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ORIGINAL ARTICLE

Electroencephalographic features associated with intermittent rhythmic delta activity

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Summary
Objective. — To investigate the clinical importance of intermittent rhythmic delta activity (IRDA) in terms of accompanying electrophysiological findings on EEG and their association with IRDA.
Methods. — We retrospectively assessed all EEG studies recorded in our institution from 2011 to 2017. Patients with intermittent rhythmic delta activity (IRDA) in EEGs were included. Clinical data were collected from charts of the patients with IRDA.
Results. — We identified 69 EEGs with IRDA in 58 patients from a total of 18,625 EEG recordings. The most common IRDA type was frontal IRDA (FIRDA; 55%), followed by temporal IRDA (TIRDA; 28.9%). Unilateral (UL) distribution was present in 36.8% of FIRDAs and 95% of TIRDAs. The frequency of focal epileptiform discharges (FED) was 78.5% in UL FIRDA group and 89.4% in UL TIRDA group. Among the EEGs with FEDs, in UL FIRDA group 90.9% and in UL TIRDA group 70.5% of the FEDs were ipsilateral. Concordance of focal structural brain lesions and FEDs with UL TIRDA was 30.7%, and with UL FIRDA was 50%. UL FIRDA had a 71.4% positive predictive value for ipsilateral focal epileptic focus and UL TIRDA had 63.1%. The frequency of focal structural lesions and FEDs were significantly higher in the UL FIRDA group than bilateral FIRDA group ($P = 0.03$; $P = 0.01$). Among the patients with focal structural lesions, ipsilateral FED association is significantly higher in the UL FIRDA group than BL FIRDA group ($P = 0.03$).

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Conclusions. — UL FIRDA is more likely to indicate a focal lesion and a focal epileptic focus compared to bilateral FIRDA, and it had similar characteristics to UL TIRDA. It can be considered that UL FIRDA has as good a lateralizing value for ipsilateral focal epileptic focus and focal lesion as UL TIRDA.

Introduction

Intermittent rhythmic delta activity (IRDA) is a characteristic electroencephalographic (EEG) pattern characterized by bursts of rhythmic and monomorphic slow waves [3]. IRDA is named according to the location of the main cortical area involved on EEG: frontal (FIRDA), temporal (TIRDA), and occipital (OIRDA). Each of these patterns is considered to be associated with different clinical pathologies. FIRDA is thought to be associated with physiologic, metabolic, degenerative and neoplastic causes rather than epilepsy [2,7,17]. TIRDA is recorded mostly in the anterior temporal areas [14]; it has been suggested that TIRDA is associated with ipsilateral mesial temporal lobe epilepsy and that it is highly indicative of ipsilateral pathology [5]. Since OIRDA is typically almost always seen in children, it was initially taken to be an occipital equivalent of FIRDA due to age-related inadequate maturation, and was assumed to be due to the same pathophysiological process [3]. However, it was later suggested that OIRDA was associated with epilepsy [10,11,15,20]. Its high correlation with epilepsy makes OIRDA more similar to TIRDA than it is to FIRDA [11].

In this study, we aimed to present more evidence for the clinical importance of IRDA in terms of the frequency of accompanying electrophysiological findings on EEG and their association with IRDA.

Methods

We examined the routine, sleep and video-monitoring EEG reports of inpatients and outpatients who were admitted to Cerrahpasa Medical Faculty EEG Laboratory of Istanbul University between January 2011 and December 2017, retrospectively. All recordings were digitally recorded using bipolar longitudinal/referential montage, using 21 electrodes according to the international 10—20 system. First, EEG reports with ''delta activity'' were selected from the archives and then the EEG traces of these reports were reevaluated by two neurophysiologists who were blind to the previous reports. From these reevaluations, patients with polymorphic delta activity were excluded and patients with intermittent rhythmic delta activity (IRDA) were included in the study.

We described IRDA as transient intermittent rhythmic slow waves at a frequency of 1 to 4 Hz with an amplitude of 50—100 microvolt. We noted the epileptiform activities such as spike, sharp, sharp and wave on EEG associated with IRDA. We grouped epileptiform activities into 2 categories:

- focal epileptiform discharges (FED);
- generalized epileptiform discharges (GED).

Demographic, clinical, laboratory data including age, gender, consciousness level, hepatic and renal function, comorbid conditions, presence of seizure and cranial imaging radiological reports were recorded from the files of patients with IRDA. Types of seizures were classified according to the guidelines recommended by the ILAE [8].

A control group was gathered for comparison, composed of EEG recordings performed just before and after each EEG recording with IRDA in the study group. The control group and study group were matched for age and location of EEG abnormalities. Clinical data and radiological findings were examined from the files of the patients in the control group. Categorical values were compared with Chi^2 test for statistical analysis.

Results

Out of the 18,625 EEG recordings performed between 2011 and 2017, we detected 83 EEG recordings with IRDA in 69 patients within an age range of 8—79 years. In order to have a homogenous group, patients under 18 years were then excluded. A total of 69 EEG recordings of 58 patients were included in the study. They were grouped as FIRDA, OIRDA, TIRDA and, if located on all electrodes in single or both hemispheres, as generalized IRDA (GIRDA) according to their locations on EEG. The mean age of the patients was 34.9 (18—79) years. Twenty-four of the patients were male and 34 were female (Table 1).

The patients were classified according to diagnosis, MRI findings and epilepsy type. Evaluated with respect to the diagnosis, 58 patients were grouped into three sections: (1) patients with epilepsy, $n = 50$; (2) patients with metabolic events, $n = 3$; patients with paroxysmal events other than epilepsy such as syncope, $n = 5$. Evaluated with respect to brain images, 19 of the 58 patients had no structural lesions. Structural lesions were grouped into three categories: (1) hemispheric localized focal lesions, (2) multifocal lesions and (3) lesions not directly related to epilepsy. In 24 patients, there were hemispheric focal lesions such as mesial temporal sclerosis (MTS), focal cortical dysplasia. Bilateral multifocal structural lesions, such as stroke, encephalitis or perinatal asphyxia, were observed on brain imaging in 5 patients. In 5 patients' images, lesions were not directly related to epilepsy (e.g., brain atrophy, Arnold Chiari malformation). Data for 5 patients' brain images were not available. Patients with epilepsy were further classified

Table 1 Demographic and clinical data of studied individuals and comparison between control group and patients with intermittent rhythmic discharge activity (IRDA).

	Patients with IRDA($n=58$)	Control group($n=138$)	P
Age mean ± SD (years)	34.9 ± 14.6	37.5 ± 17.1	NS
Sex: male/female, number (%)	24 (41.3)/34 (58.6)	78 (56.5)/60 (43.4)	NS
Epilepsy, number (%)	50 (86.2)	97 (70.2)	0.01
Focal structural lesions, number (%)			
Within all IRDA patients	24 (41.3)	41 (29.7)	NS
Within UL FIRDA patients	7 (58.3)	41 (29.7)	0.04
Within UL TIRDA patients	9 (69.2)	41 (29.7)	0.00

UL: unilateral; FIRDA: frontal intermittent rhythmic discharge activity; TIRDA: temporal intermittent rhythmic discharge activity; NS: not specific.

as having generalized onset (GO; 4 patients) and focal onset (FO; 46 patients) seizures.

The distribution of IRDA among 18,625 EEG recordings was as follows: 0.2% FIRDA, 0.1% TIRDA, 0.01% OIRDA and 0.04% GIRDA. Among the 69 EEG recordings with IRDA, the most common type was FIRDA (55%), followed by TIRDA (28.9%), OIRDA (4.3%) and GIRDA (11.5%) (Fig. 1). The IRDA subtypes were divided into unilateral (UL) and bilateral (BL), which will be mentioned in the subheadings. Fig. 2 Fig. 2 illustrates bilateral and unilateral FIRDA examples. Persistent IRDA presence was observed on EEGs recorded at different times in 7 patients, the most common of which were seen in the TIRDA group. FEDs accompanied IRDA in 43 EEG recordings (62.3%): in 20 (52.6%) recordings with FIRDA, in 17 (85%) recordings with TIRDA, in 6 (75%) recordings with GIRDA and none with OIRDA.

Amongst the comparison group of 138 patients without IRDA, there were 41 patients with focal structural lesions and 44 patients with focal epileptiform discharges. In the control group, 97 patients with epilepsy were referred for an EEG and 41 patients with suspected seizures were referred for an EEG to rule out any paroxysmal activity. When EEGs with IRDA and the control group were compared, the frequency of epilepsy and FEDs were significantly higher in patients with IRDA (respectively $P=0.01$ and $P=0.00$) (Table 1, Table 2).

FIRDA group

We found FIRDA on 38 EEG recordings in 35 patients. Two patients had persistent FIRDA on consecutive EEGs. The mean age of the patients was 38.3 (18—79) years. Thirty patients (85.7%) had epilepsy; 3 of them had GO and 27 had FO seizures. Three patients were diagnosed with metabolic imbalance such as renal insufficiency. Two patients underwent EEG in order to investigate etiology of syncope (Table 3). Twelve patients had focal lesions and four patients had multifocal structural lesions. In 3 patients' images, lesions not directly related to epilepsy were presented. Brain images of 14 patients were normal, and we did not have sufficient data on two patients' images (Table 4). Epileptiform activities were observed in 22 EEGs (57.8%), 20 (90.9%) were focal (FED) and 2 (9%) were generalized (GED). There were 24 bilateral (BL; 63.1%) and 14 unilateral (UL; 36.8%) FIRDAs on EEGs (Table 3).

Bilateral FIRDA group

One patient had persistent FIRDA on two different EEGs. Among 23 patients with BL FIRDA, 16 patients had FO seizures and 3 patients had GO seizures. Four patients did not have epilepsy. The frequency of FEDs in recordings was 23.6% (9 recordings). The frequency of focal structural lesions on MRI was 14.2% (5 patients). Three patients in this group had both FED and focal lesions and they were concordant in their location (8.5%).

Unilateral FIRDA group

Among the twelve patients, one patient had persistent FIRDA on three different EEGs, resulting in a total of 14 recordings. Eleven of these 12 patients presenting with UL FIRDA had FO epilepsy. The frequency of FEDs in EEG recordings was 78.5% (11 recordings). All but one of the FEDs (90.9%) was on the same side as the FIRDA and located in frontal or frontotemporal electrodes. The frequency of focal lesions was 58.3% (7 patients) in this group. UL FIRDA and focal lesions presented on the same side in 6 patients (50%). The locations of FED and focal lesions were concordant with UL FIRDA in 6 patients (50%) (Table 5). The positive predictive value for ipsilateral focal epileptic focus of the UL FIRDA was 71.4% and the sensitivity was 52.6% (Table 5). When compared to the control group, in patients with UL FIRDA the frequency of focal structural lesions and focal epileptiform discharges were significantly higher (respectively, $P=0.04$ and $P=0.01$) (Table 1, Table 2).

Comparison of bilateral to unilateral FIRDA

The frequency of focal structural lesions in the UL FIRDA group was significantly higher when compared to the BL FIRDA group ($P=0.03$). The frequency of FED was significantly higher in the UL FIRDA group than the BL FIRDA group ($P=0.01$). Among the patients with focal lesions, ipsilateral FED association was significantly higher in the UL FIRDA group than the BL FIRDA group ($P=0.03$).

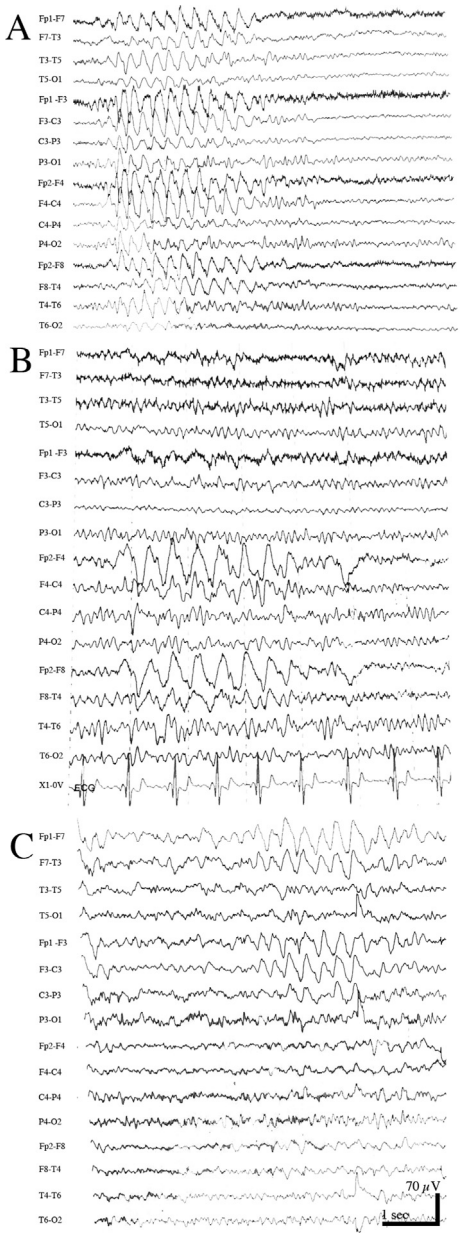

Figure 1 The distribution of IRDA among 69 EEG recordings with IRDA. FIRDA: frontal intermittent rhythmic discharge activity; TIRDA: temporal intermittent rhythmic discharge activity; GIRDA: generalized intermittent rhythmic discharge activity; OIRDA: occipital intermittent rhythmic discharge activity.

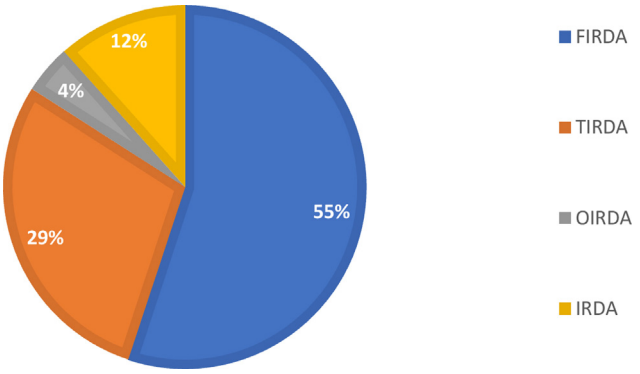

Figure 2 Examples of bilateral (A) and unilateral (B, C) FIRDA. High frequency filter: = 70 Hz, low frequency filter = 0.5 Hz.

TIRDA group

We detected TIRDA on 20 EEG recordings in 14 patients. Four patients had persistent TIRDA on consecutive EEG recordings. The mean age of the patients was 29.7 (18—37) years. Thirteen patients had epilepsy with FO seizures. Clinical data was not available in one patient (Table 3). Consequently, all patients had cranial MR images except one; three were normal, nine had focal structural lesions, and one had a lesion not related to epilepsy (Table 4). There was one (5%) EEG recording with BL TIRDA and 19 (95%) EEGs with UL TIRDA (Table 3).

Bilateral TIRDA group

Clinical data of the one patient with BL TIRDA was not available. The patient had no epileptiform discharges on the EEG recording.

Unilateral TIRDA group

Four patients had persistent TIRDA on consecutive EEG recordings. There were 13 patients presenting UL TIRDA with a total of 19 EEG recordings, all with FO seizures. The frequency of FEDs in EEGs was 89.4% (17 recordings). Among the EEGs with TIRDA and FED, TIRDA and FED were concordant in 12 EEG recordings (70.5%) of 9 patients, but not in 2 patients' recordings (contralateral to TIRDA) (Table 5). In the remaining two patients, persistent UL TIRDA changed sides in different EEG recordings. The frequency of focal

Table 2 Comparison of focal epileptiform discharges between control group and EEGs with intermittent rhythmic discharge activity (IRDA), UL FIRDA and UL TIRDA.

	EEGs with IRDA(n = 69)	EEGs of control group(n = 138)	P
EEG recordings with focal epileptiform discharges, number (%)			
Within all IRDA recordings	43 (62.3)	44 (31.8)	0.00
Within UL FIRDA recordings	20 (52.6)	44 (31.8)	0.01
Within UL TIRDA recordings	17 (85)	44 (31.8)	0.00

Frequency of focal epileptiform discharges were significantly higher in EEGs with IRDA. UL: unilateral; FIRDA: frontal intermittent rhythmic discharge activity; TIRDA: temporal intermittent rhythmic discharge activity.

Table 3 Distribution of IRDA types according to location on EEG, diagnosis, presence of ED in EEG.

IRDA type	Location	Number of patients	Number of EEGs	Diagnosis (patient No/EEG No)	Additional EEG findings (EEG No)
FIRDA	Total	35	38		
	BL	23	24	Any paroxysmal event (4/4)	No ED (4)
				GO (3/3)	GED (2) No ED (1)
				FO (16/17)	FED (9) No ED (8)
	UL	12	14	Any paroxysmal event (1/1)	No ED (1)
				FO (11/13)	FED (11) No ED (2)
TIRDA	Total	14	20		
	BL	1	1	Any paroxysmal event (1)	No ED (1)
	UL	13	19	FO (13/19)	FED (17) No ED (2)
OIRDA	Total	3	3		
	BL	3	3	FO (1/1)	No ED (1)
				Any paroxysmal event (2/2)	No ED (1)
GIRDA	Total	6	8		
	BL	4	6	FO (3/5) GO (1/1)	FED (5) GED (1)
	UL	2	2	FO (2/2)	FED (1) No ED (1)
Total		58	69		

BL: bilateral, UL: unilateral, ED: epileptiform discharge, FED: focal epileptiform discharge, GED: generalized epileptiform discharge, FO: focal onset seizure, GO: generalized onset seizure.

Table 4 Lesion type and distribution according to IRDA presentation with accompanying FED.

		Focal lesion	Multifocal lesion	Lesion not epilepsy related	Data not available	Normal	Total
FIRDA	BL FIRDA + FED	4	1	0	2	1	8
	UL FIRDA + FED	6	0	0	0	3	9
	Total FIRDA	12	4	3	2	14	35
TIRDA	BL TIRDA + FED	0	0	0	0	0	0
	UL TIRDA + FED	8	0	1	0	2	11
	Total TIRDA	9	0	1	1	3	14
OIRDA	BL OIRDA + FED	0	0	0	0	0	0
	Total OIRDA	0	0	1	2	0	3
GIRDA	BL GIRDA + FED	2	1	0	0	0	3
	UL GIRDA + FED	0	0	0	0	1	1
	Total GIRDA	3	1	0	0	2	6

BL: bilateral, UL: unilateral, FED: focal epileptiform discharge. The total number specified in the row is the total number of all IRDAs with and without accompanying FED.

structural lesions was 69.2% (9 patients). TIRDA and focal lesions were present on the same side in 7 patients (53.8%). TIRDA, focal lesions and FED were all present on the same side in 4 patients (30.7%) (Table 5). The positive predictive value for ipsilateral focal epileptic focus of the UL TIRDA was 63.1% and the sensitivity was 100% (Table 5). When compared to control group, in UL TIRDA group the frequency of focal structural lesions and focal epileptiform discharges were significantly increased (respectively, $P = 0.00$ and $P = 0.00$) (Table 1, Table 2).

Comparison of bilateral and unilateral TIRDA

Nine of 13 patients (69.2%) with UL TIRDA had a focal lesion, 11 of 13 patients (81.2%) with UL TIRDA had FEDs. The patient with BL TIRDA had no FED.

Comparison of unilateral TIRDA and unilateral FIRDA

There was no statistically significant difference between UL TIRDA and UL FIRDA groups in terms of positive predictive value for ipsilateral epileptic focus (respectively, 63.1% vs. 71.4%; $P > 0.05$), focal lesion frequency (respectively, 69.2% vs. 58.3%, $P > 0.05$), ipsilateral focal lesion (respectively, 53.8% vs. 50%, $P > 0.05$), frequency of FEDs (respectively, 89.4% vs. 78.5%, $P > 0.05$) and concordance of focal lesion, UL TIRDA/FIRDA and FEDs (respectively 30% vs. 50%; $P > 0.05$) (Table 5).

OIRDA group

There were 3 EEG recordings in 3 patients with OIRDA and all OIRDAs were bilateral (Table 3). The mean age of the

Table 5 Comparison of unilateral TIRDA and unilateral FIRDA.

	Patients with UL FIRDA($n=12$)	Patients with UL TIRDA($n=13$)	P
Focal structural lesions, number (%)	7 (58.3)	9 (69.2)	NS
Ipsilateral focal structural lesions, number (%)	6 (50)	7 (53.8)	NS
Ipsilateral focal lesion and ipsilateral FEDs, number (%)	6 (50)	4 (30.7)	NS
	EEGs with UL FIRDA($n=14$)	EEGs with UL TIRDA($n=19$)	
FEDs, number (%)	11 (78.5)	17 (89.4)	NS
Ipsilateral FEDs among EEGs with FEDs, number (%)	10 (90.9)	12 (70.5)	NS
Positive predictive value for ipsilateral epileptic focus	71.4%	63.1%	NS

There is no statistical difference according to presence of ipsilateral focal structural lesion, presence of ipsilateral FEDs, and concordance of UL TIRDA/FIRDA, ipsilateral FED and focal lesion. UL: unilateral, TIRDA: temporal intermittent rhythmic delta activity, FIRDA: frontal intermittent rhythmic delta activity, FED: focal epileptic discharges; NS: not specific.

patients was 34.3 (28—40) years. One patient with OIRDA had focal onset epilepsy. Clinical data was not available in two patients. The patients had no epileptiform discharges on EEG recordings (Table 3) and two patients had no focal structural lesions on MRIs. Only one patient had a lesion not related to epilepsy (empty sella) (Table 4).

Generalized IRDA (GIRDA) group

GIRDA was detected in a total of 8 recordings in six patients. Two patients had persistent IRDA each in two different EEG recordings. The average age was 28.8 (19—41) years. All patients had epileptic seizures (1 GO, 5 FO). The patient with GO had GED in the EEG recording and the frequency of FEDs was 75% (6 recordings) (Table 3). The frequency of structural lesions was 66.6% (4 patients): 3 patients had focal, 1 patient had multifocal structural lesions (Table 4). Two patients had UL GIRDA and 4 patients had BL GIRDA.

Bilateral GIRDA

Four patients had BL GIRDA, all of whom had epilepsy (3 patients with FO, 1 with GO). The frequency of FED was 75% (3 patients) and GED was 25%. The 3 patients with FO seizures had focal structural lesions on MRI and FEDs on EEGs. In these three patients, the structural lesions and GIRDA were presented on the same side (75%).

Unilateral GIRDA

There were two patients with unilateral GIRDA, and both had FO seizures. One had a structural lesion on the MRI. The lesion and GIRDA were concordant and no FED were present. The other patient had FED on the same side as GIRDA.

Discussion

Rhythmic delta activities are not frequent features of awaked adult EEG recordings, and rhythmic delta activities are generally regarded as nonspecific pathological activities. Their significance regarding etiology has been discussed in the literature, but their relation to accompanying epileptiform activities has not been adequately examined. Thus, we investigated the significance of IRDA and associated epileptiform discharges. In this retrospective data, the most frequent rhythmic activities were FIRDA and TIRDA. OIRDA was observed in 0.01% of the whole sample. This is low, as expected, since only adult patients were studied: according to the literature, OIRDA is a pathologic activity mostly observed in an age-dependent fashion in childhood. For this reason, we performed statistical analysis only for FIRDA and TIRDA.

In our patient population, FIRDA was detected mostly in patients with epilepsy, and unilateral FIRDAs were concordant with ipsilateral foci on EEG (71.4%). However, it was previously reported that FIRDA is mostly non-epileptic, being associated with epileptic activity in less than 2% of patients [12]. It has also been reported that FIRDA has been observed with concomitant changes in consciousness and is associated with focal structural lesions in the absence of encephalopathic changes [6]. In 2002, Watemberg et al. [19] suggested that FIRDA was most commonly caused by diffuse brain injury; however, brain tumours were another, less frequent cause of FIRDA in this study. Most recently, in patients with altered mental status, the association of FIRDA and prior structural brain damage was shown [18]. A prospective study [1] found that encephalopathy and structural brain lesions were independently associated with FIRDA. We did not find as many metabolic causes in our patients as the previous literature suggests; this may be because this study was retrospective, and we were dependent on the patients referred to our laboratory. However, the control group comparison showed a higher frequency of epilepsy in patients with IRDA compared to patients without IRDA, and thus we ruled out patient referral bias.

In our study, FED and FIRDA concordance in UL FIRDA was 90.9%, while in BL FIRDA it was only 15%. We found that the frequency of focal lesions and the frequency of FEDs were significantly higher in the patients with UL FIRDA compared to those with BL FIRDA. Also, in patients with UL FIRDA, focal structural lesions were significantly more concordant with ipsilateral FEDs than BL FIRDA. FIRDA can be associated with physiologic, metabolic, degenerative or neoplastic causes such as posterior fossa tumours, subcortical lesions, cerebral edema, metabolic encephalopathy due to liver failure or uremia, basilar artery migraine,

Parkinson-plus syndromes, Creutzfeldt-Jacob disease and Lewy body dementia [7,17]. For this reason, association between FIRDA and epilepsy is thought to be low. However, the relationship between lateralization of FIRDA and epilepsy was not significant in previous studies and a small number of previous studies reported a correlation between a structural lesion and lateralized FIRDA [1,6]. In a prospective study, Accola et al. [1] found that 8 out of 9 patients with lateralized FIRDA had underlying focal brain lesions, but only 11 of the 26 patients with symmetric FIRDA patients had brain lesions; they reported an epileptic discharge co-occurrence of 5% for FIRDA in adults. Our data was similar and both Accola's findings and our findings showed that the presence of unilateral FIRDA is more likely to indicate a focal lesion and a focal epileptic focus compared to bilateral FIRDA.

Previous studies concluded that the FIRDA pattern was not epileptiform in nature because of its co-occurrence with various cerebral conditions [19]. FIRDA and epileptiform discharge co-occurrence in children and adolescents was found to be higher than in the adult population [4]. Desai et al. [4] found 18 of 20 children and adolescents with FIRDA had seizures and only 2 had no epileptiform discharges associated with it. In our study population, there were additional EEG pathologies in 54.2% of EEGs with FIRDA, and 85.7% of the patients had epileptic seizures. Our data suggests that the association of FIRDA with seizure and epileptiform discharges is similar in adults compared to these previous data in children.

We found that UL TIRDA and UL FIRDA had similar features when compared to each other. There was no statistically significant difference between the two groups for positive predictive value for ipsilateral epileptic focus, focal lesion frequency, ipsilateral focal lesion, FEDs and concordance of focal lesion, UL TIRDA/FIRDA and FEDs. It was previously suggested that TIRDA has a good lateralizing value for ipsilateral mesial temporal lobe epilepsy [2,5]. We observed that unilateral FIRDA is also a good lateralizing sign for focal epileptiform discharges and focal structural lesions. So, UL FIRDA could eventually be considered as an interictal epileptogenic pattern with the same epileptogenic importance as the spike or sharp wave discharges. This finding should be further evaluated particularly in patients who had epilepsy surgery and become seizure free.

Normand et al. [13] found concomitant FED in 23 of 27 patients with TIRDA (85%) and showed that TIRDA is a significant EEG abnormality for epileptic seizures, especially for complex partial seizures. We found that 95% of EEGs with TIRDA were unilateral and 89.4% of them were accompanied by additional FEDs, but only 70.5% were ipsilateral. This rate was higher in UL FIRDA group, the concordance of FED and ipsilateral UL FIRDA was 90.9%, and persistent UL FIRDA remained with the same lateralization. However, in some patients both TIRDA and FED were contralaterally located to the focal structural lesion. In particular, we observed that persistent UL TIRDA on consecutive EEGs of the same patients could change sides. It was previously reported that when seen bilaterally and independently, TIRDA can change sides and is often associated with anterior temporal interictal ED. Asymmetric TIRDA is considered to have good diagnostic specificity and a high positive predictive value for mesial temporal lobe epilepsy [14]. In support of this, volumetric MRI studies showed mesial temporal atrophy and an association of FED and TIRDA in EEG [9]. In our study, the relation between focal brain lesions and TIRDA was similar to the previous data. We suggest that FIRDA is at least as valuable an interictal discharge as TIRDA due to similar rate of UL TIRDA and UL FIRDA co-occurrence with focal structural lesions and FEDs as mentioned above. In addition, the UL TIRDA switches sides but UL FIRDA is more persistent.

In our study, the OIRDA rate was less frequent (4.3%) than FIRDA and TIRDA. OIRDA is almost always seen in children. The average age of our OIRDA patients was 34.3 years. Although less common, OIRDA can be seen in this adolescent group. OIRDA has been suggested to be associated with primary generalized syndromes such as childhood absence epilepsy [2,15] and localization-related epilepsy [11,20]. We found OIRDA in 1 patient with FO seizures and all patients had BL OIRDA. The number of patients was so low that we could not make any further comments.

We found 11.5% synchronous symmetrical generalized IRDA and this ratio is consistent with the previous literature [12]. Rodriguez et al. [16] suggested that generalized IRDA was not associated with seizures despite additional findings. In our study, four of the five patients with FO seizures and IRDA had FEDs. These data suggest that IRDA may be associated with focal onset seizures, but more evidence is required.

A main limitation of this study is its retrospective method. However, we believe that our data from a large database of 18,625 EEGs over a 6-year period are valuable.

Conclusion

The association of lateralized TIRDA with ipsilateral epilepsy was reported in previous studies, but the relation with lateralized epilepsy for unilateral FIRDA has not to date been emphasized in detail. In our study, we showed that the presence of unilateral FIRDA has a high positive predictive value for ipsilateral focal epileptic focus such as unilateral TIRDA. However, bilateral FIRDA presence does not exclude a focal focus. UL FIRDA might potentially be an interictal epileptogenic pattern with the same epileptogenic importance as spike or sharp wave discharges, but further evidence is needed.

Disclosure of interest

The authors declare that they have no competing interest.

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