2	3	7
	right_frontal	2	0	0	0	2
	left_frontal	1	0	0	0	1
	right_temporal	0	0	16	0	16
	left_temporal	0	0	1	8	9
Total		4	1	19	11	35

Table 8
Symmetric measures.

	Value	Asymptotic Standardized Error	Approximate T	Approximate Significance
Measure of agreement Kappa	**0.613**	0.093	6.130	<0.005
Number of valid cases	35			

Table 9
Case processing summary.

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
PET localization vs. MRI_localization	35	100.0%	0	0.0%	35	100.0%

Table 10
Crosstabulation between PET_localization and MRI_localization.

		mri_localization					Total
		Not found	Right_frontal	Left_frontal	Right_temporal	Left_temporal	
pet_localization	not found	2	1	1	2	1	7
	right_frontal	0	2	0	0	0	2
	left_frontal	0	0	0	1	0	1
	right_temporal	2	0	14	0	0	16
	left_temporal	0	0	0	9	0	9
Total		4	3	15	12	1	35

4. Discussion

Epilepsy is characterized as a brain disorder manifesting by small, moderate or general seizure/es which lead to neurologic, cognitive, psychosocial consequences. Mainly epilepsy can be effectively adjusted by pharmacological approach. In case of drug-resistant epilepsy when seizures persist despite adequate mono or poli-medication the patient must adapt to this worse clinical situation or to try to choose between the continuous consume of antiepileptic medication or the treatment of epilepsy by surgery. Among the criteria for surgery could be the increasing or existing high risk of neurological dis-

Table 11
Symmetric measures.

	Value	Asymptotic Standardized Error	Approximate *T*	Approximate Significance
Kappa agreement value	0.035	0.031	1.594	0.111
Number of valid cases	35			

orders or low chance of liberation from seizures. This article focuses on the structural etiology of epilepsy for the following reasons.

The diagnosis of epilepsy commonly includes a complete neurological and radiological examinations: extracranial or intracranial electroencephalogram (EEG), specific blood tests, MRI, MR spectroscopy, single photon emission computed tomography (SPECT), and PET studies. Interestingly, SPECT imaging started to be widely used in the detection of epileptic foci. Meta-analytic sensitivities of SPECT in patients with temporal lobe epilepsy were reported as 44% (interictal), 75% (postictal) and 97% (ictal) (Devous *et al*., 1998). PET, particularly PET/CT provides better quality and higher resolution images as compared to SPECT and at the same time allows quantitative measurements. In study performed by Won *et al.*, interictal PET and ictal SPECT correctly lateralized the epilepsy lesion in 85%, and 73% of patients, respectively (Won *et al*., 1999). Our study had some limitations, since the diagnosis of epilepsy with modern radiological research methods like PET/CT began relatively recently and scanning protocols are still being optimized. On the other hand, there are not much data, because mentioned studies are very expensive and mostly performed at big University hospitals or scientific centres, which results in low patient samples and lower accuracy of results. PET/CT studies require well experienced staff as well as on-site equipment. However, PET/CT is an extremely useful imaging method to assist in the localization of epileptogenic zones.

The International League Against Epilepsy (ILAE) suggests that everyone with epilepsy should have, in the ideal situation, a high quality MRI (Basevičius *et al*., 2012). However, MRI for epilepsy diagnosis is highly accessible to most of the population in developed economies, whereas not available or available only in big cities in most developing countries (Basevičius *et al*., 2012). Modern MRI techniques, such as MR spectroscopy, MR volumetry, MR perfusion, and functional MR imaging require high-performance MRI scanners and experienced staff.

FDG brain PET/CT is a well-established imaging technique, whose imaging protocol is described in detail in Society of Nuclear Medicine (SNM) and European Association of Nuclear Medicine (EANM) guidelines (Society of Nuclear Medicine, 2008; Varrone *et al*., 2009). It may allow resection of the epileptogenic focus without intracranial EEG guidance before the operation. Some of the studies have demonstrated that FDG-PET is highly sensitive for presurgical localization of epileptogenic foci in patients with medical refractory epilepsy who have noncontributory EEG or MRI. For example, in children with frontal lobe epilepsy, the sensitivity and specificity of FDG-PET were 92% and 62.5%, respectively (da Silva *et al*., 1997). Functional information that brain PET/CT provides complementary to anatomical imaging of MRI and functional information of

EEG are very important techniques in the process of sorting out patients to whom surgery may be needed. FDG-PET images co-registered to MR images or obtained on an integrated PET/MR scanner provide better structural and functional information (Maganti and Rutecki, 2013). We found that epileptogenic foci detected on PET/CT and EEG had quite high correlation, but correlation on MRI and PET/CT was much lower. According to the study of Gok B. *et al.*, PET was able to lateralize the seizure focus in 95% of MRI positive, 69% of MRI equivocal and 84% of MRI negative patients (Gok *et al*., 2013). Our data show no statistically significant difference between epileptogenic foci detected on MRI and PET/CT studies. That might indicate that not all structural lesions possibly are epileptogenic. There were some cases when epileptogenic changes were not found on neither MRI nor PET/CT evaluation. However, these cases were enough rare.

De Cocker *et al*. reported that in medication refractory epilepsy the most common location of the epileptogenic lesion is temporal lobe (60%), frontal lobe (20%) and parietal lobe (10%), periventricular (5%) and occipital (5%) (Epilepsy, 2008). Our data is based on comparison if all three diagnostic methods show that the most common localization of epileptogenic foci is temporal lobe which might be associated with the fact that hippocampus is often involved in seizures, even if they are not generated there. Whether hippocampal sclerosis is a cause or the effect of seizures is a subject of ongoing debate. Localizing epileptogenic focus by FDG-PET especially in presurgical period provides an important information about the functional status of the brain – assesses the functional deficit or abnormal functioning zone. This could be associated with poor outcome after surgery. Thereby, we agree with studies demonstrating that FDG-PET can predict epilepsy surgical outcomes. Preoperative hypometabolism observed in the resected temporal lobe was associated with significantly better postoperative seizure control (Radtke *et al*., 1993; Theodore *et al*., 1992; Manno *et al*., 1994).

Surgical treatment may offer hope for patients with intractable epileptic seizures, but it can cause permanent neurological deficits. The success rate depends on the accuracy of eliptogenic locus detection and the type of surgery. It is well-known fact that children who underwent temporal resection usually get better outcomes than children who have an extra-temporal resection. Commonly, 70% children after surgery will stop having seizures. For adults, it's approximately 60%. In our study positive outcomes also reached 70%. The advantages of this treatment must be weighed against the risk of worsening the patient's neurological condition; therefore, it is extremely important to determine the precise location of the epileptogenic lesion. Surgery of the structural abnormalities can only be advised when there is also a functional confirmation made with PET and provided that the EEG indicates that the lesion is indeed epileptogenic.

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