

Tesis doctoral

# FRONTAL LOBE EPILEPSY AND EEG: NEUROPHYSIOLOGICAL APPROACH

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M.J.T.B.

M.J.T.B.

M.J.T.B.

Patient who started having seizures at 6 years old. Infectious pathologic antecedent with residual lesions on MRI. She had daily seizures of some seconds of duration (around 5 seconds). Clinically during the seizure she had mild impaired consciousness, with oral motor automatisms and dysphasia, with variation of EKG and breathing frequency.

EEG characteristics:

She shows interictal sharp waves, sometimes followed by an irregular slow wave, and also presents isolated slow waves of 50-100  $\mu$ V with right predominance. The focal activity appears with variable diffusion, sometimes very widespread but other, when less active, more located in right front-central region. Seizure recorded with global attenuation, followed by a synchronized rhythm at around 30 Hz with immediate diffusion, of very brief duration.

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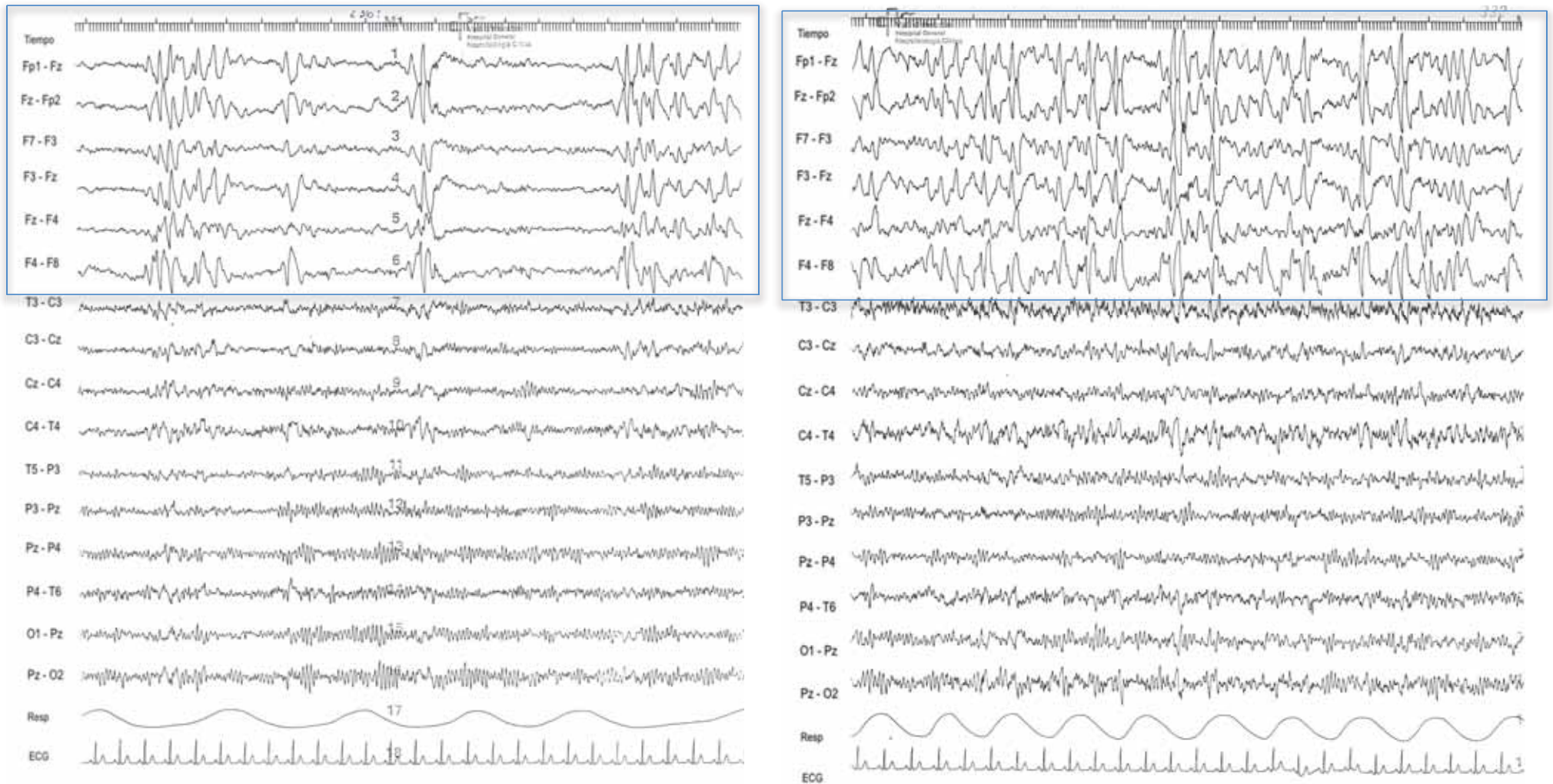


Fig. 1.1, 1.2 Transversal montage. Spikes and sharp waves with right predominance, but still quite widespread and more active in 1.2. Maximal expression of the IED in F4, Fz. Alfa rhythm in both posterior regions indicating awake, eyes closed state.



M.J.T.B.

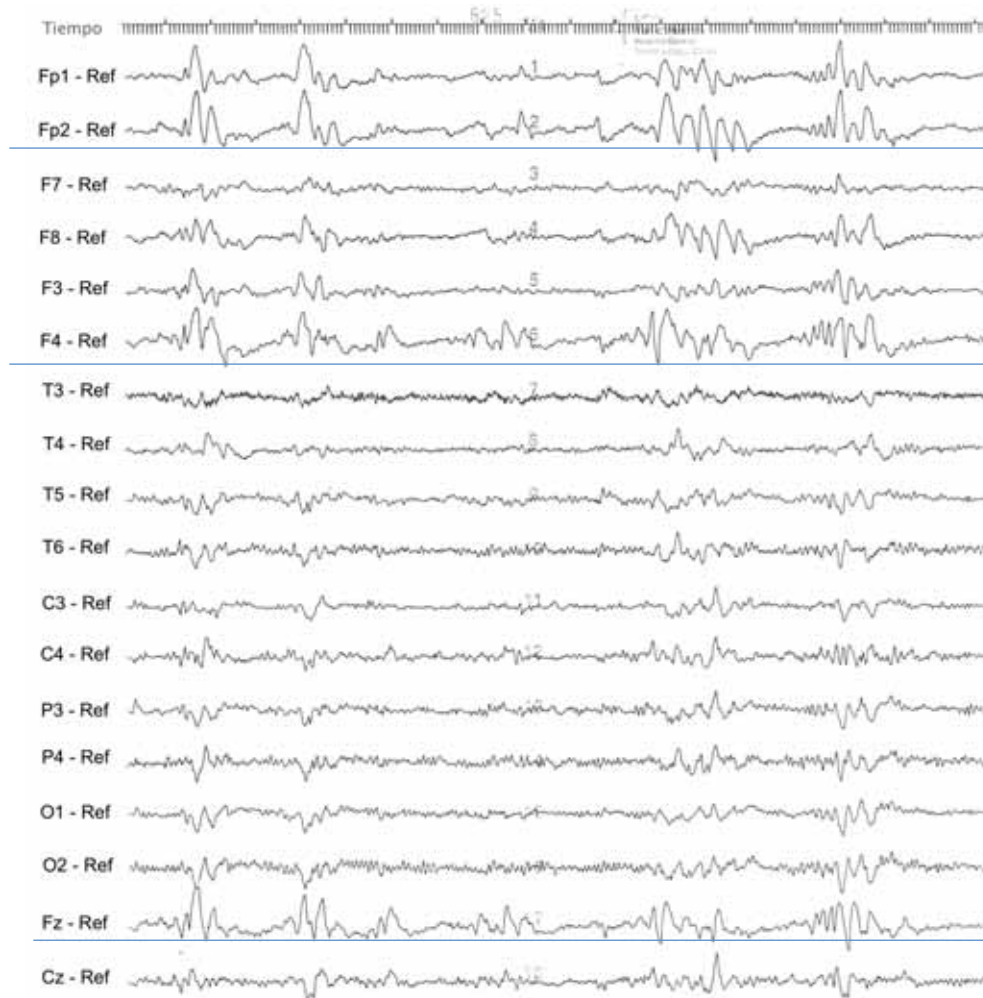


Fig. 2 Referential montage. Less active interictal activity. The less activation and the referential montage help in locating the IED in right frontal regions, with maximal expression in front-central region, F4.

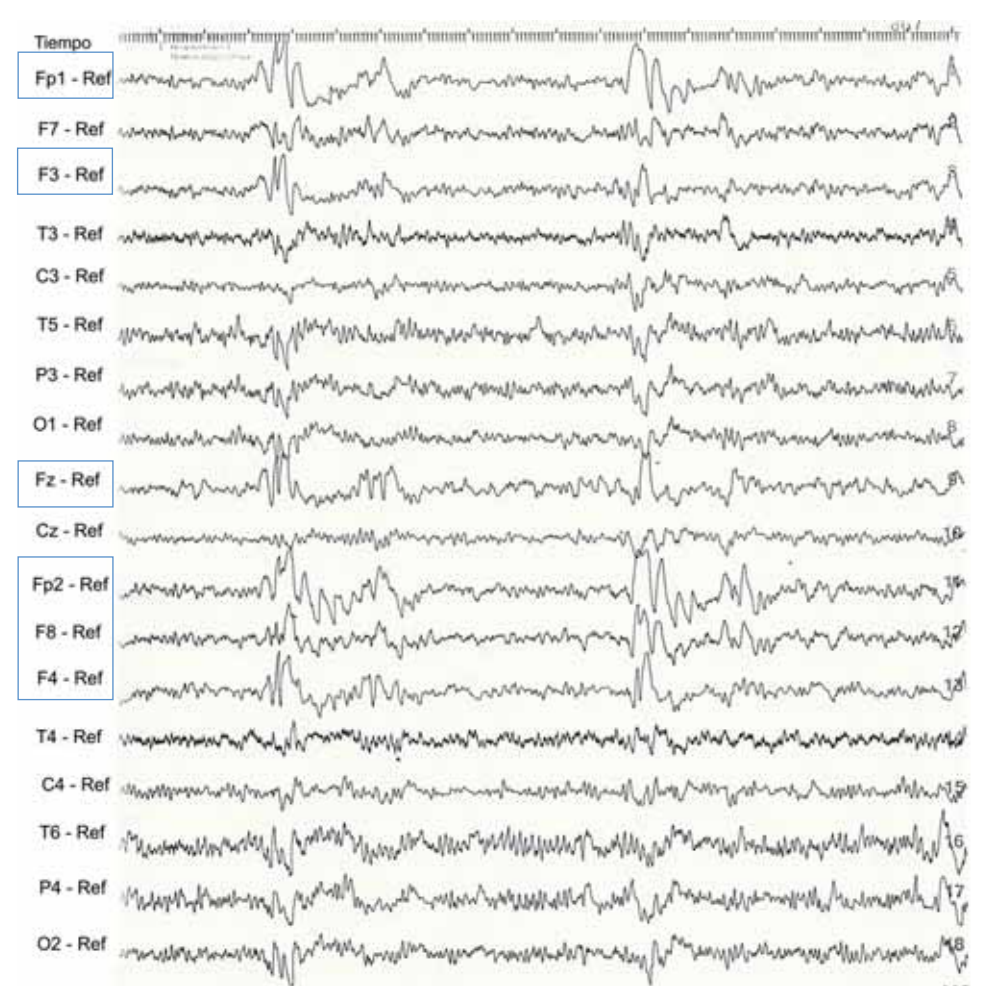


Fig. 3 Referential montage by hemispheres. Sharp waves of 100-200  $\mu$ V with maximal expression in F4, and diffusion to Fp2, Fz, Fp1, F3 and F8.

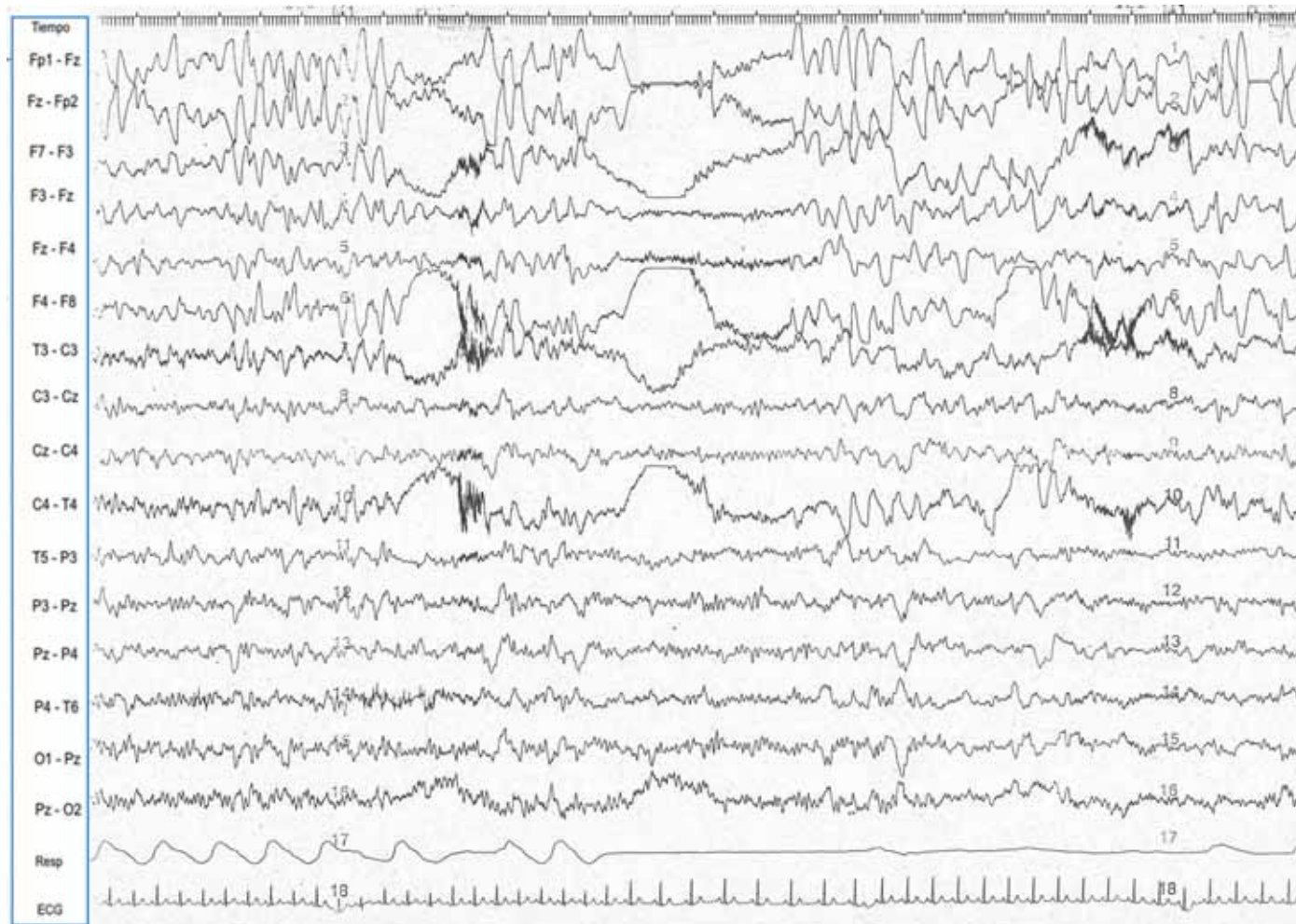


Fig. 4 Seizure in a bipolar transversal montage, with attenuation and low amplitude synchronized rhythm in frontal regions, with maximal expression in front-central regions, F4, Fz, F3 with bradycardia and apnoea during the seizure.

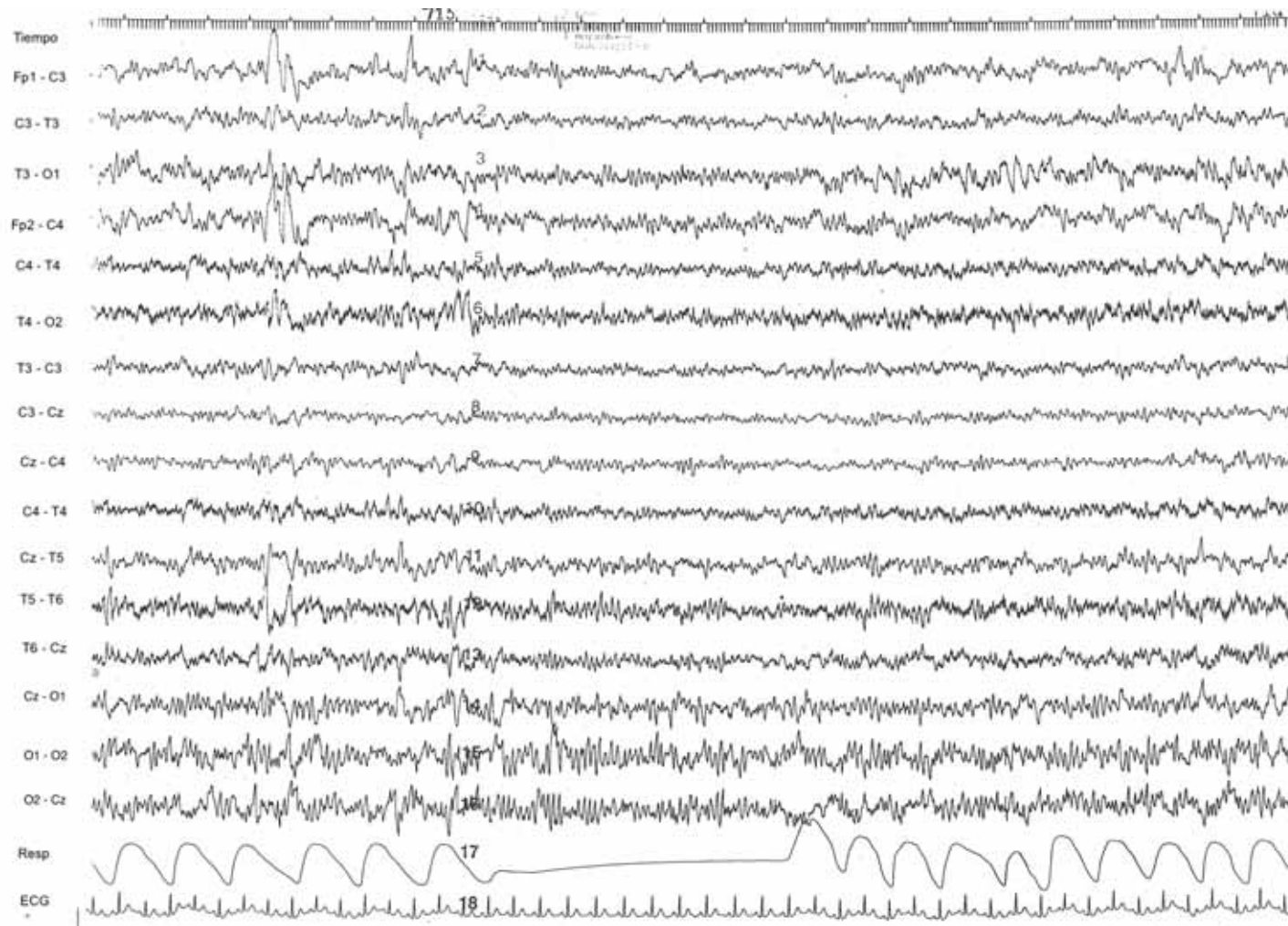


Fig. 5 Seizure recorded without any movement, with back of the irregular slow waves and the IED. Apnoea reflected in the polygraphy helps in locating the ictal activity, with clinical motor automatisms.

M.H.

M.H.



M.H.

Patient with a tumoral antecedent who started having seizures at 46 years old. MRI showed post-surgery changes of the left frontal region with tumoral recidivant lession. During the seizures he presents aphasia at onset and after a variable period of time, impaired consciousness. In some of the seizures he also presented head and eyes deviation toward the right depending on the intensity of the ictal activity.

EEG characteristics:

Left inferior frontal region shows irregular alpha and theta waves at 4-5 Hz, sometimes with rhythmic aspect and high amplitude delta waves in the same regions, with maximal expression in F7. From that region arises a synchronized rhythm at alpha frequenciesat seizure onset, which progressively increases in amplitude and diffusion (sequence in figures 1, 2, 3, 4) from F7 to T3, Fz, F3, Fp1, and C3. This activity lasts around 8 minutes with the clinical manifestations previously referred.

M.H.

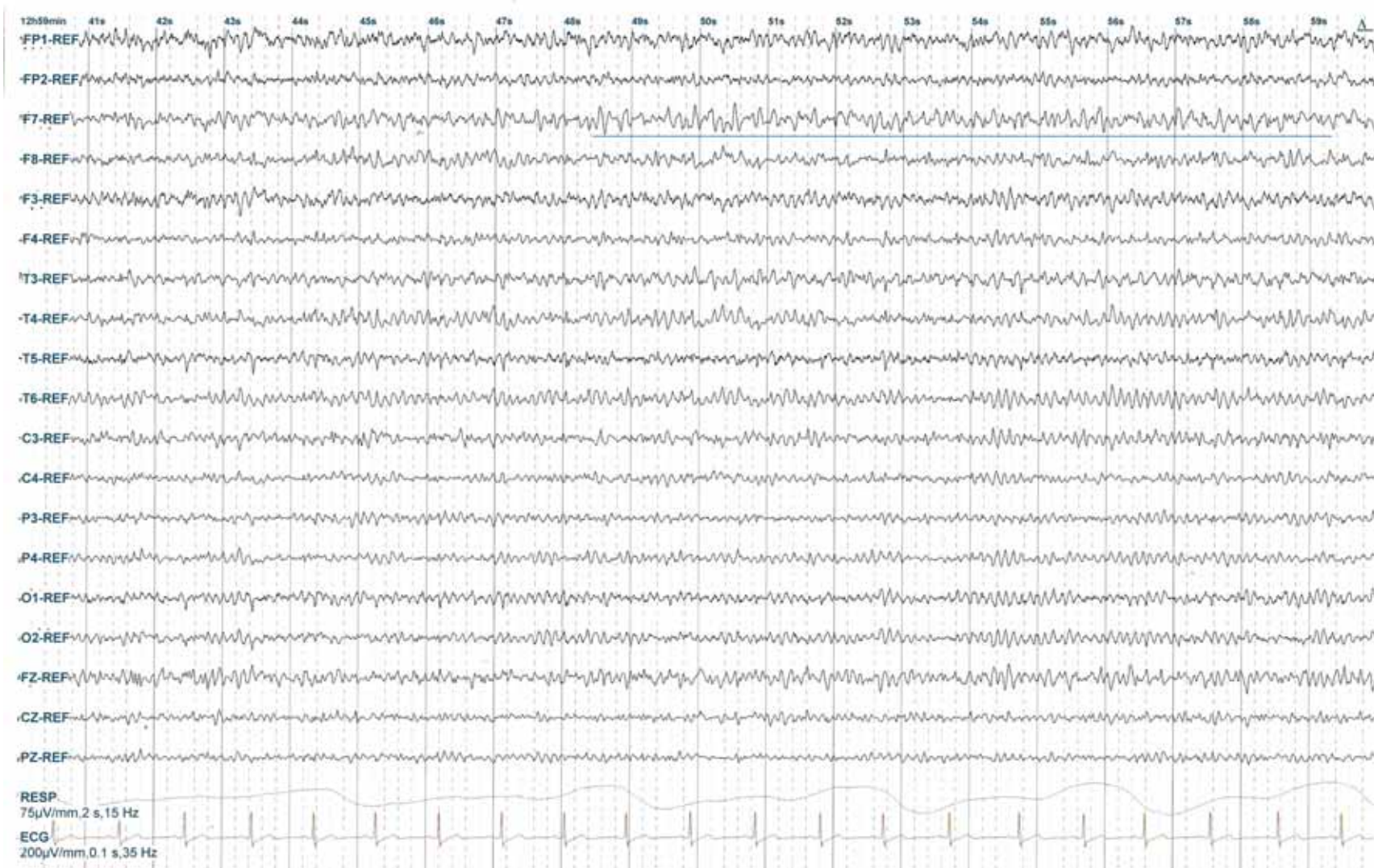


Fig. 1 Referential montage. Irregular waves on left inferior-frontal region, with maximal expression in F7 and progressive diffusion to adjacent regions.

M.H.



Fig. 2 On-going ictal activity with increasing diffusion, especially to F3 region.



M.H.

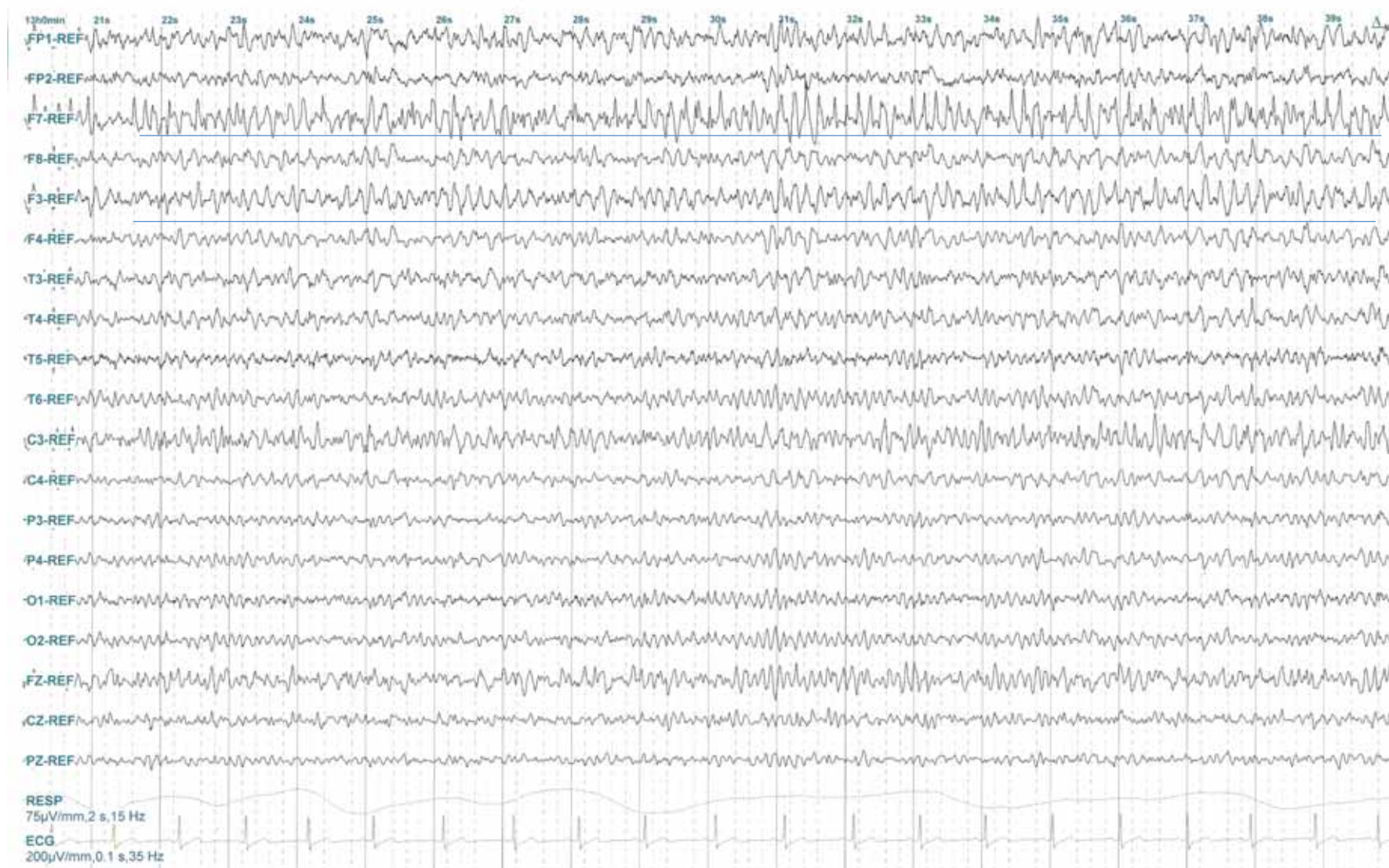


Fig. 3 Seizure progression, with increasing diffusion to left regions especially to F3 and less evident in Fp1, C3, Fz.



M.H.

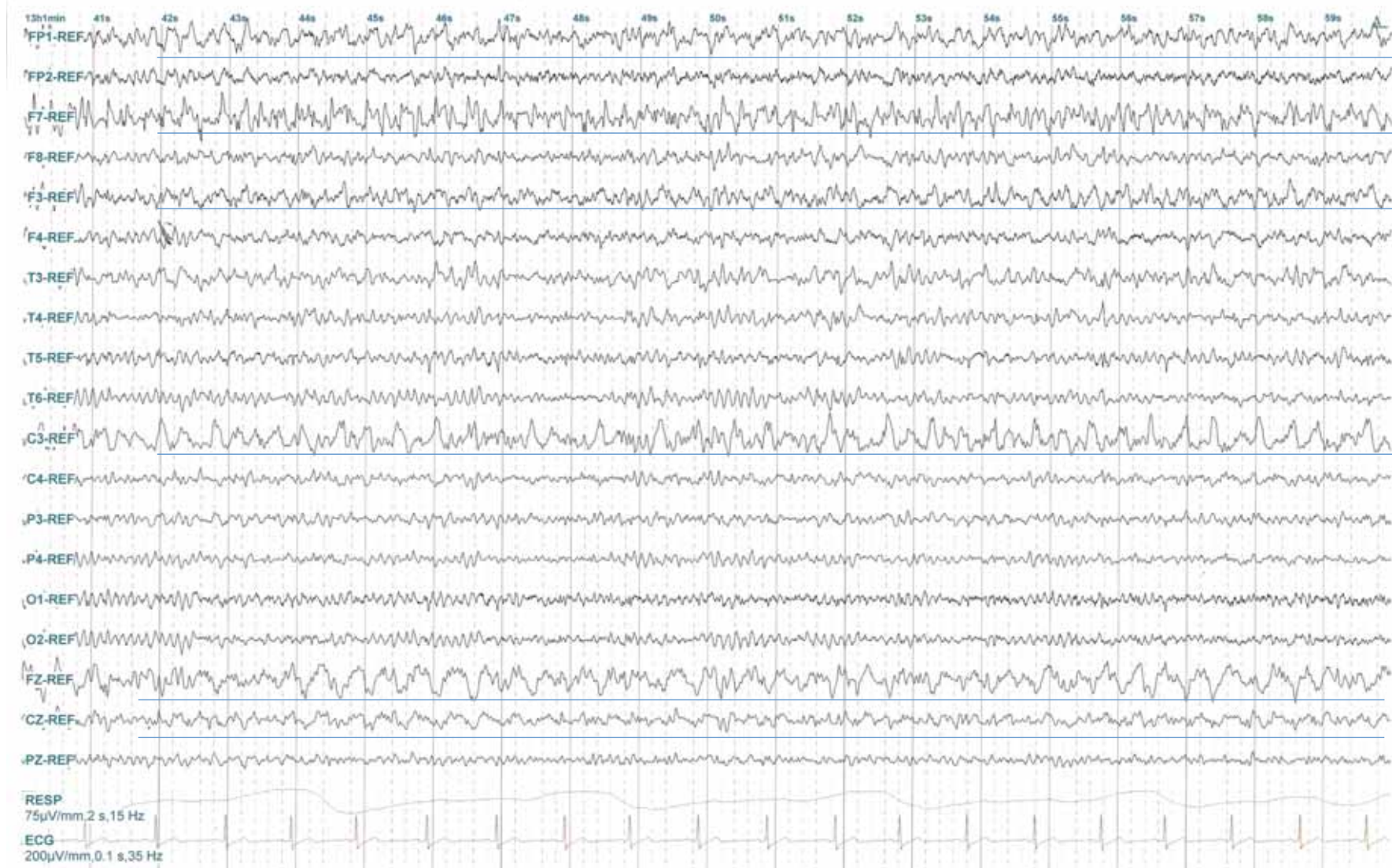


Fig. 4 On-going seizure, with more diffusion and slowing of ictal activity to the previously quoted regions, with left frontal predominant expression.

M.H.

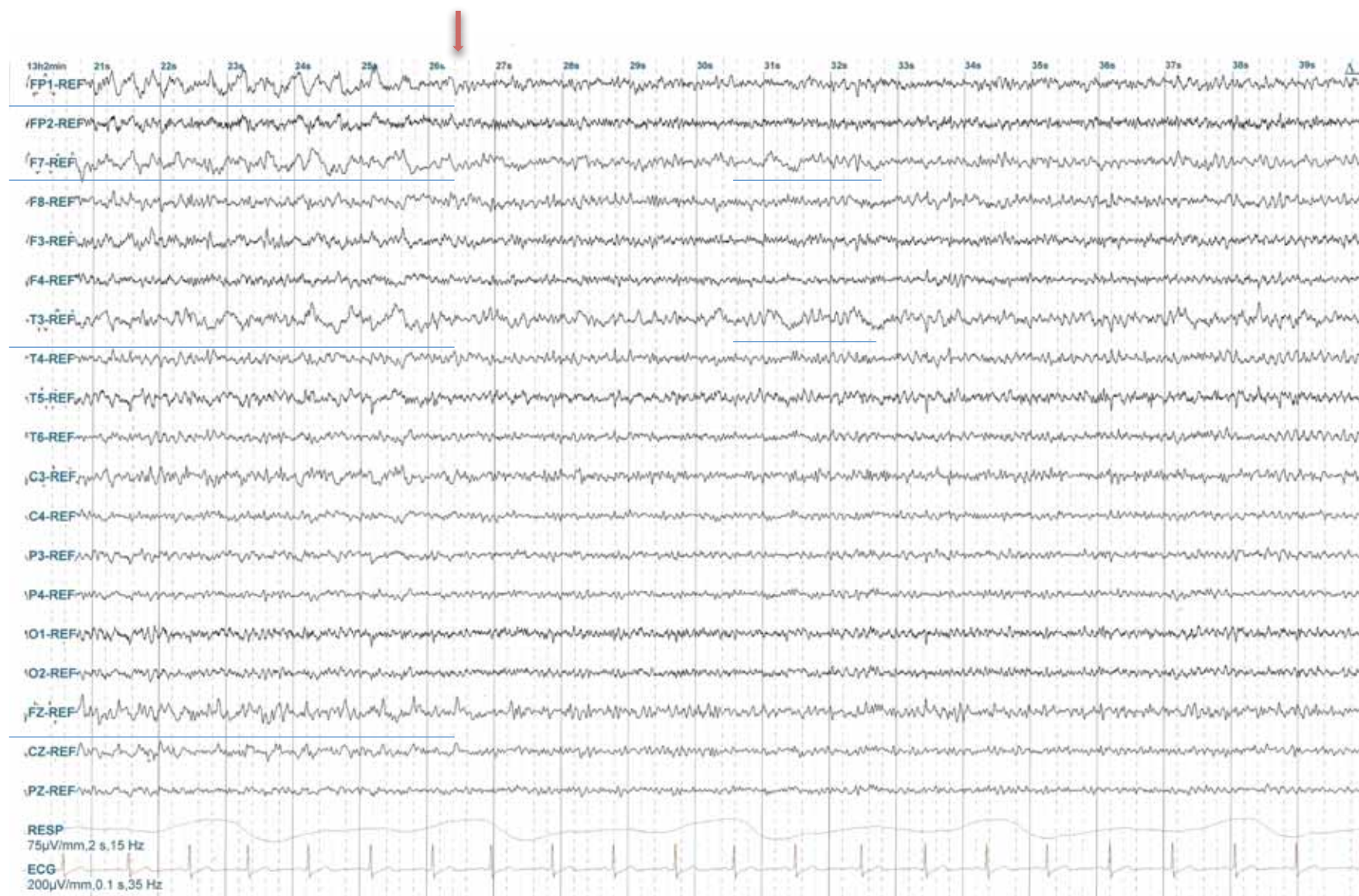


Fig. 5 Seizure ending after 8 minutes, with block of the ictal activity and some irregular slow waves in both F7 and T3 regions.

O.R.T.

O.R.T.

O.R.T.

Patient with right parietal esquizefalia who started having seizures at 5 years old. He usually had seizures during sleep. Clinically, during the seizures, the patient suddenly raises his head and body while there is tachycardia, with restlessness appearance and sometimes mouth automatisms.

EEG characteristics:

He had three independent foci described, being the most active the one in right inferior frontal, F8, followed by a focus in right parietal region, P4, and a last one in left front-central . The later was much more active than the former, with more frequent expression, especially in superficial sleep, when the patient had more seizures.

In the EEG recordings there are spikes and isolated sharp waves of 50-100  $\mu$ V with maximal expression in F8 with synchronized rhythm with higher expression in right frontal regions during the seizures. Post-ictal slowing is more expressive in right frontal regions.



O.R.T.

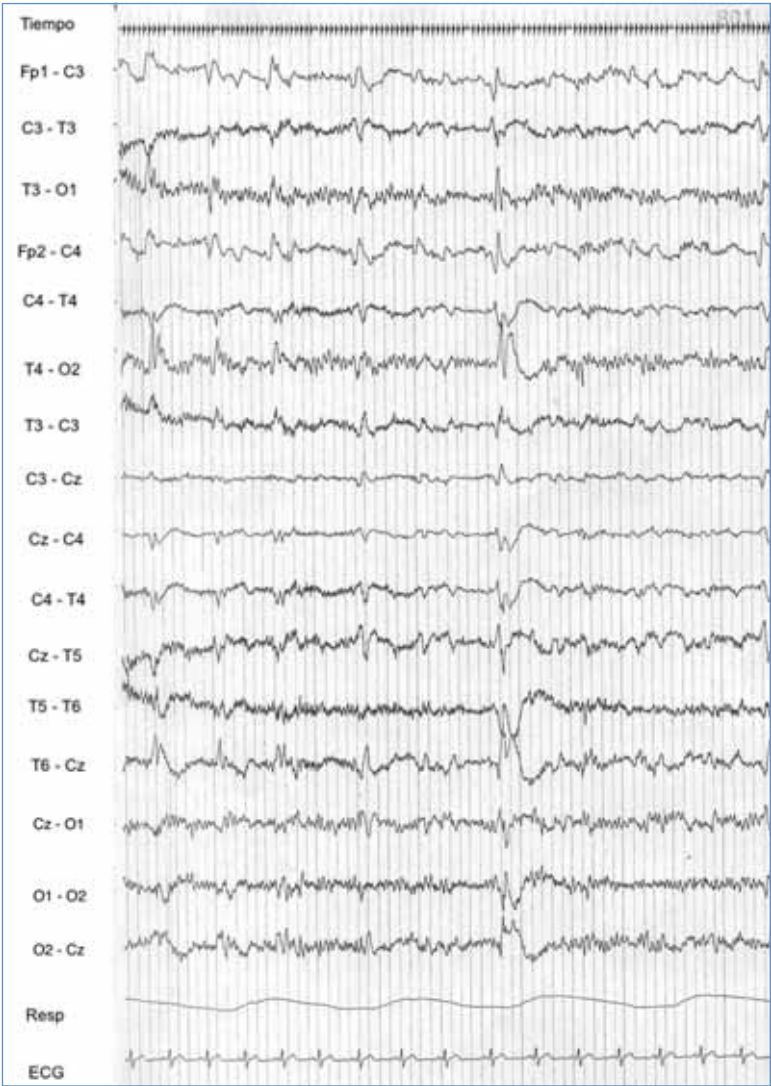


Fig. 1 Standard bipolar montage, right predominance of IED. Awake basal activity in both posterior regions

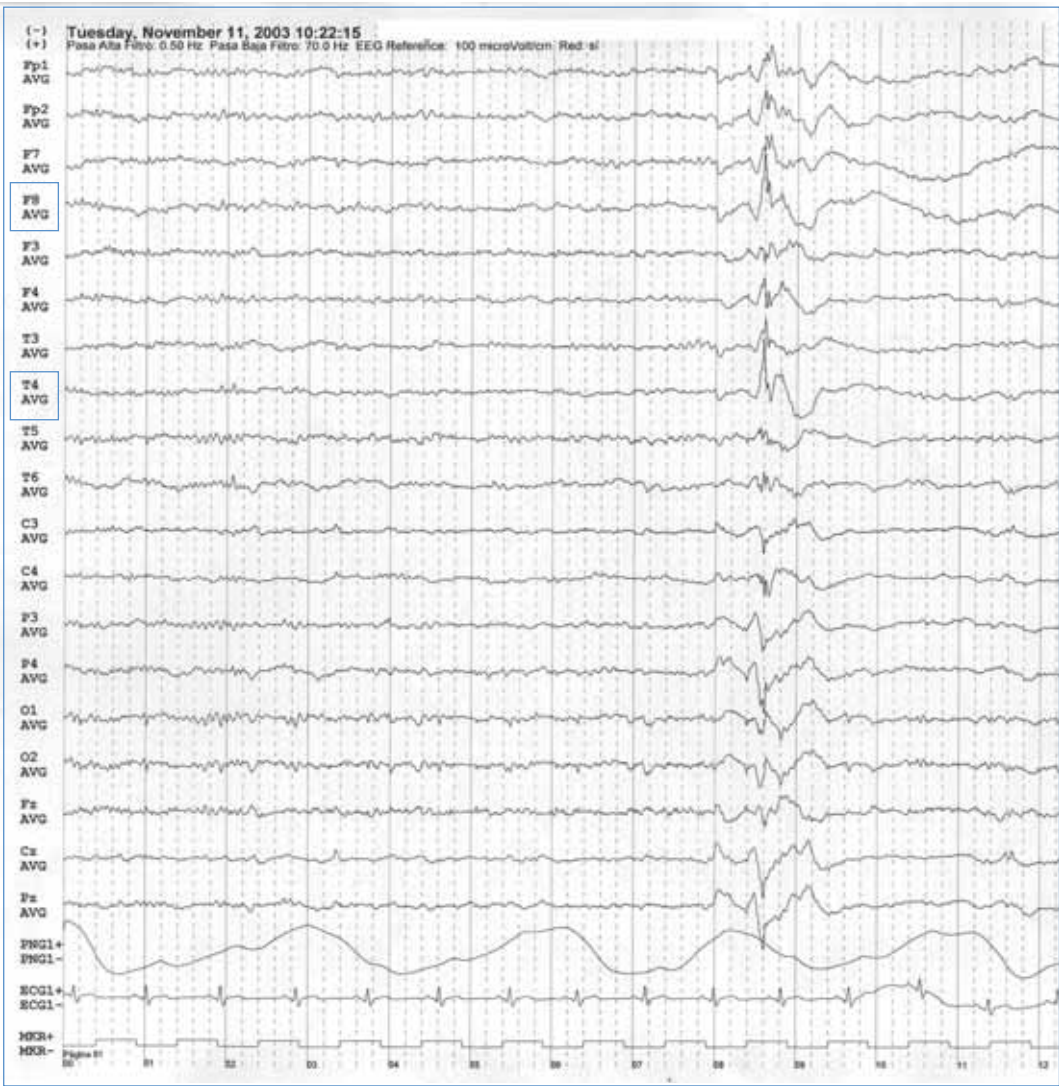


Fig. 2 Referential montage. This montage helps a lot in locating the IED, with maximal expression in right inferior frontal region F8 and diffusion to adjacent regions, especially to T4.

O.R.T.

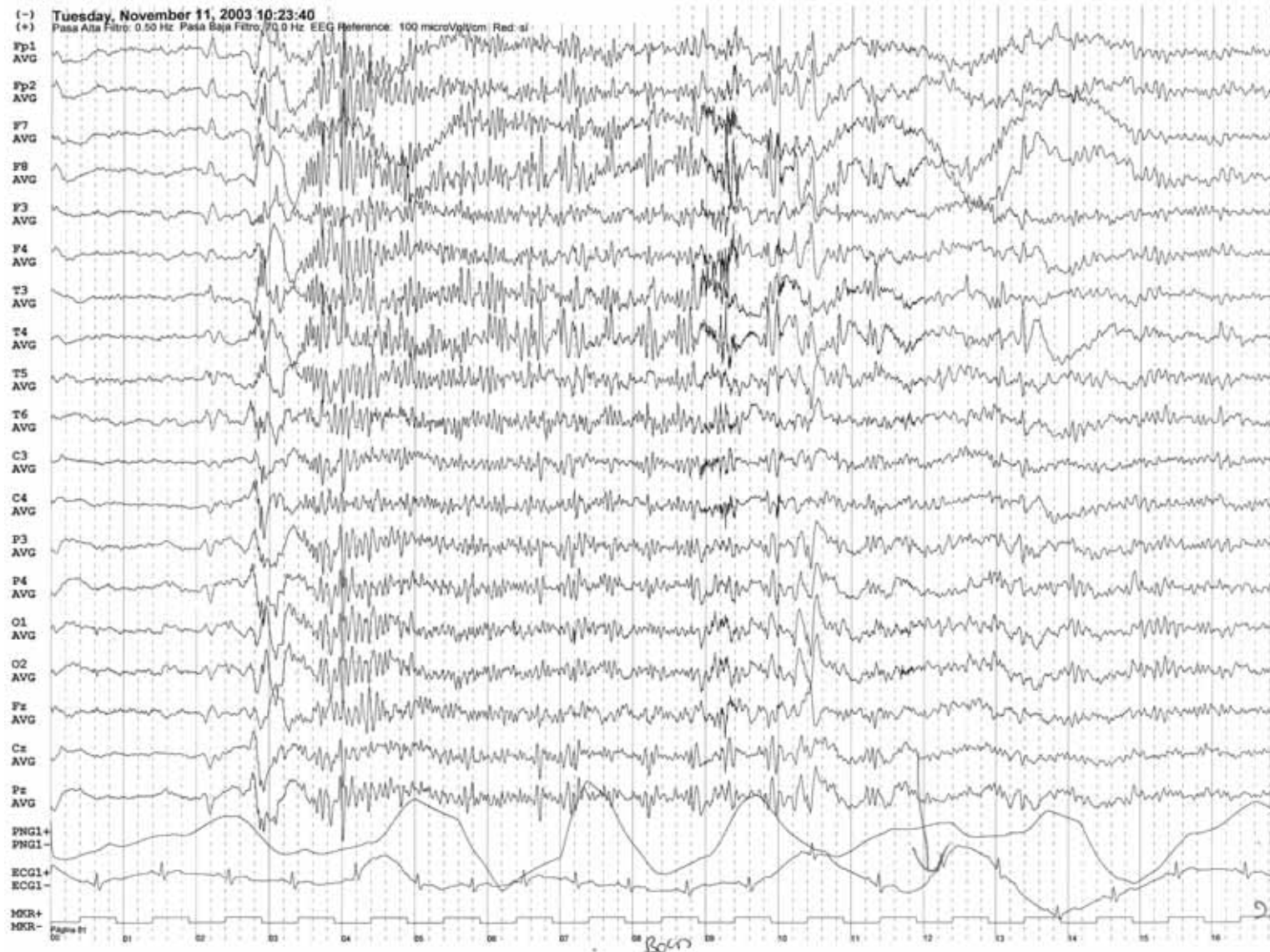


Fig. 3 Referential montage. Ictal onset with synchronized rhythm with maximal expression in right inferior-frontal F8 and immediate diffusion especially to both prefrontal regions, Fp1, Fp2 right front-central region, F4, and right mid temporal region, T4. Breathe change in polygraphy, as well as tachycardia. Clinically the patient suddenly raises his head and body while there is tachycardia, with restlessness appearance



O.R.T.



Fig. 4 Referential montage. The amplitude and duration of the reluctant rhythm in this seizure is slightly smaller. Maximal expression of the reluctant rhythm in F8, with rapid diffusion to both pre-frontal, front-central and mid-temporal (Fp1, F2, F4, T4). After four seconds there is a slowing but the ictal activity arises again from F8, ending two seconds later. We can see again the effect in breathing and a possible slight increase in EKG frequency.

S.R.R.

S.R.R.



S.R.R.

Patient with cerebral paralysis antecedent who started having seizures at 1 year old. Clinical manifestations are related to the degree of intensity of the ictal activity, from eyes opening in the milder to involvement of the body with a tonic raise of the head and body with head deviation towards the left side.

EEG characteristics:

Focal interictal activity with poly-spikes of 100-200  $\mu$ V of amplitude with maximal expression in left inferior frontal region, 7. Seizures arise from that region with synchronized rhythm without attenuation, with frequencies of around 13 Hz and variable duration and intensity. Post-ictal slowing in left frontal areas.

S.R.R.

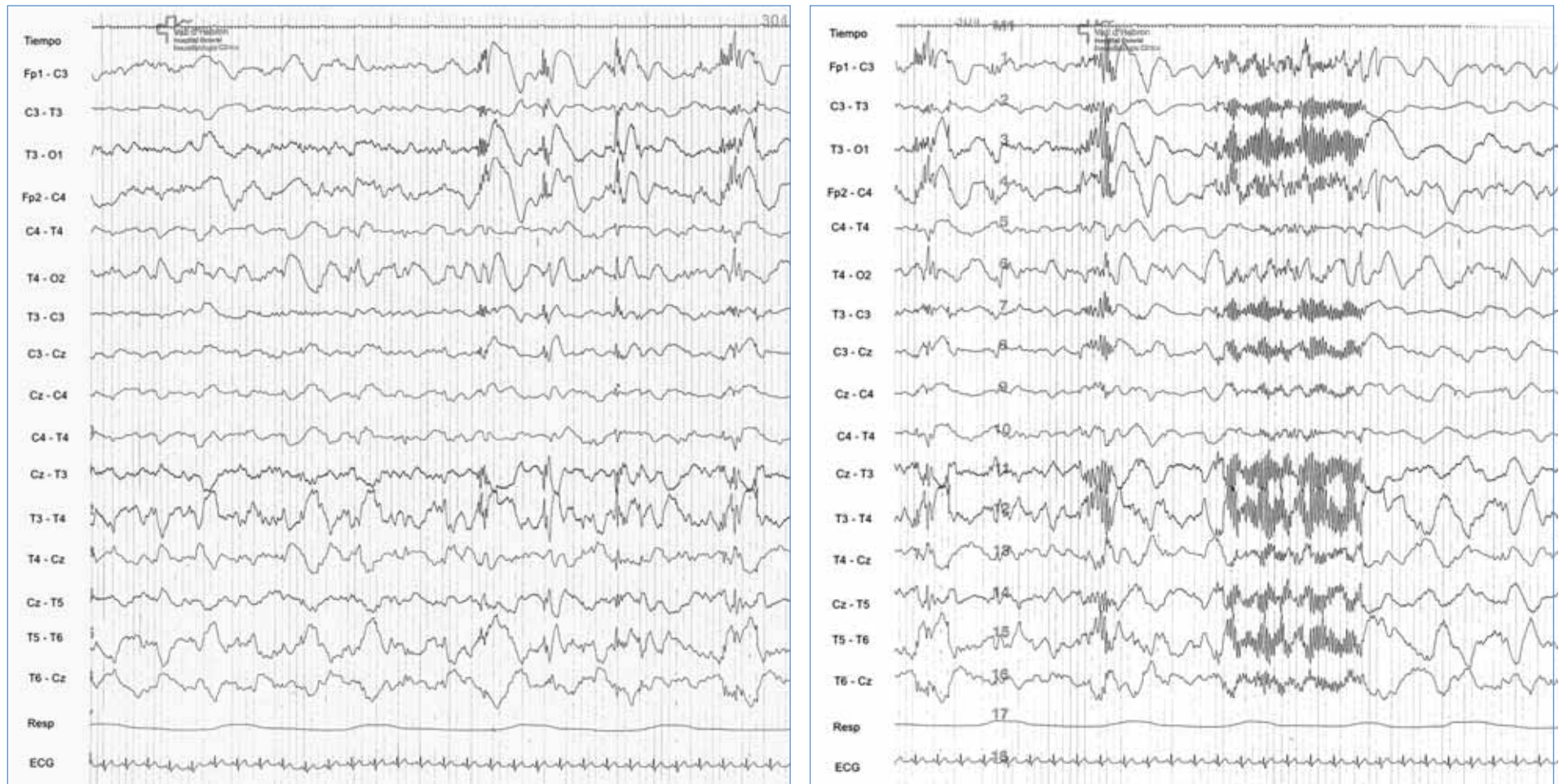


Fig. 1.1, 1.2 Standard bipolar montage. Different intensity of ictal activity consisting of a relict rhythm with maximal expression in left regions. A precise location of the IED as well as the seizure onset requires a referential montage approximation to the recording (view 2.1 and 2.2). Clinical manifestations are related to the degree of intensity of the ictal activity, from eyes opening in the milder to involvement of the body with a tonic raise of the head and body with head deviation.

S.R.R.

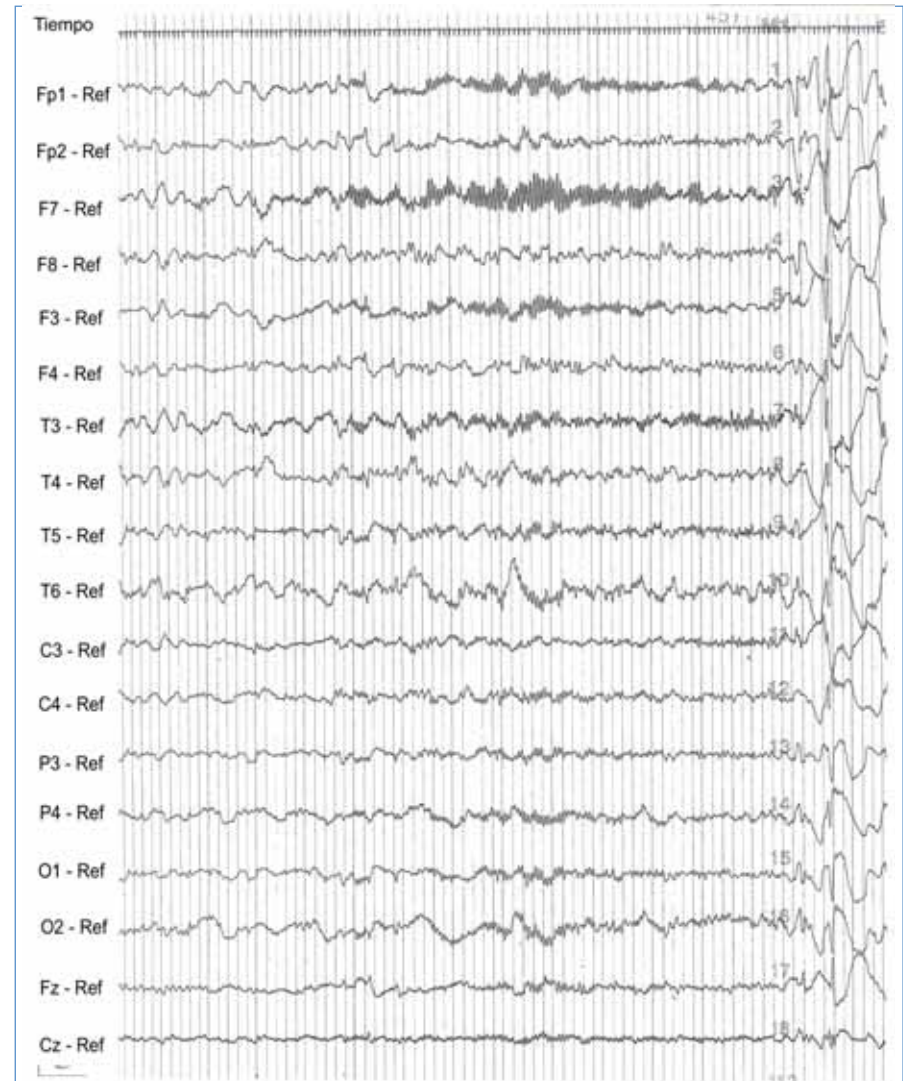
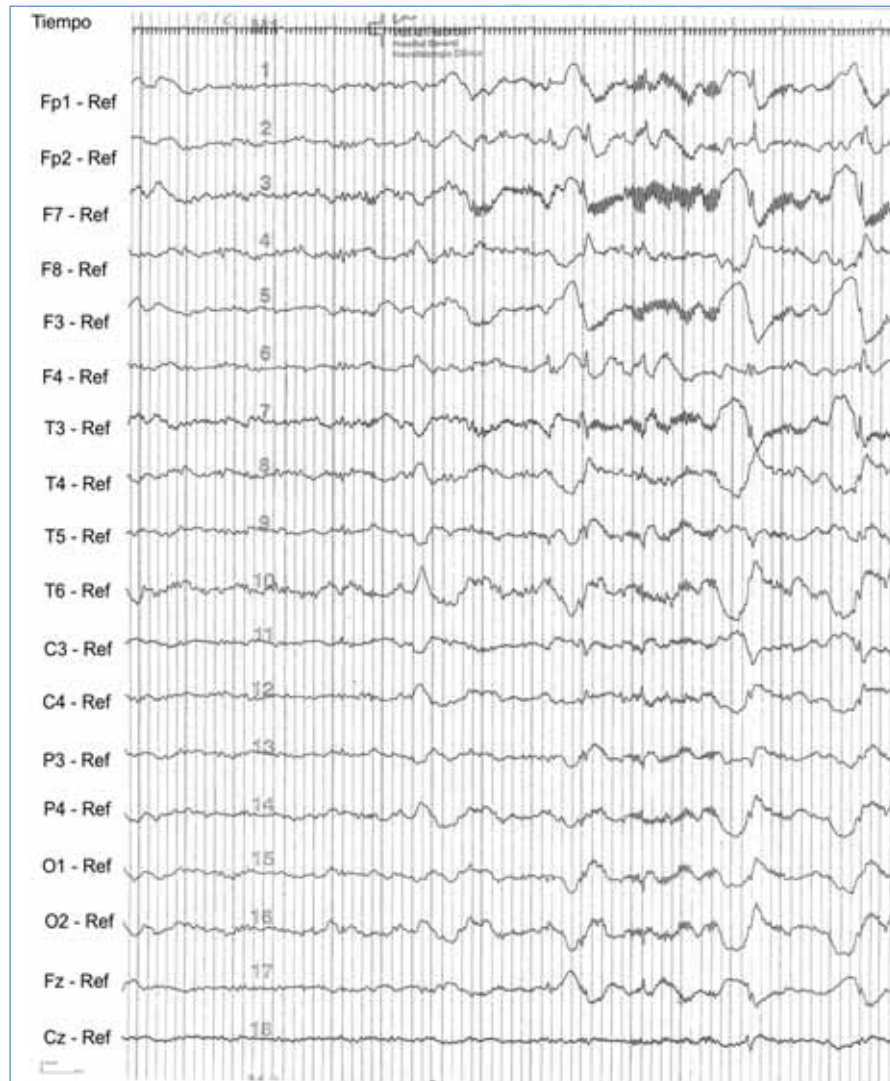


Fig. 2.1, 2.2 Referential montage that helps a lot in locating the seizure origin, with maximal expression in F7 and fast diffusion especially to other left regions (Fp1, F3, T3)



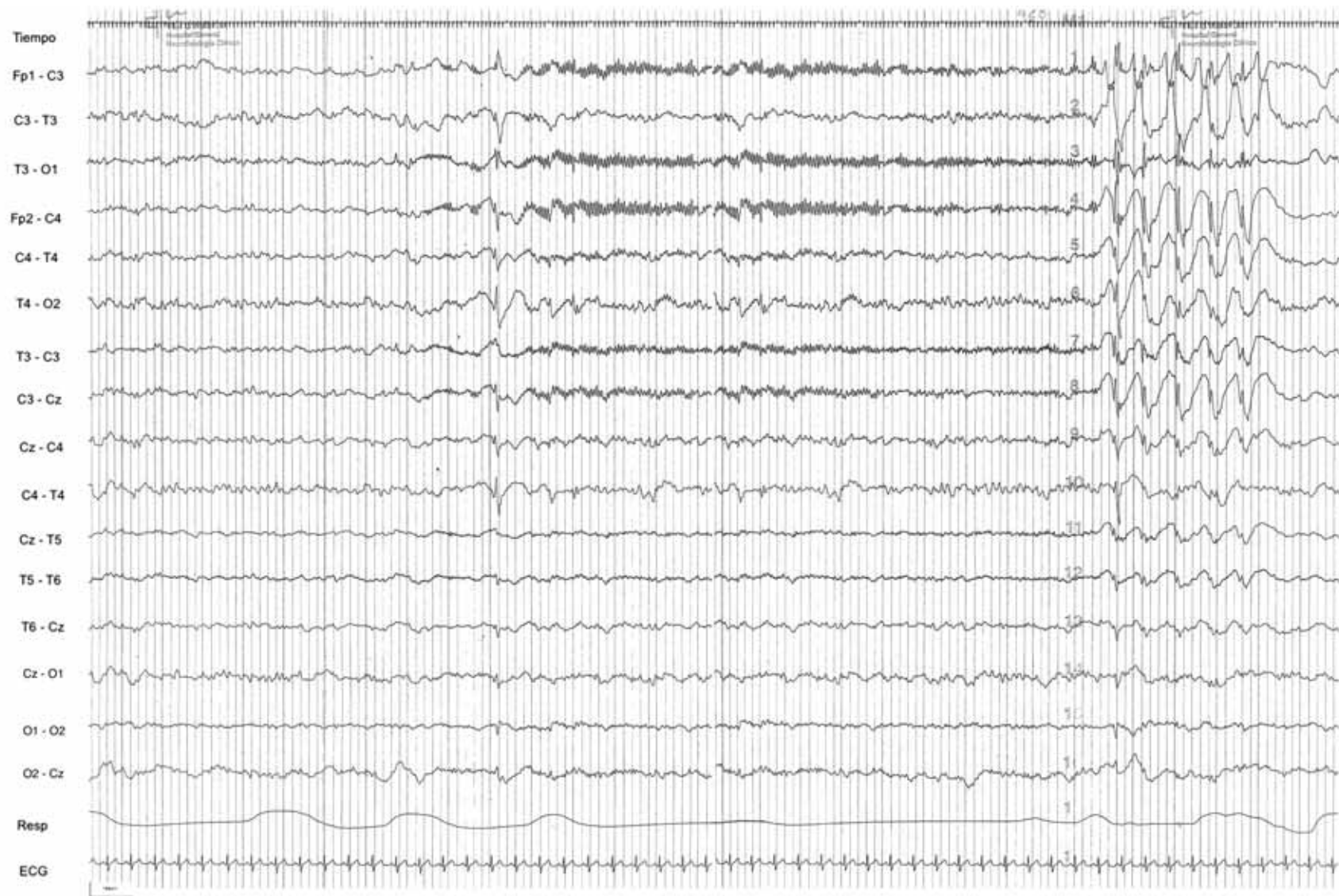


Fig. 3 Seizure in a bipolar standard montage, with maximal expression in both pre-frontal regions with left predominance. Apnoea and tachycardia in polygraphy during the seizure.



M.C.A.P.

M.C.A.P.

M.C.A.P.

Patient with multiple vascular malformations that started with seizures at 16 years old. Clinically she remains conscious but aphasic, sometimes she raises right leg. She refers other type o seizures with unmotivated laugh. Sometimes they have secondary generalization.

EEG characteristics:

EEG recordings show two independent foci, in right front-central region, F4, and left inferior frontal, F7. With the available settings we could see a left predominance of the synchronized rhythm at seizure onset. Seizures starts with a low amplitude synchronized rhythm at 30 Hz approximately.

M.C.A.P.

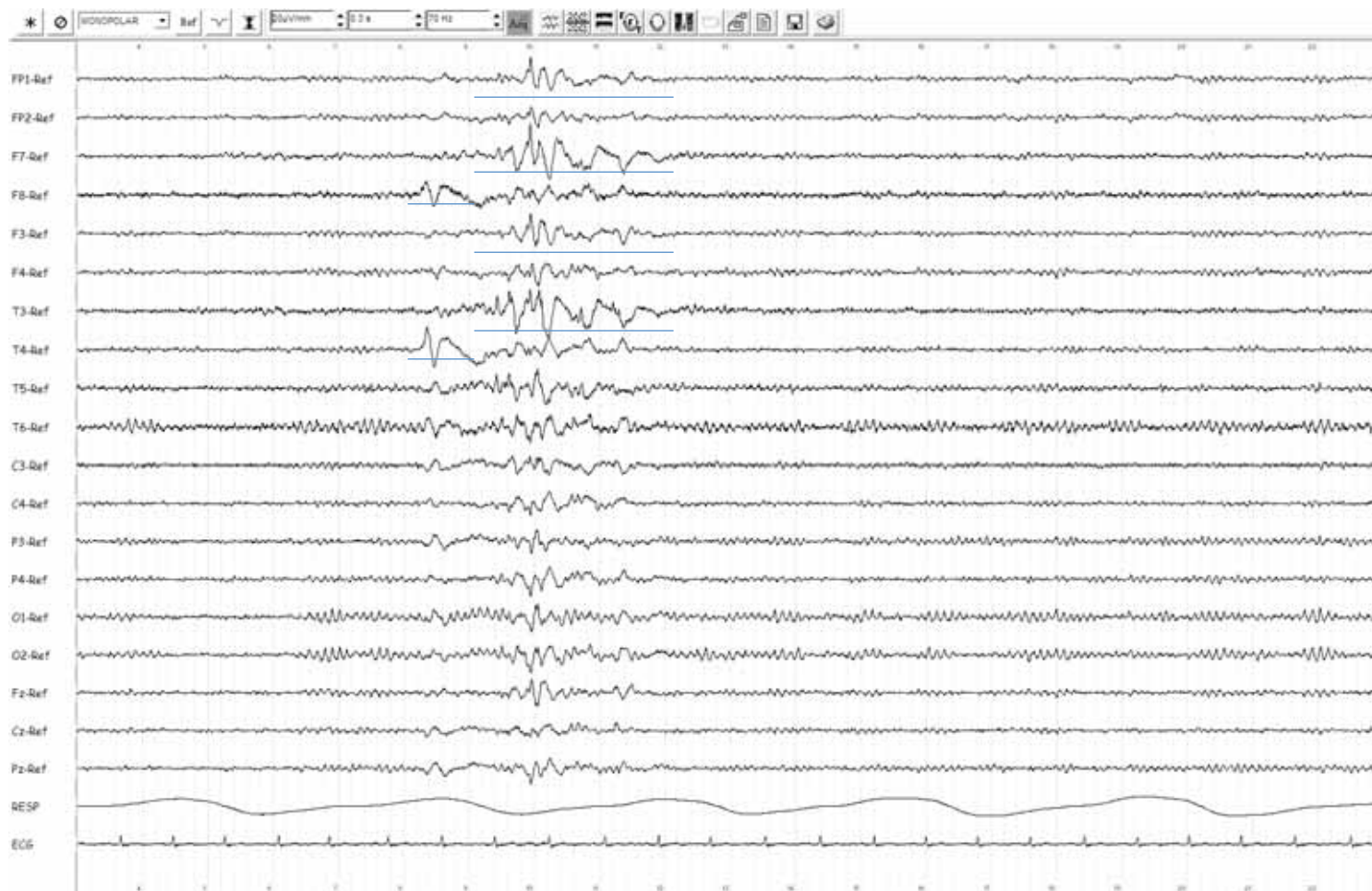


Fig. 1 Referential montage. Two epileptic independent foci over right and left hemispheres, with maximal expression in T4>F8 and F7 with diffusion to Fp1, T3, F3.

M.C.A.P.

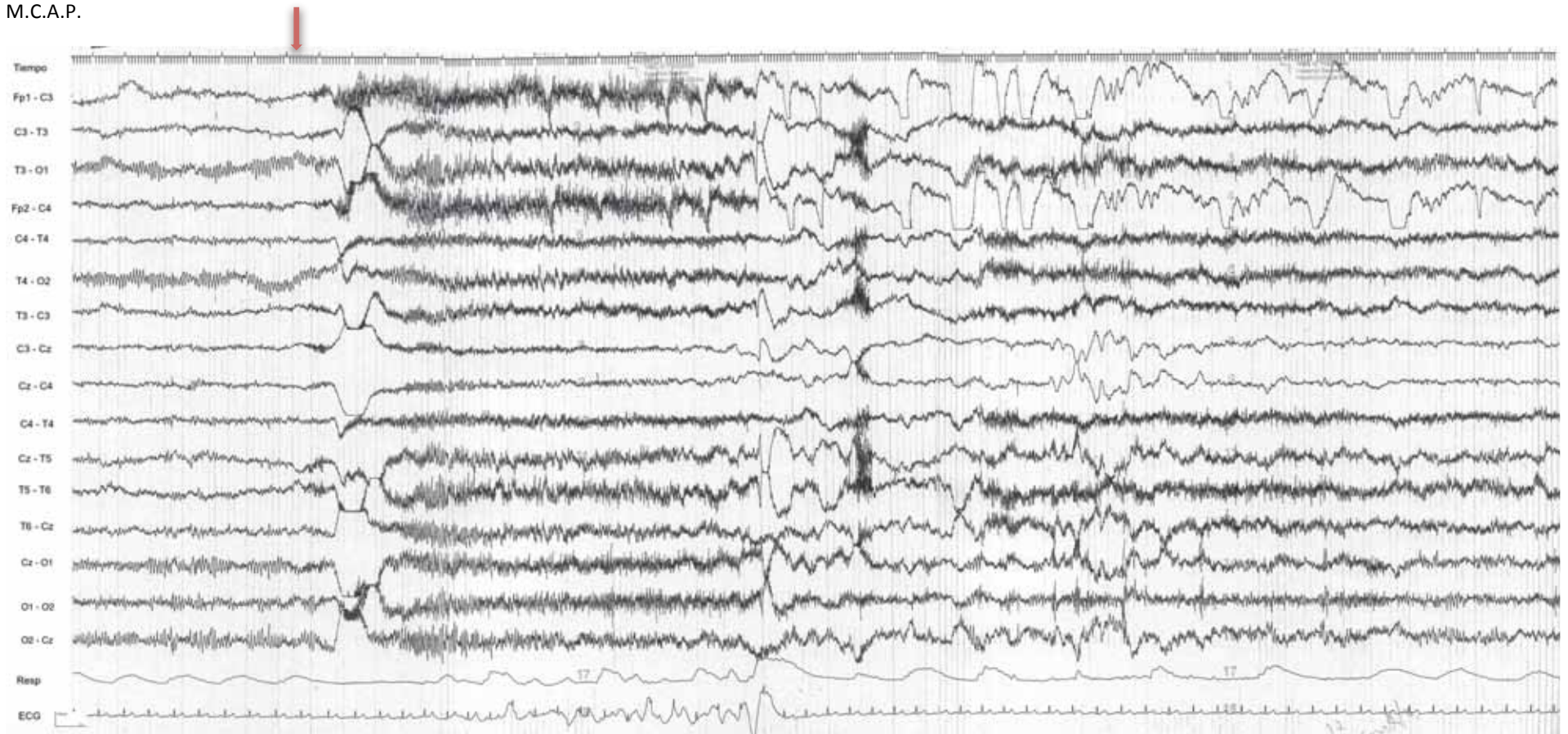


Fig. 2 Standard bipolar montage. Seizure with a slight left predominant of synchronized rhythm just at onset. EMG artefact alters its characterization. We can see breathing stop and irregularity during the seizure.



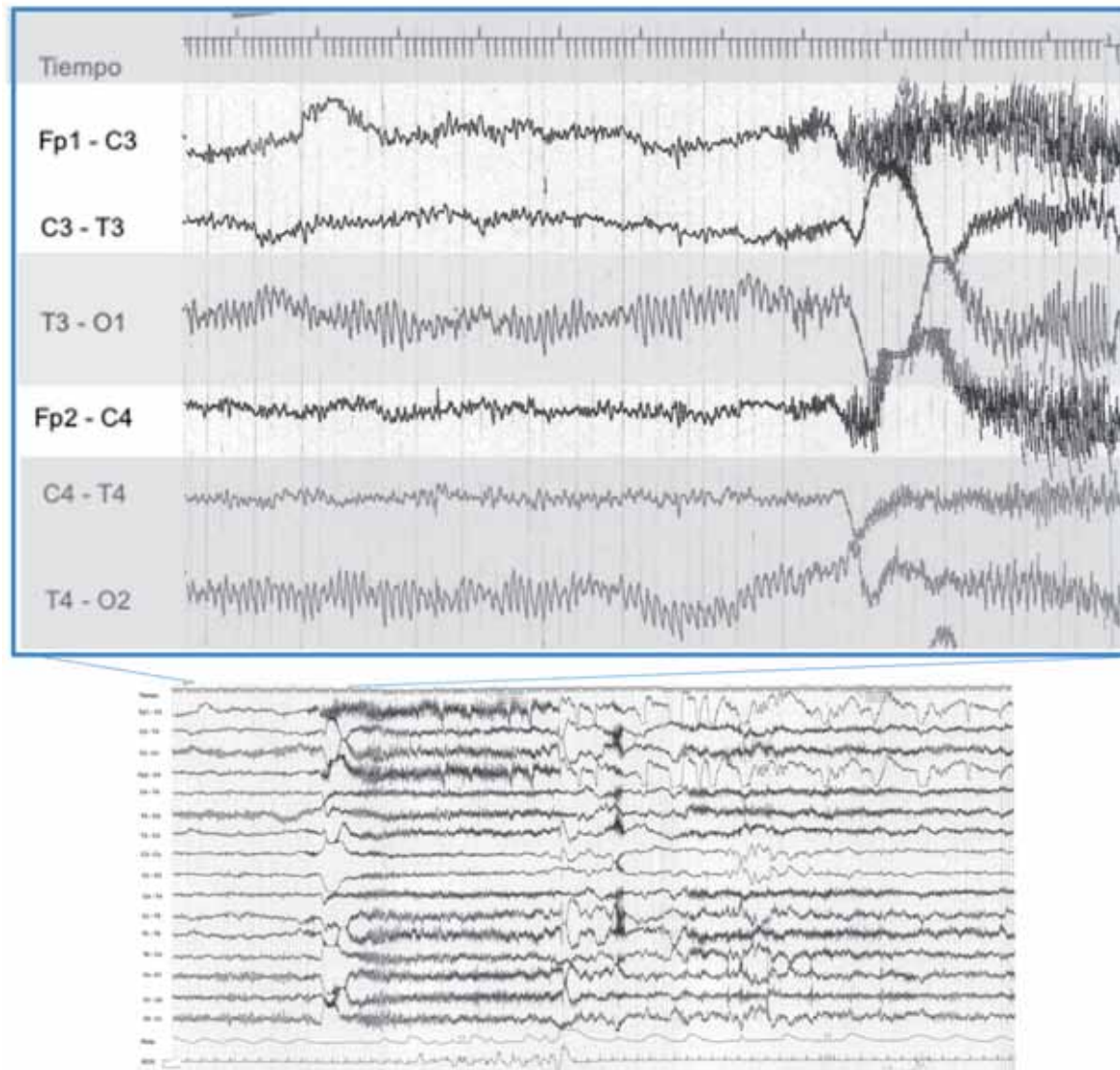


Fig. 4 Detailed view of low amplitude synchronized rhythm in both pre-frontal regions, with maximal expression in left frontal region.

L.S.C.V.

L.S.C.V.

L.S.C.V.

Patient who started with seizures at 35 years old, with tumoral antecedent, who underwent surgery and had a ventricular peritoneal shunt. Clinically we could not identify clinical manifestations related (such as movements, sensibility alterations, pupillary size, olfactory perception, impairment of consciousness, ascendant and descendent numerical series...) and, as we recorded, they frequently appeared in clusters.

EEG characteristics:

EEG recordings show interictal epileptiform activity in left pre-frontal region, Fp1, showing isolated spikes of less than 50  $\mu$ V, isolated Sharp waves of 50-100  $\mu$ V, isolated diphasic Sharp waves of 50-100  $\mu$ V and irregular slow waves of 50-100  $\mu$ V. Seizures arise from left pre-frontal regions at around 9 Hz, with fast diffusion to inferior frontal region, F7, and left front-central region, F3, where acquires more electrical expression with spikes within a delta rhythmic activity. Afterwards there is a slowing at around 6 Hz during 60 seconds.

We recorded up to 12 seizures in the same recording.

L.S.C.V.

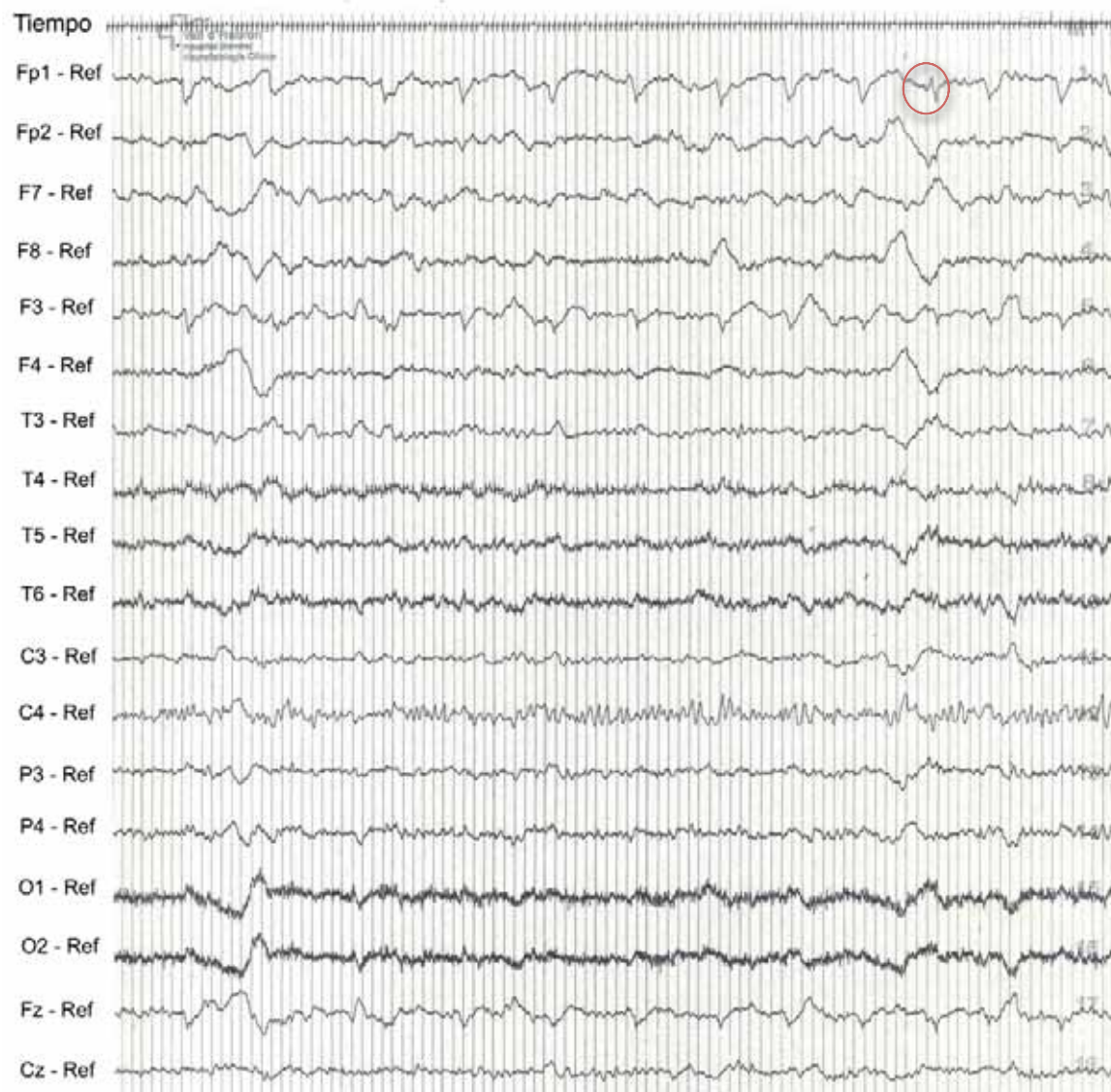


Fig. 1 Referential montage. Low voltage sharp waves in left pre-frontal region, Fp1, and left front-central region, F3. Independently, breach rhythm in right central region, C4 and right slowing.



L.S.C.V.

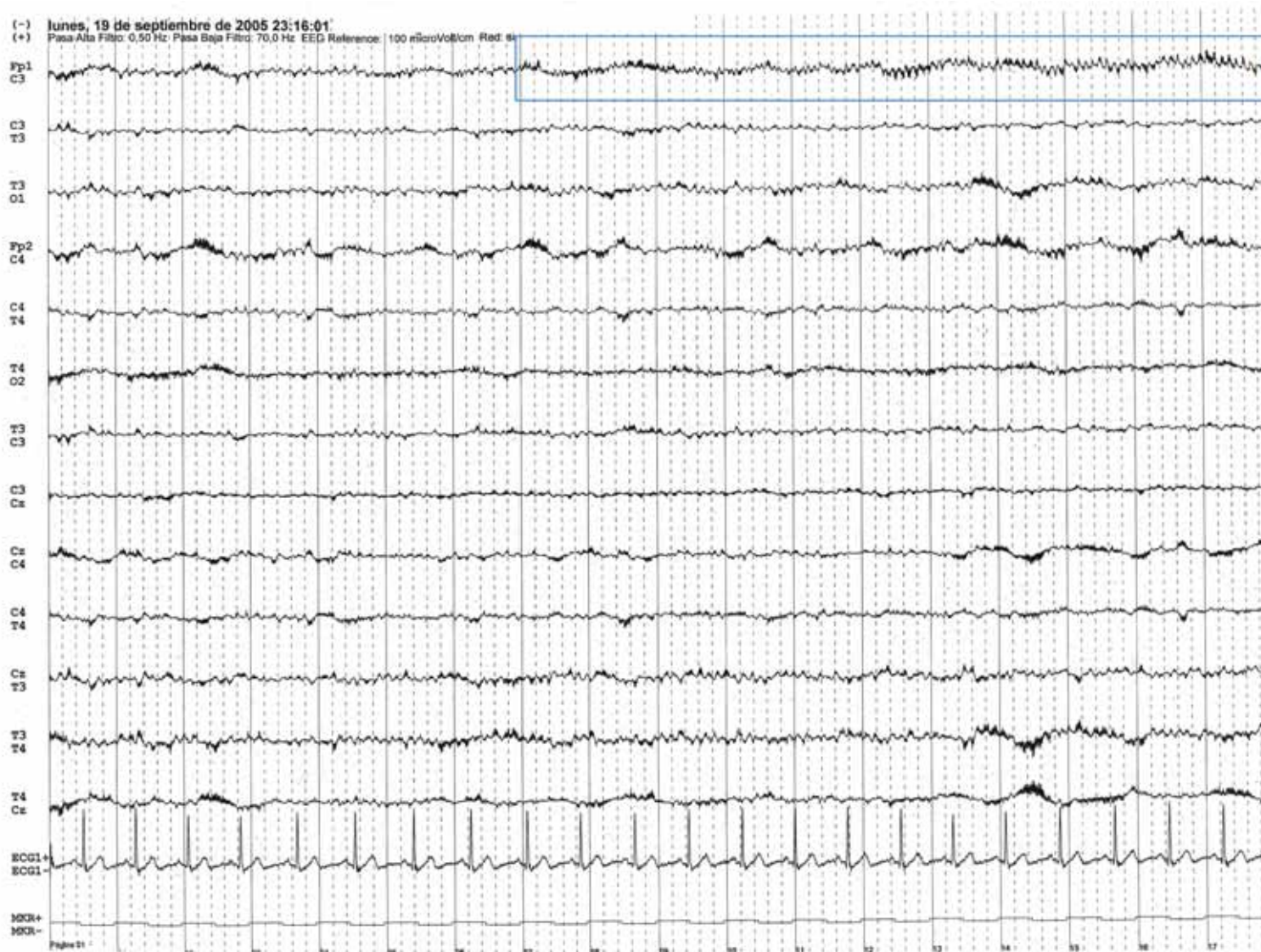


Fig. 2 Standard bipolar montage. Seizure is arising from left pre-frontal region, Fp1, with a synchronized rhythm at around 9-10 Hz,.

L.S.C.V.

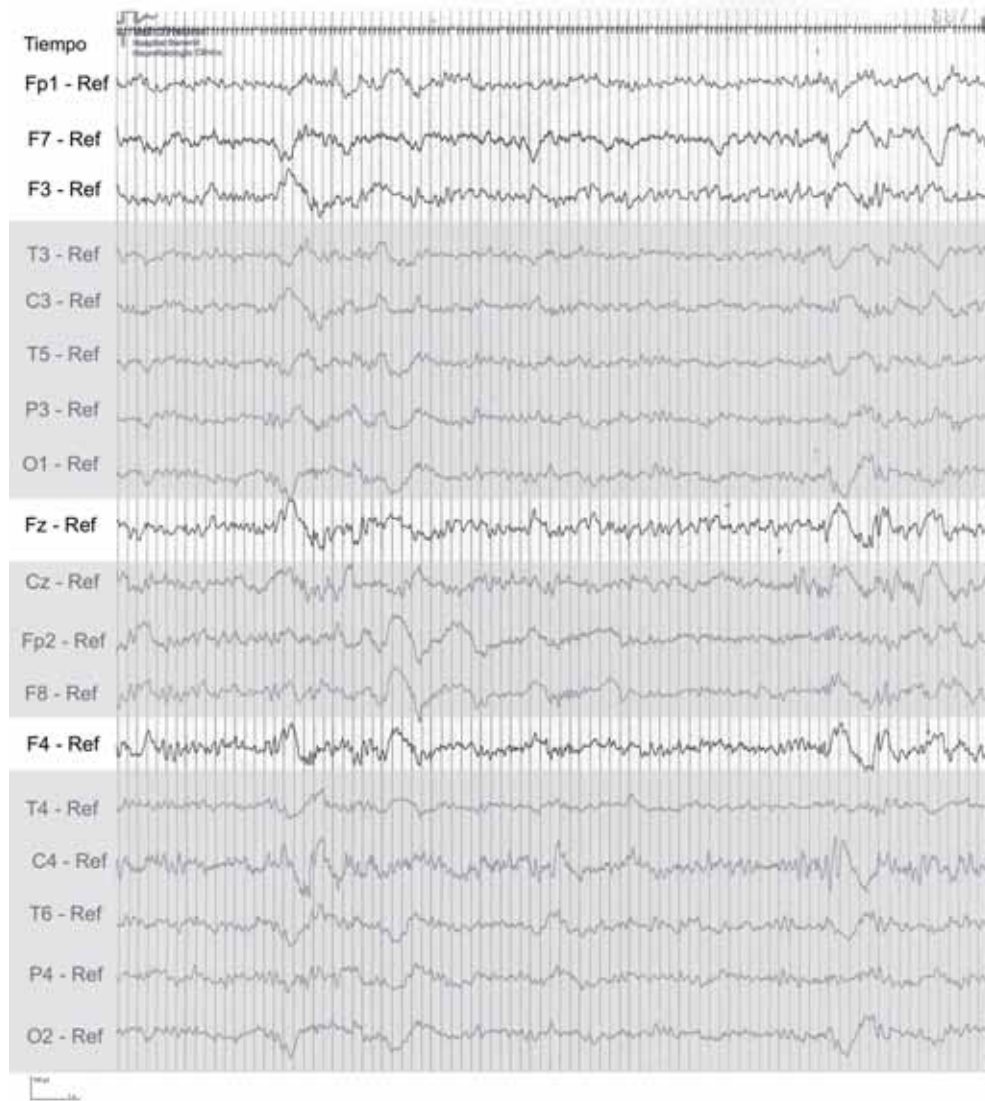


Fig. 3 Referential montage. left pre-frontal synchronized rhythm with more diffusion to adjacent regions: F7, F3, Fz, F4. Independent slowing in right frontal regions and breach rhythm in C4>Cz.

L.S.C.V.

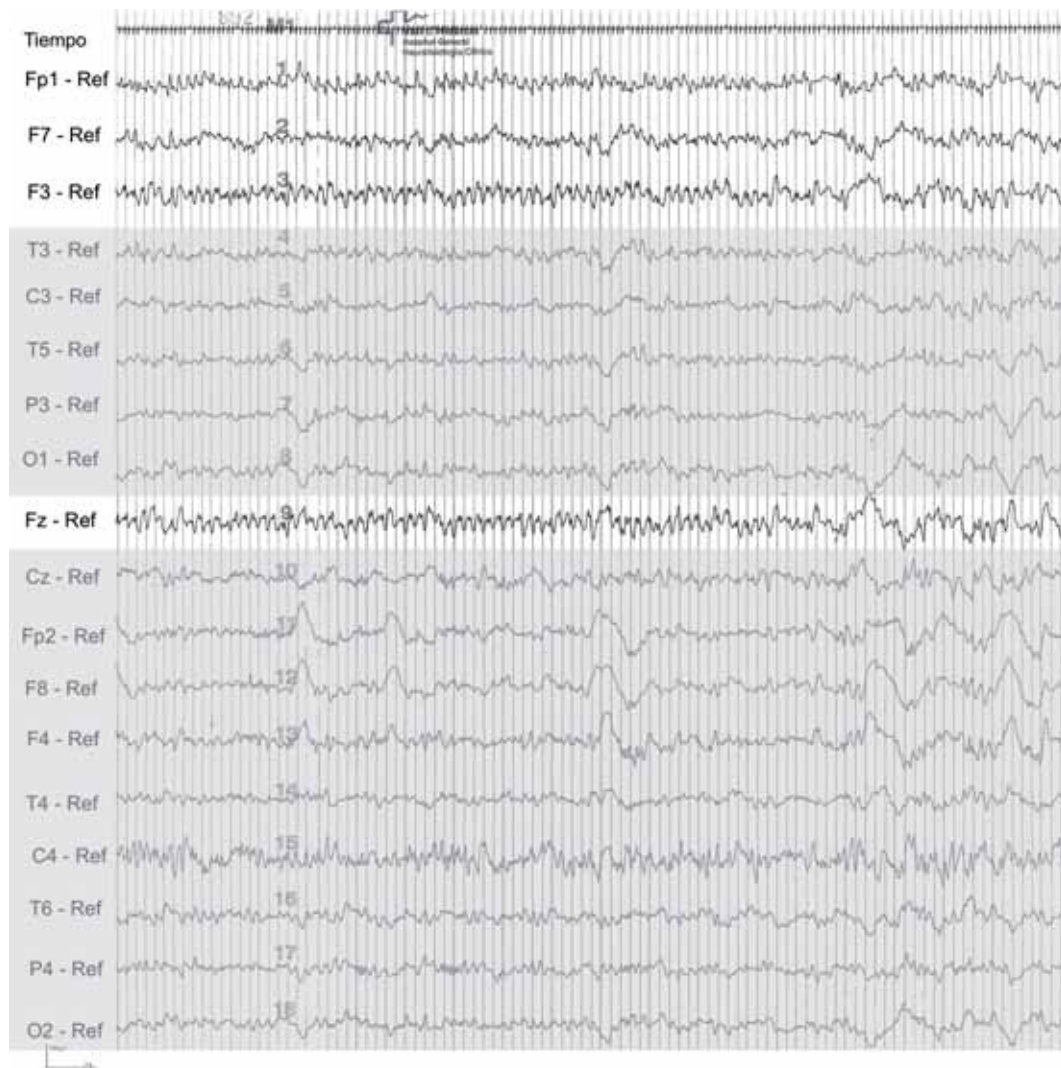


Fig. 4 Referential montage. On-going seizure, 120 seconds later. Increasing amplitude and diffusion of the ictal activity in left frontal regions. Breach rhythm in right central region(C4) with slow waves in right frontal regions.



L.S.C.V.

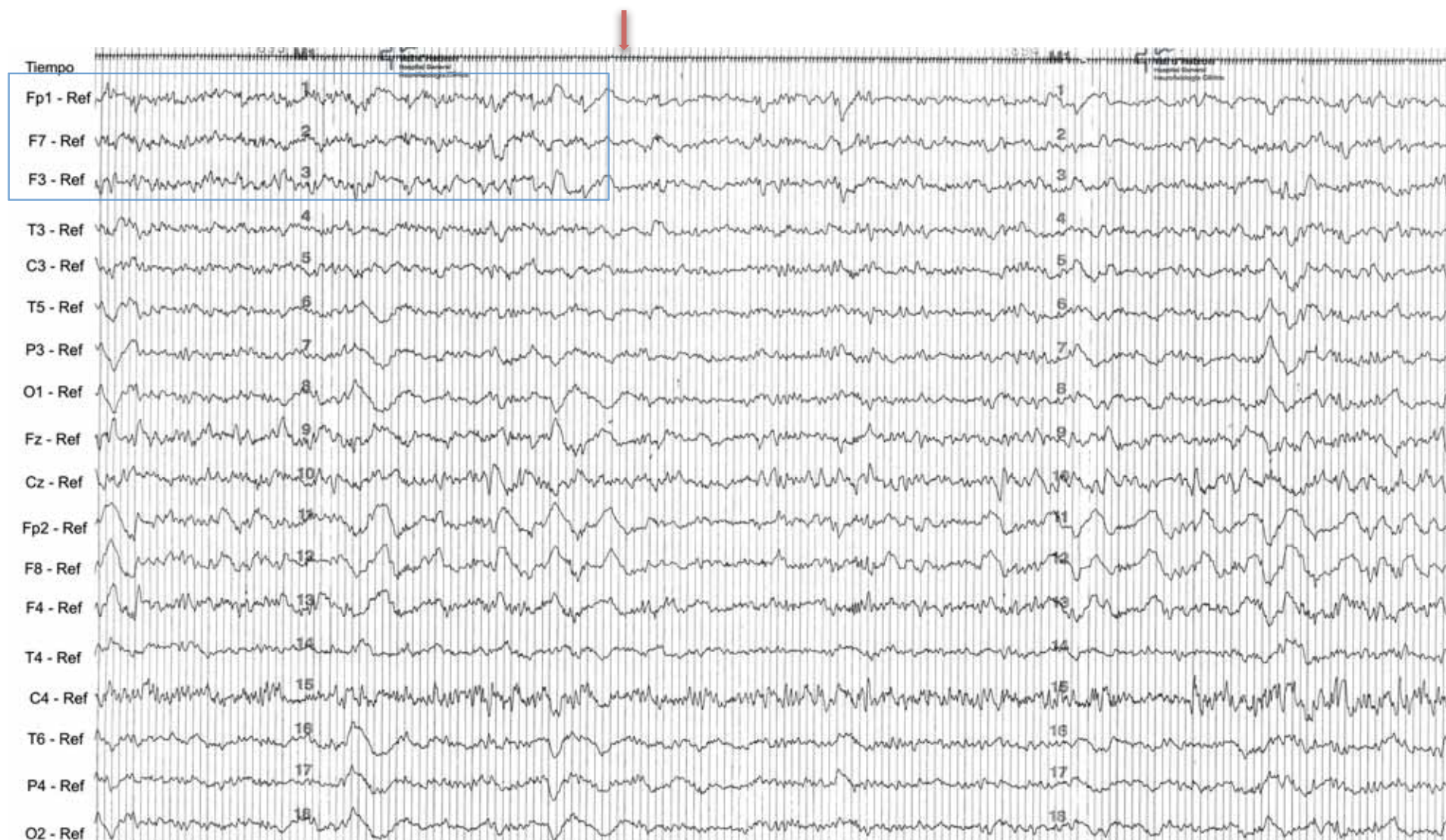


Fig. 5 Referential montage. Seizure ending with back of the ictal activity in left frontal regions.

Independently there continues the right slowing in right frontal regions and the breach rhythm in right front-central region.



M.P.L.

M.P.L.

M.P.L.

Patient with tumoral antecedent during childhood, who started seizures at 5 years old. Clinically she raises her right arm up to his head and a raises a bit less her left arm and both legs.

EEG characteristics:

EEG recordings show focal epileptiform activity in left prefrontal electrode, with isolated spikes of less than 50  $\mu$ V, isolated sharp waves of 50/100  $\mu$ V and sharp wave followed by an irregular slow wave. Seizures start with a synchronized rhythm without a significant change in amplitude, at around 20 Hz, with progressive slowing.

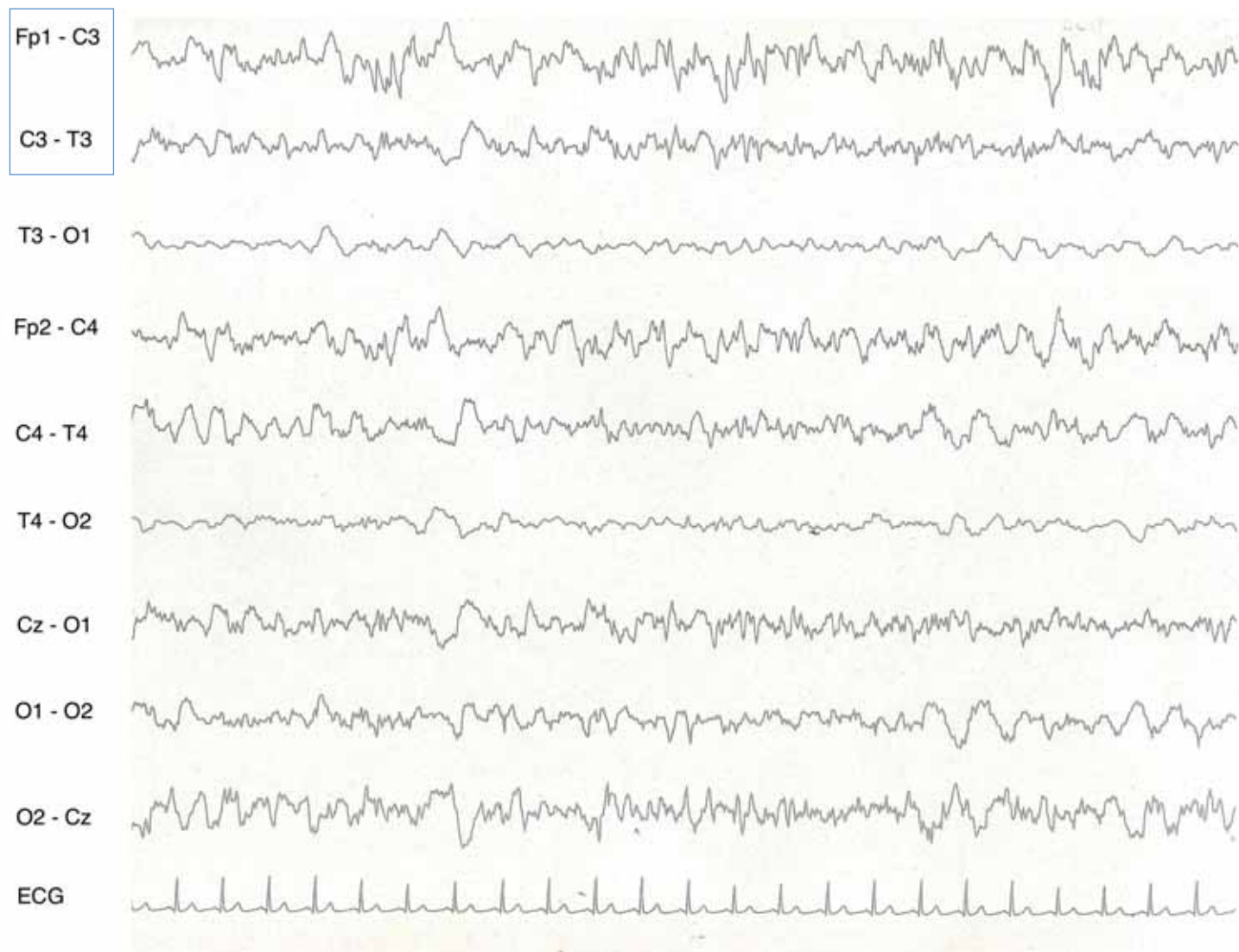


Fig. 1 Bipolar standard. IED with spikes in left frontal regions, as we can see in the first two channels of the recording.

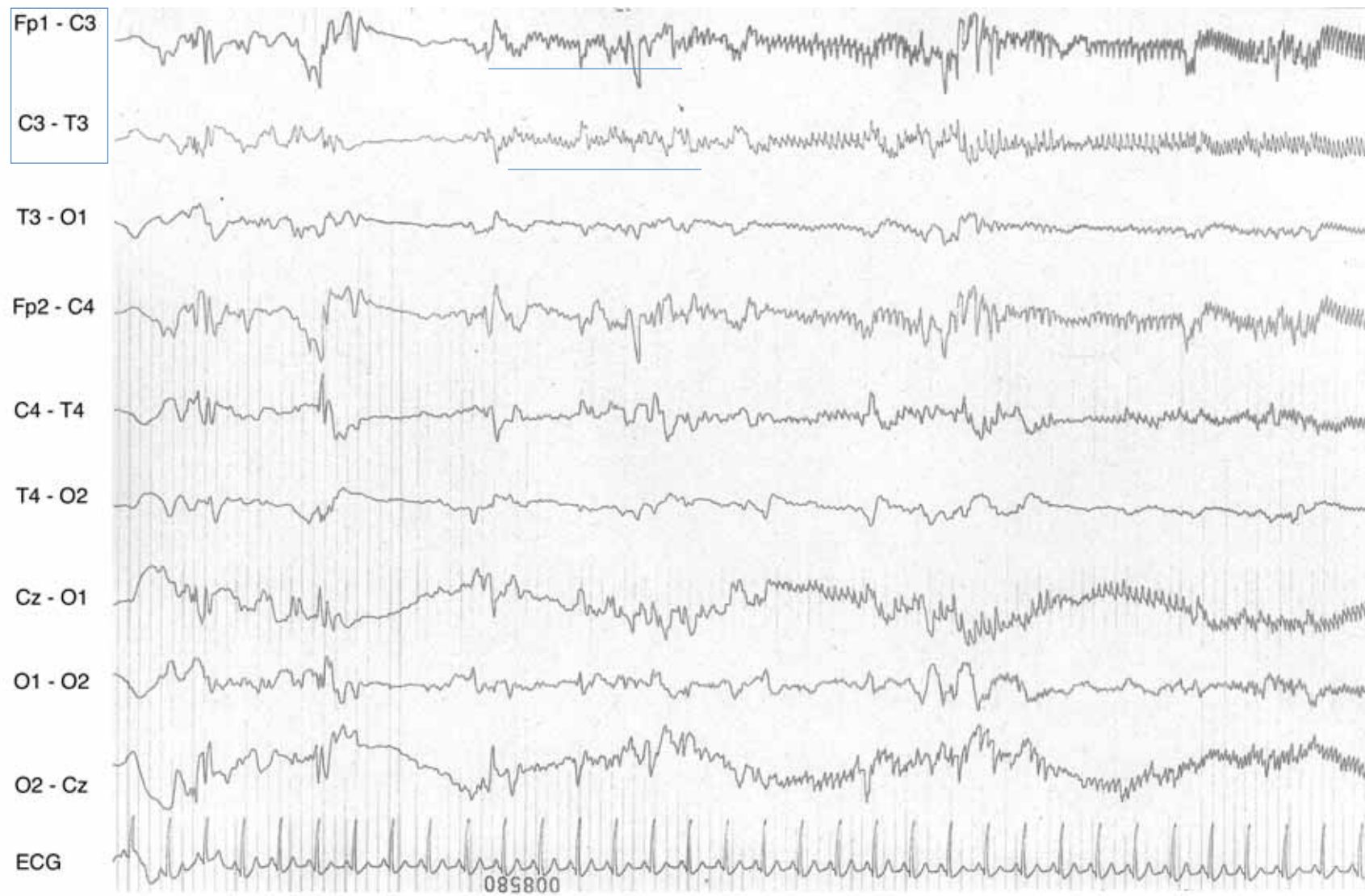


Fig. 2 Seizure arising from left frontal regions where the synchronized rhythm acquires maximal expression, with fast diffusion to right frontal region.



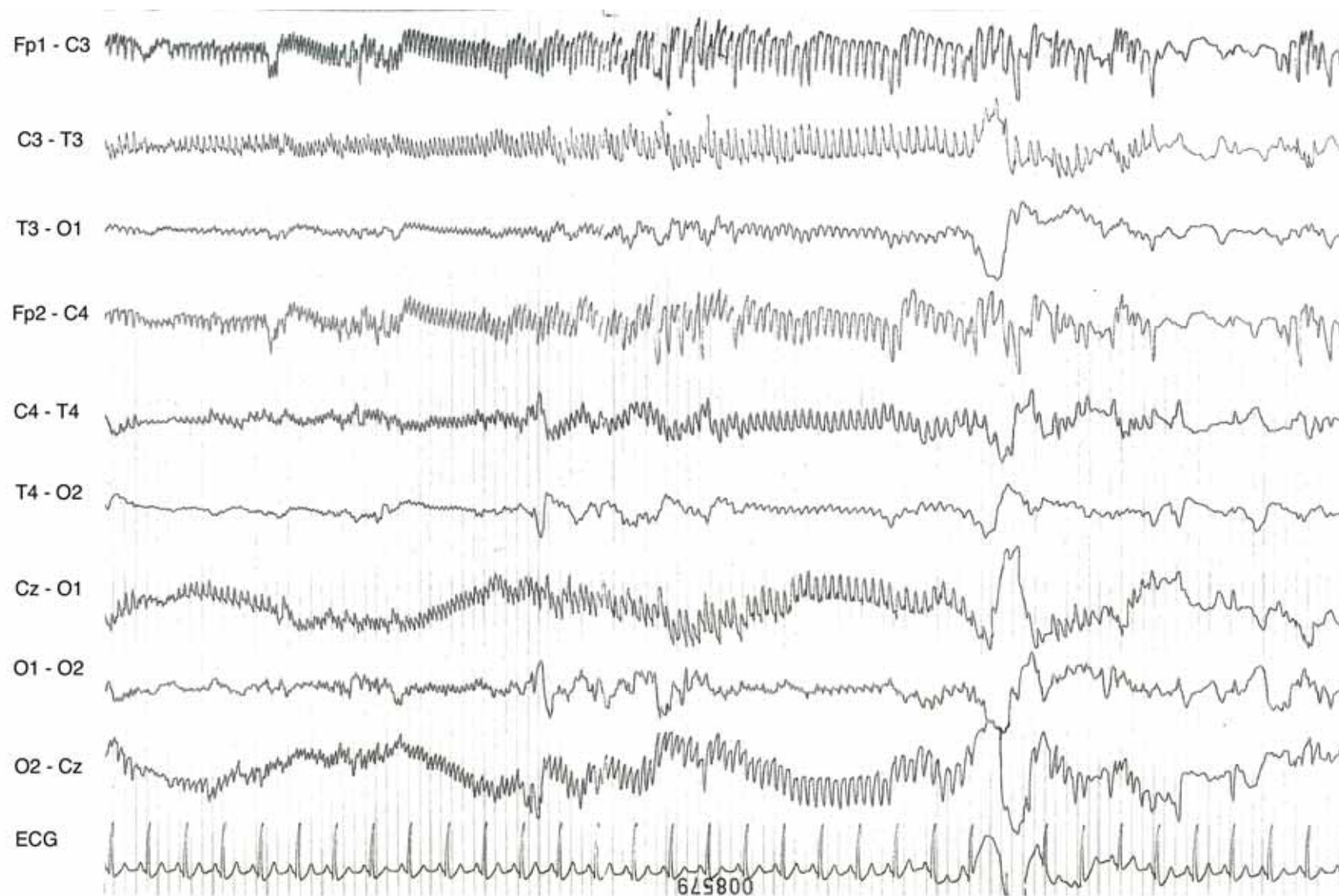


Fig. 3 Standard bipolar montage. On-going seizure, with more amplitude and diffusion of the ictal activity.

M.P.L.

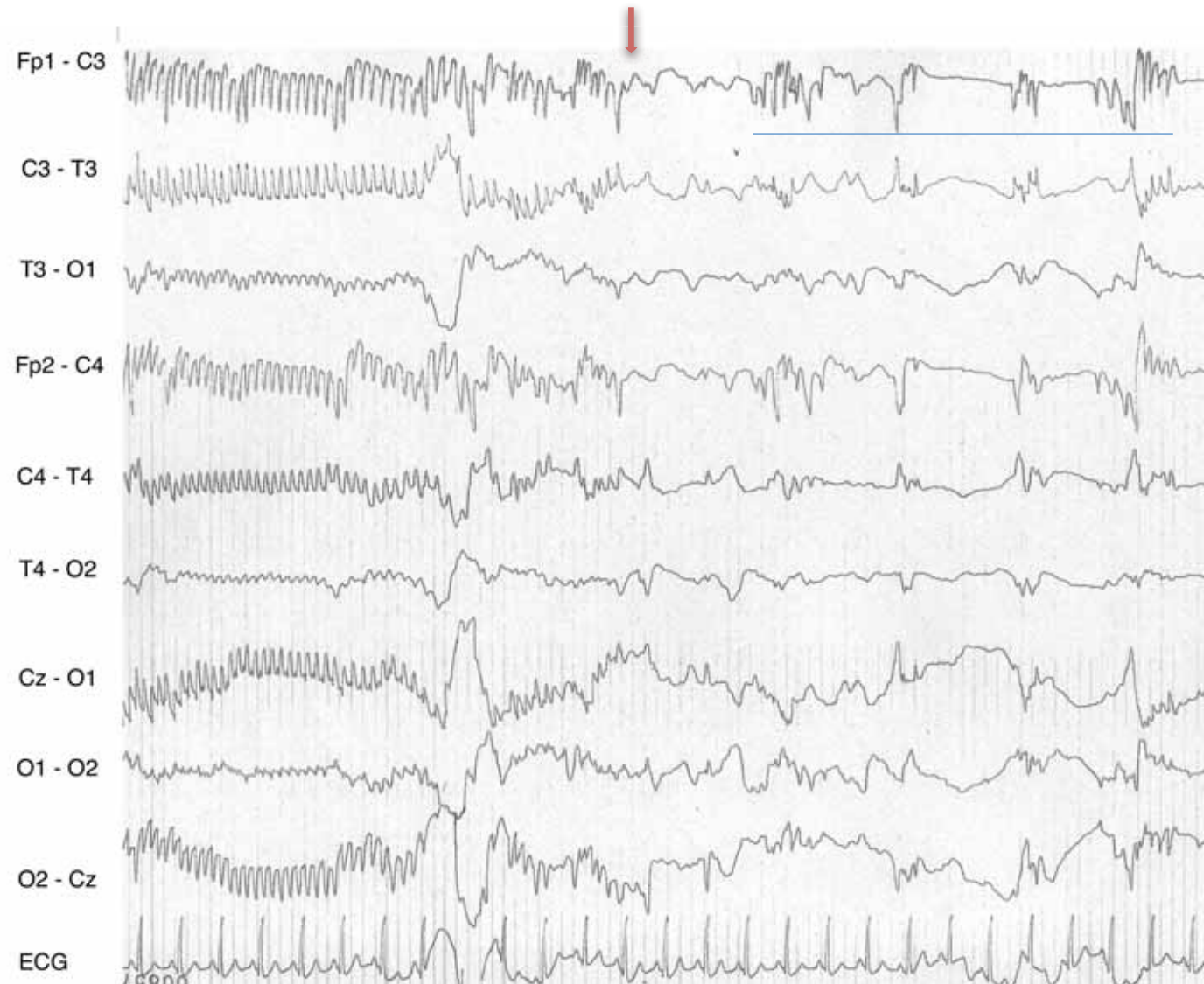


Fig. 4 Standard bipolar Seizure ending, with some rest spiky paroxysmic activity with maximal expression in left pre-frontal region, Fp1.

M.P.L.

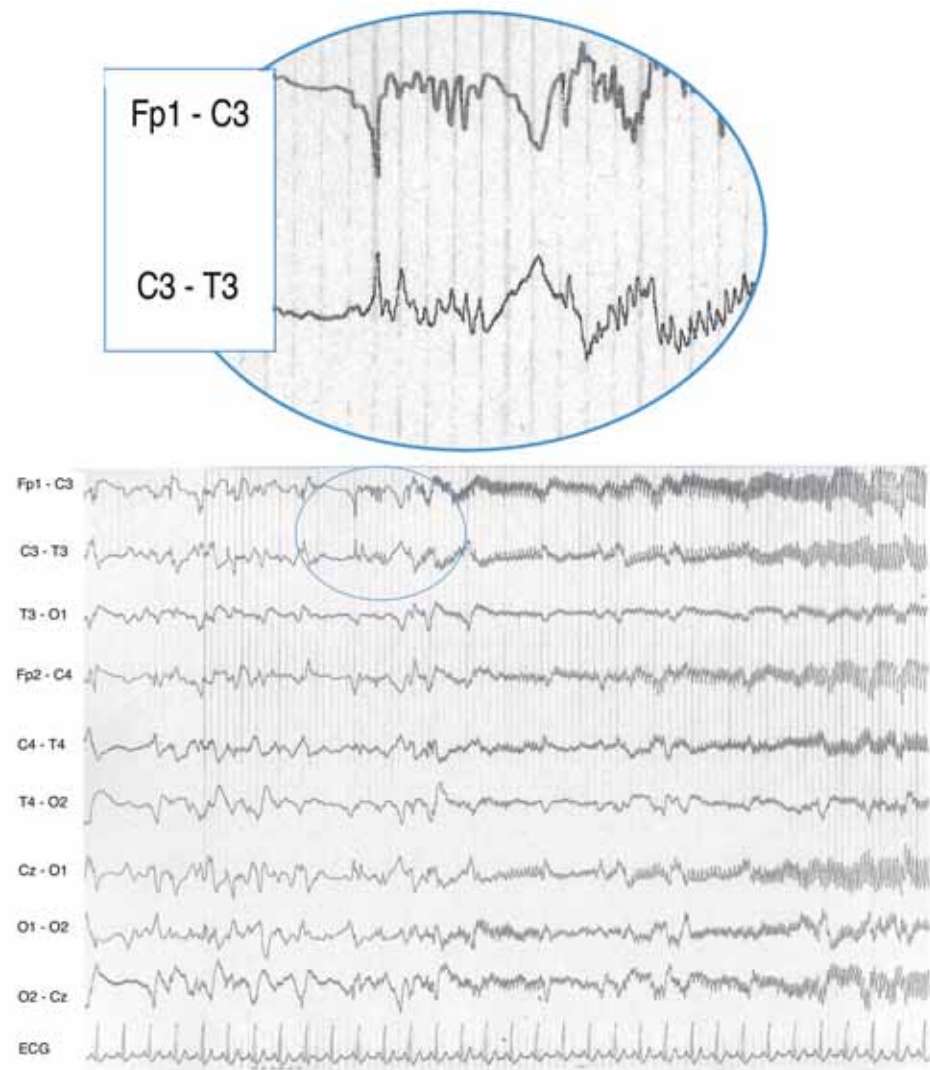


Fig. 5 Standard bipolar. Detailed view of seizure onset. Synchronized rhythm arising from left frontal regions.

C.L.T.

C.L.T.



C.L.T.

Patient with a traumatic antecedent who started having seizures at 14 years old. Clinically he has nocturnal partial complex seizures, sometimes with secondary generalization. Clinically, as ictal manifestations, he opened his eyes with astonishment expression, answering correctly some simple questions while referring a body shake feeling. Post-ictal dysphasic manifestations.

EEG characteristics:

EEG recordings show isolated sharp waves of less than 50  $\mu$ V and irregular slow waves in left inferiorfrontal, F7. Seizures start with synchronized rhythm without a prominent change in amplitude in that region. We have recorded several seizures, with different intensities both electrical and clinical.

C.L.T.

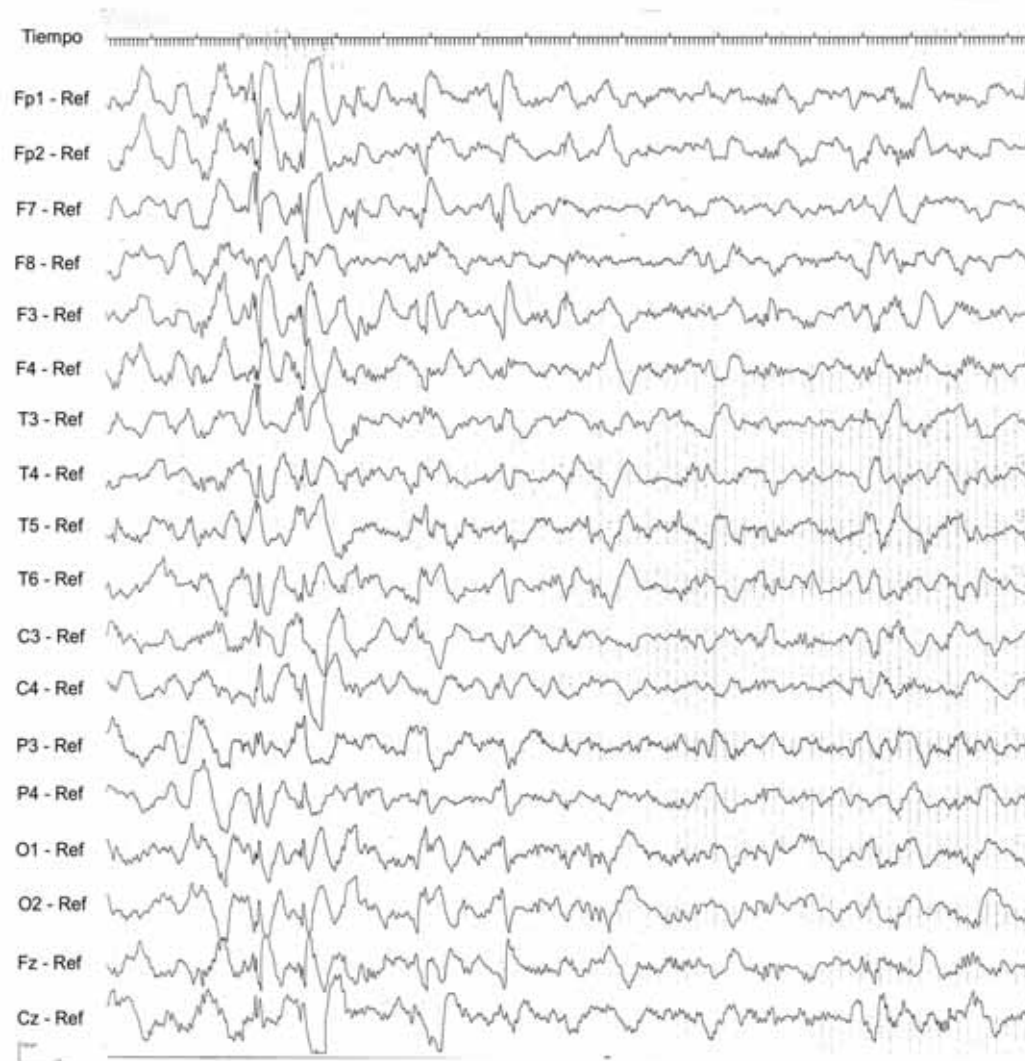


Fig. 1Referential montage. Very active focal activity, that appears quite widespread. Looking in detail we can see a clear left side predominance, with maximal expression in F7 and diffusion to Fp1, F3, T3 and Fp2. Evident contribution of this electronegativity to the mean, causing an opposite deflection in the rest of the channels (T4-Ref, T6-Ref, C4-Ref, O1-Ref, O2-Ref).

C.L.T.

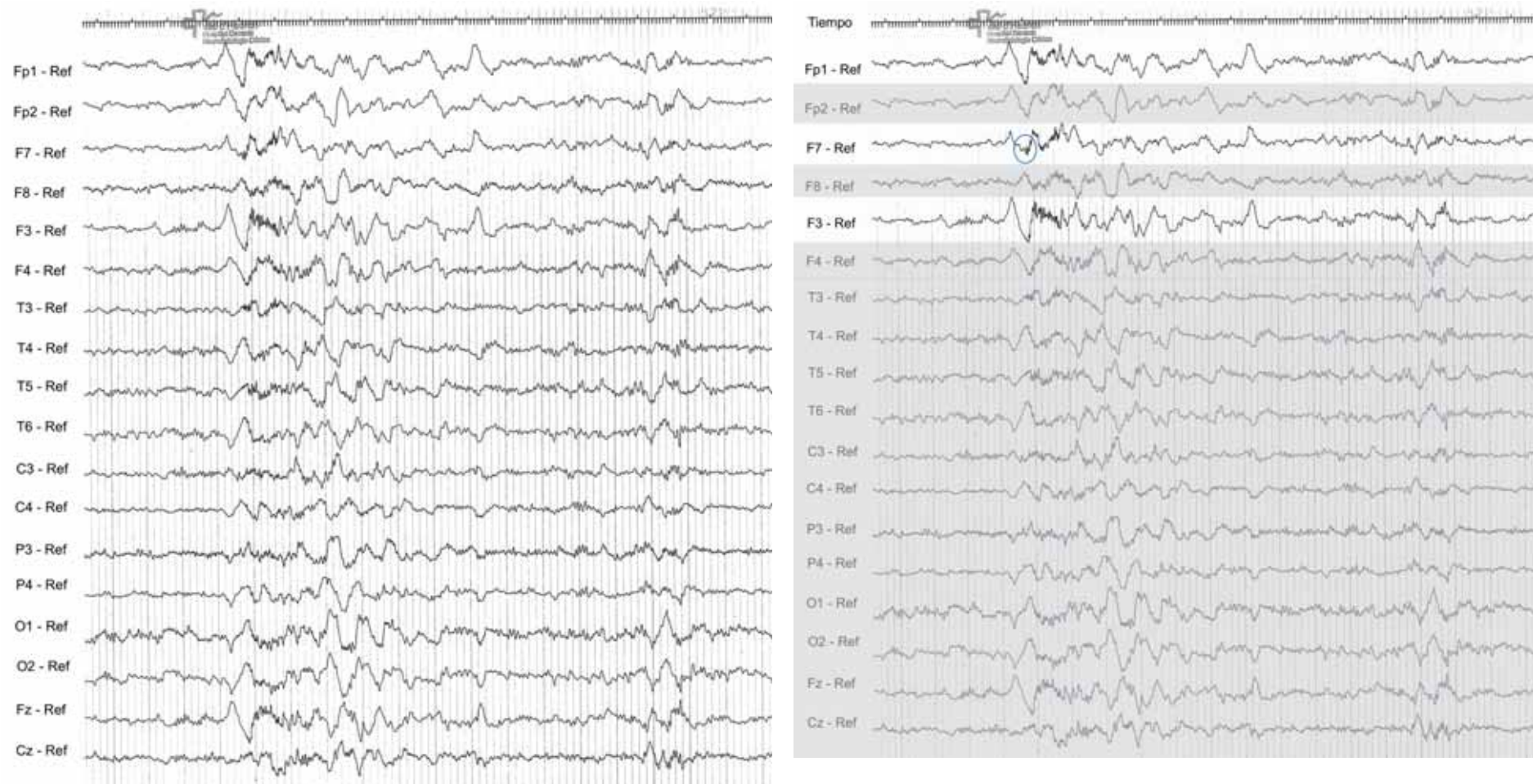


Fig. 2.1 and 2.2 Same epoch with a detail highlighted in fig. 2.2. Referential montage. A synchronized rhythm arises first in inferior frontal region, F7, with fast diffusion to other regions, especially to left pre-frontal, Fp1 and left front-central, F3.

C.L.T.

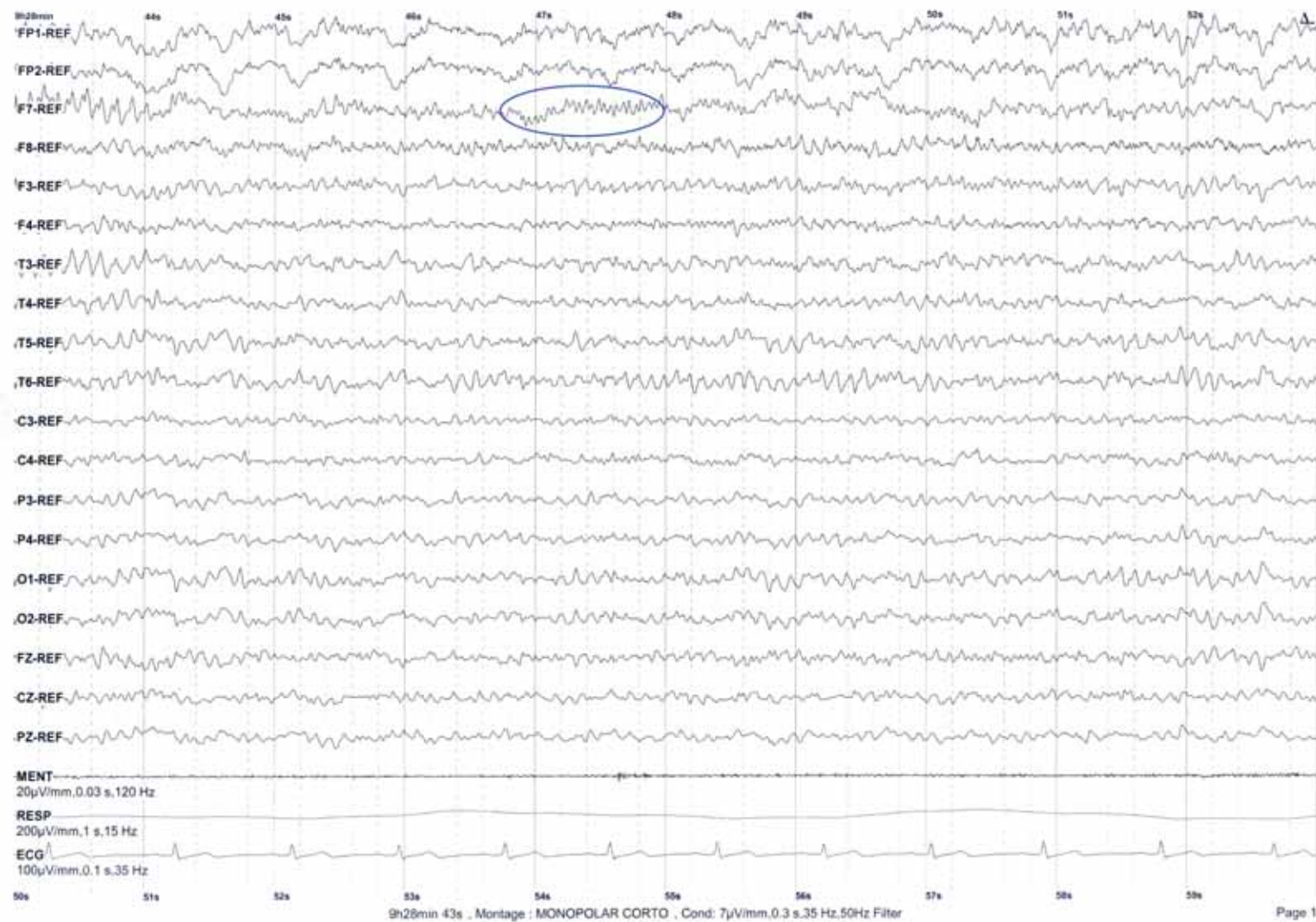


Fig. 4 Referential montage. 10 seconds per page for a more detailed view of the synchronized rhythm that arises from left inferior frontal region.



C.L.T.

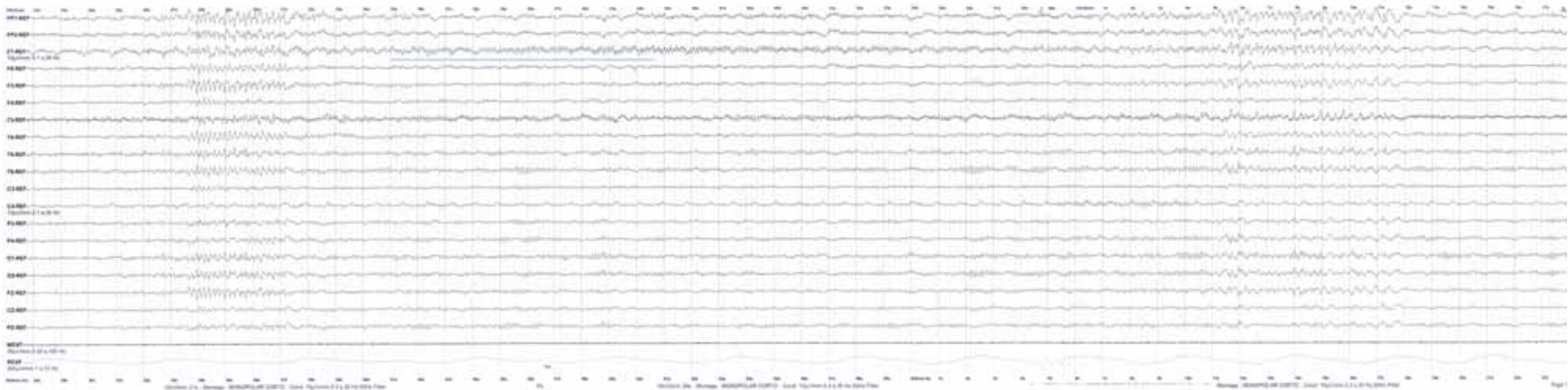


Fig. 5 Referential montage. Collage for a full seizure view.

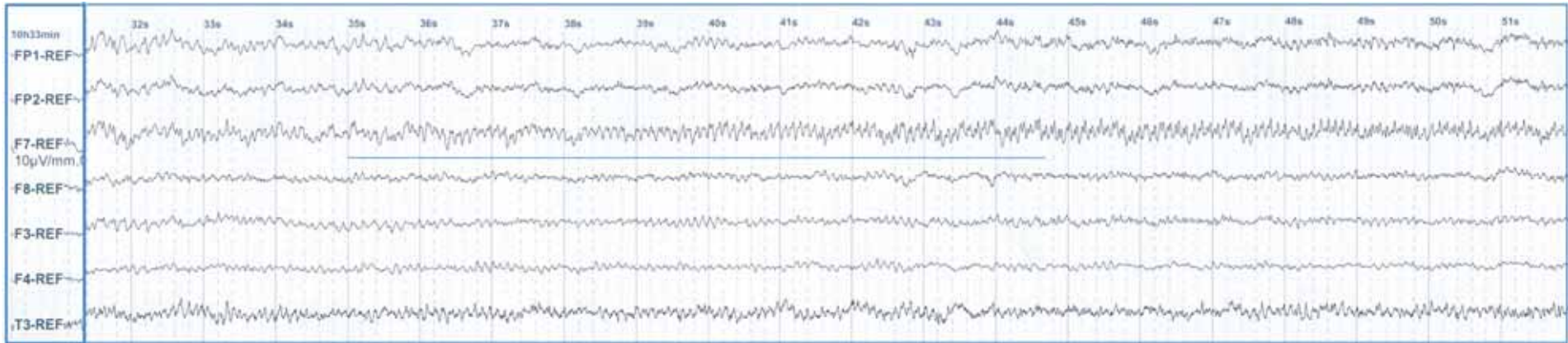


Fig. 6 Referential montage. Detailed view of fig. 5: Synchronized rhythm arising from left inferior frontal region, F7.

A.R.S.

A.R.S.

A.R.S.

Patient with tumoral antecedent who underwent surgery and started having seizures at 57 years old.

EEG characteristics:

EEG recordings show isolated spikes of less than 50  $\mu$ V in left prefrontal regions, mixed with breach rhythm due to the surgery antecedent.

Seizures arise from left pre-frontal region at around 13 Hz

A.R.S.

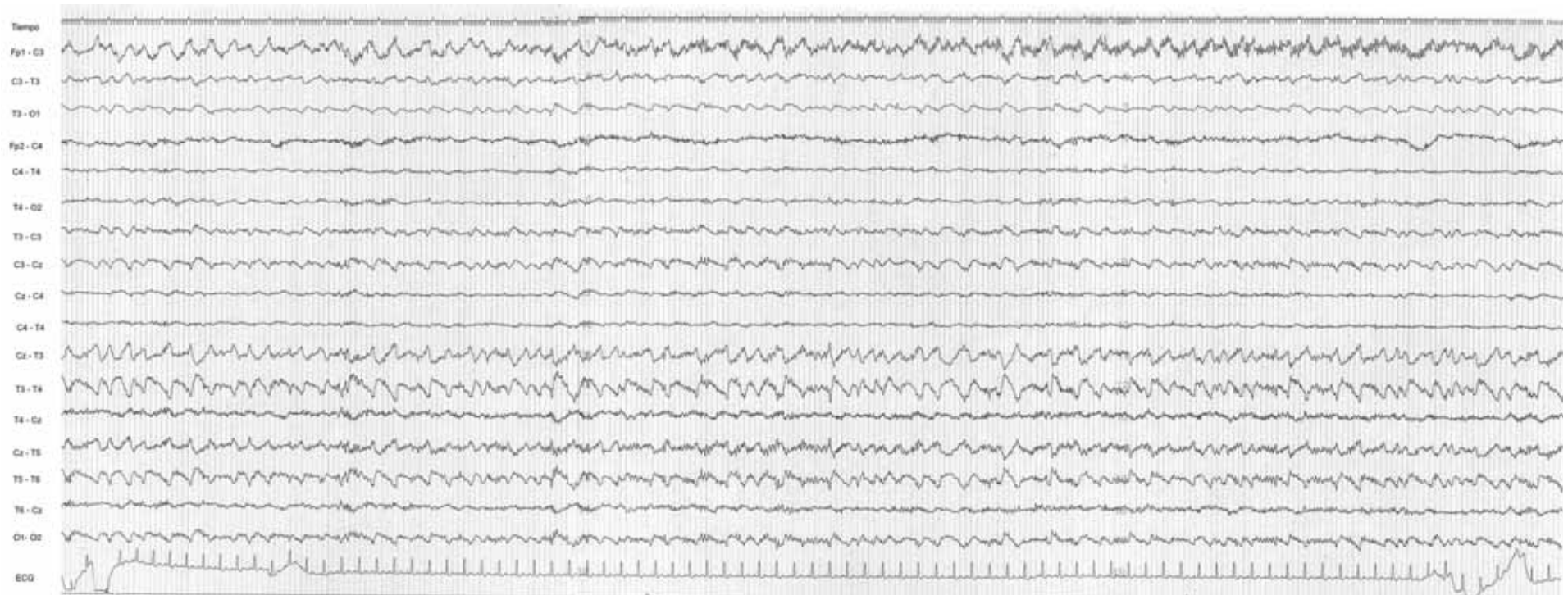


Fig. 1 Standard bipolar. We only have this recorded seizure, arising from left pre-frontal region, Fp1. Tachycardia in polygraphy signal



A.R.S.

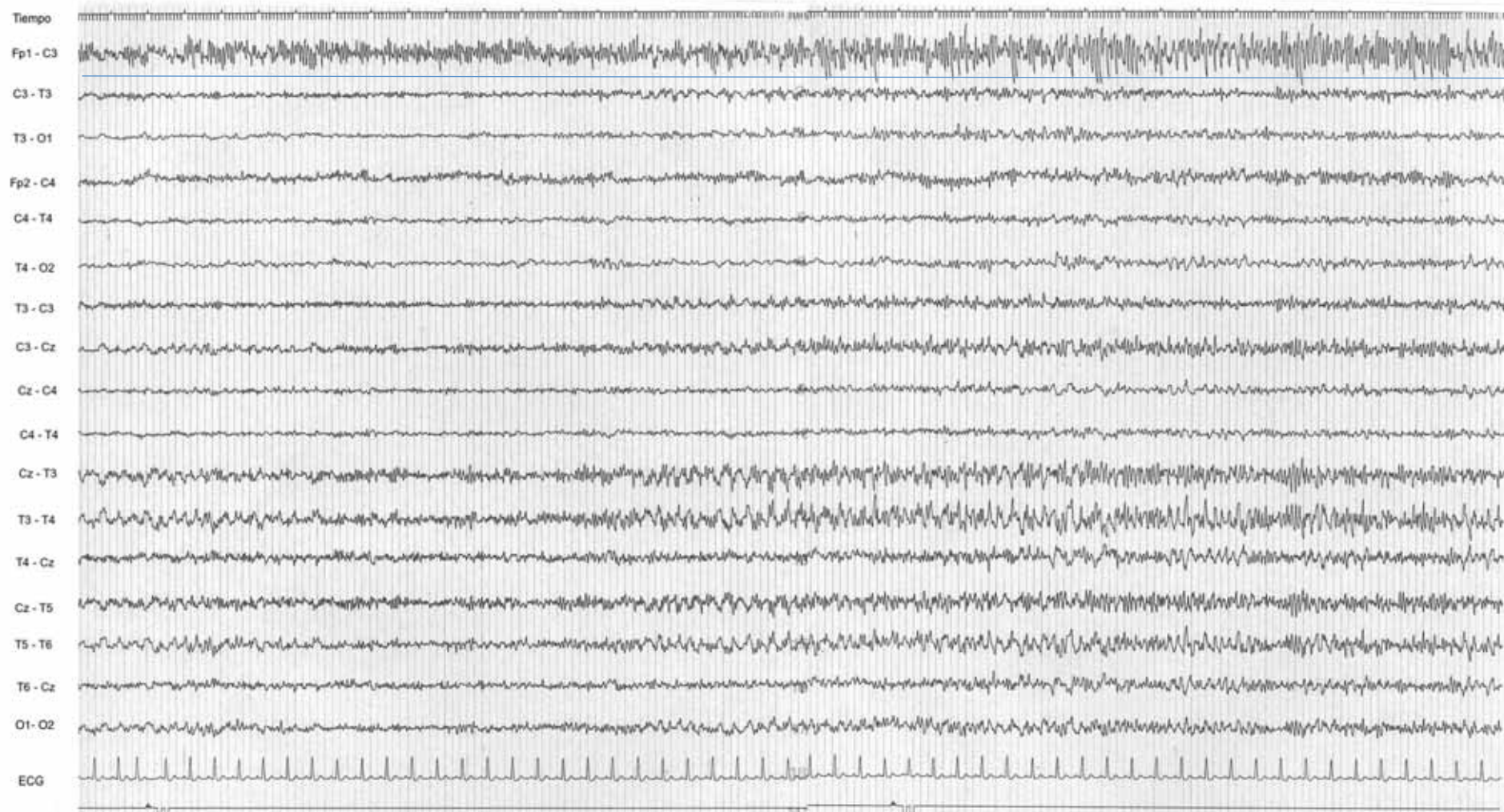


Fig. 2 Bipolar standard montage. After 40 seconds, the ictal activity is more widespread.

A.R.S.

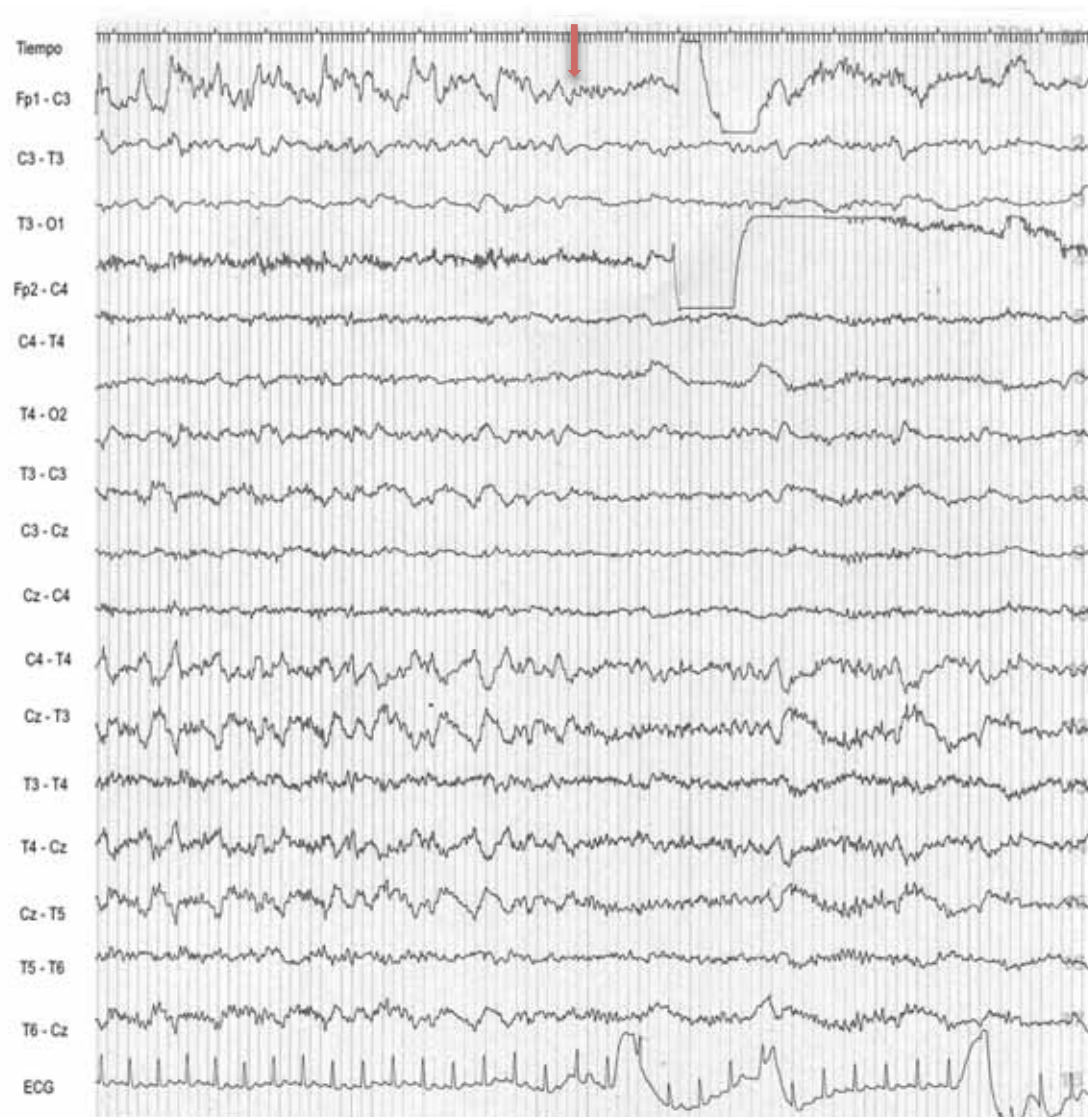


Fig. 3 Seizure ending and immediate re-structuration of the alpha rhythm.

J.R.O.

J.R.O.

J.R.O.

Patient who started having seizures at 6 years old. Antecedent of Dandy Walker syndrome with cerebellar atrophy showed by MRI. Clinically he presents simple partial seizures with motor manifestations: he seat on the bead with opened eyes, blowing and raising of the right arm tonically. Sometimes with secondary generalization.

EEG characteristics:

He presents a left front-central focus, with spikes of 50-100  $\mu$ V followed by a slow wave and isolated sharp waves of 50-100  $\mu$ V. Seizures starts with a low amplitude synchronized rhythm at around 13 Hz, more evident in left front-central region, where there is also evident slowing after seizures.





Fig. 1 Standard bipolar montage. Spike followed by a slow wave. This montage does not give accurate location of IED.



Fig. 2 Referential montage. This montage helps a lot in locating the IED, with maximal expression in left front-central region, F3, and diffusion to Fz, Fp1, F7, F4. Opposite waveform in other channels as T4, T6, O1, O2 due to the contribution of this activity to the reference.

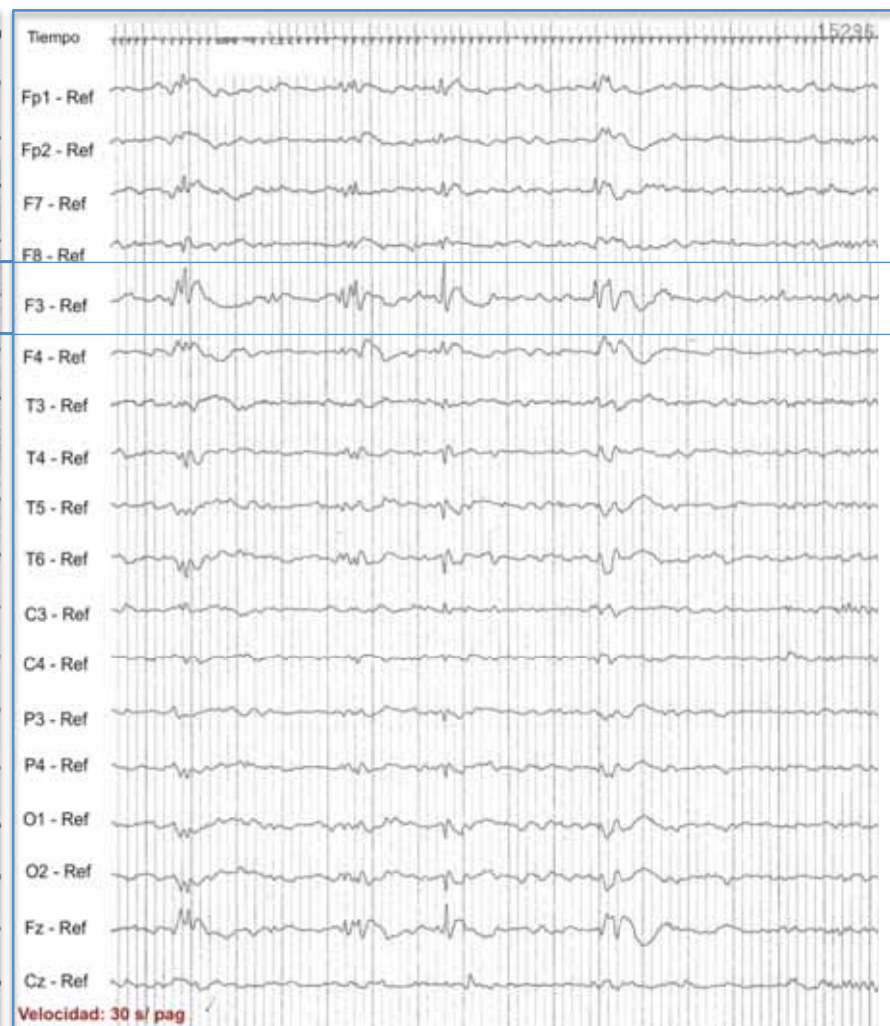


Fig. 3 Speed settings at 10 seconds/page. We can even improve the location of the activity looking for the epochs when the focus presents less active, appearing more located in left front-central region, F3.

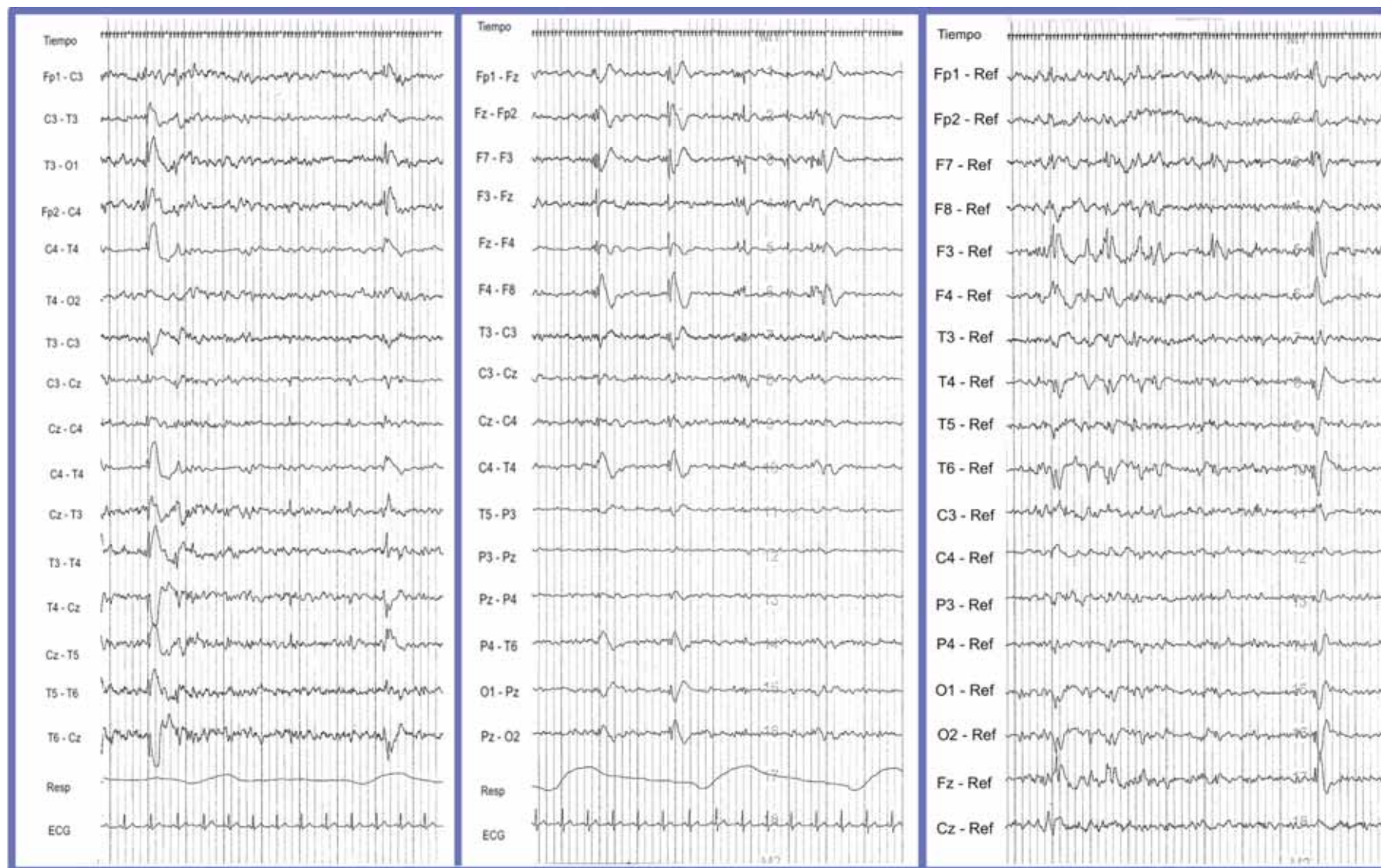


Fig. 4 Collage of bipolar standard, transversal, and referential montage. Comparing the aspect of interictal activity.



J.R.O.

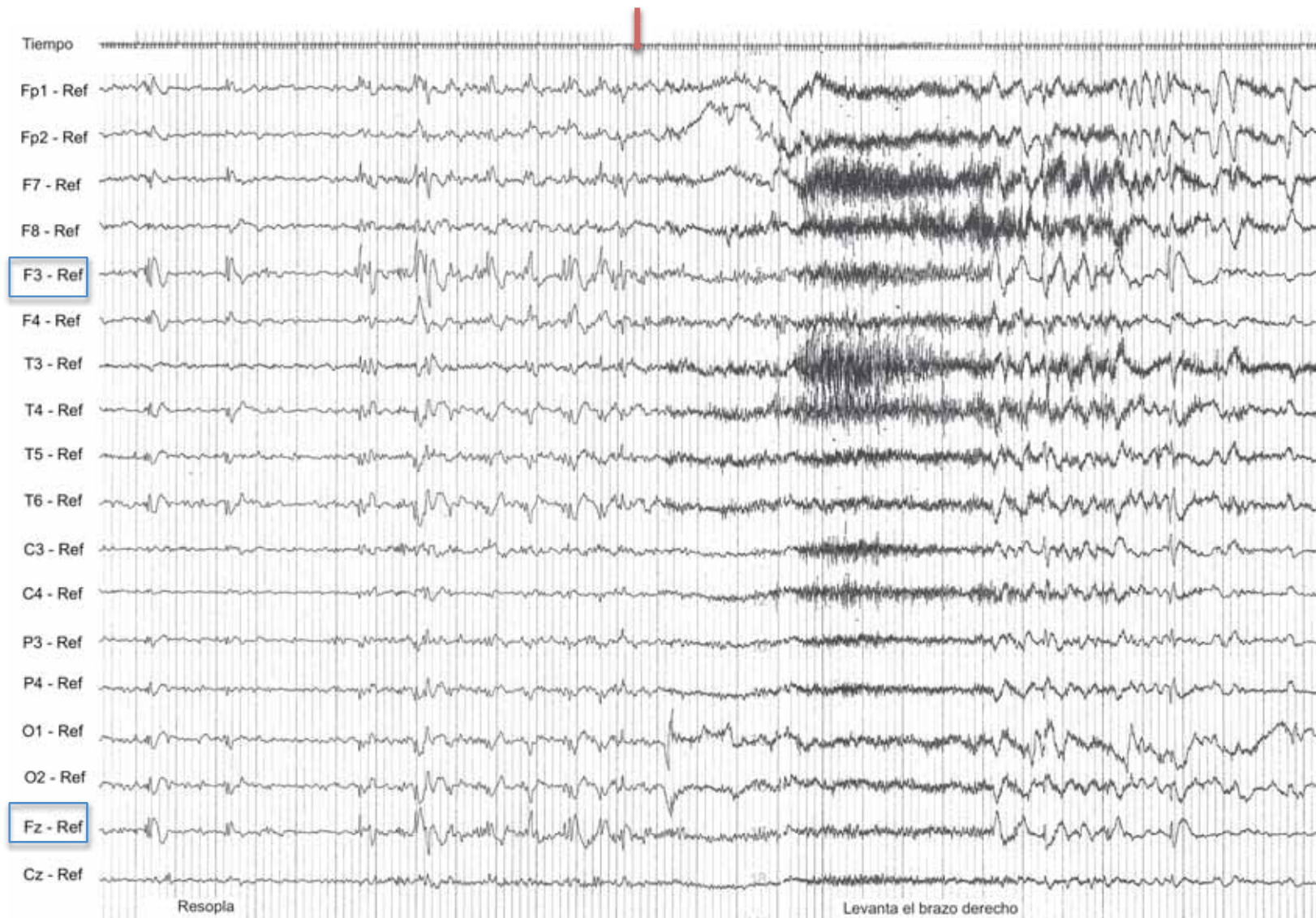


Fig. 5 Referential montage. Increasing IED and short seizure starting with low amplitude synchronized rhythm with more attenuation in left front central areas, F3. Postictal slowing prominent in both frontal regions, with left front-central region predominance and IED appearing again after seizure with maximal expression in F3.



C.G.S.

C.G.S.

C.G.S.

Patient who started having seizures at 6 years old, one week after a cranial traumatism. Normal MRI. Being an adult, she was studied in our department. She presented simple and complex partial seizures, sometimes with secondary generalization, regarding the intensity and diffusion of the ictal activity, with dysphasia and with psychic manifestations, “being unable of be aware of perceptions” (in her own words) in the simple partial seizures.

EEG characteristics:

The basal activity was well structured (Fig. 1), but with the standard montage we do not appreciate the asymmetric features observed with bipolar transversal montage, in which we can see, as interictal activity, a few very low voltage sharp waves with more expression in left central and front-central regions (Fig. 2). Seizure is recorded, with left frontal origin.

C.G.S.

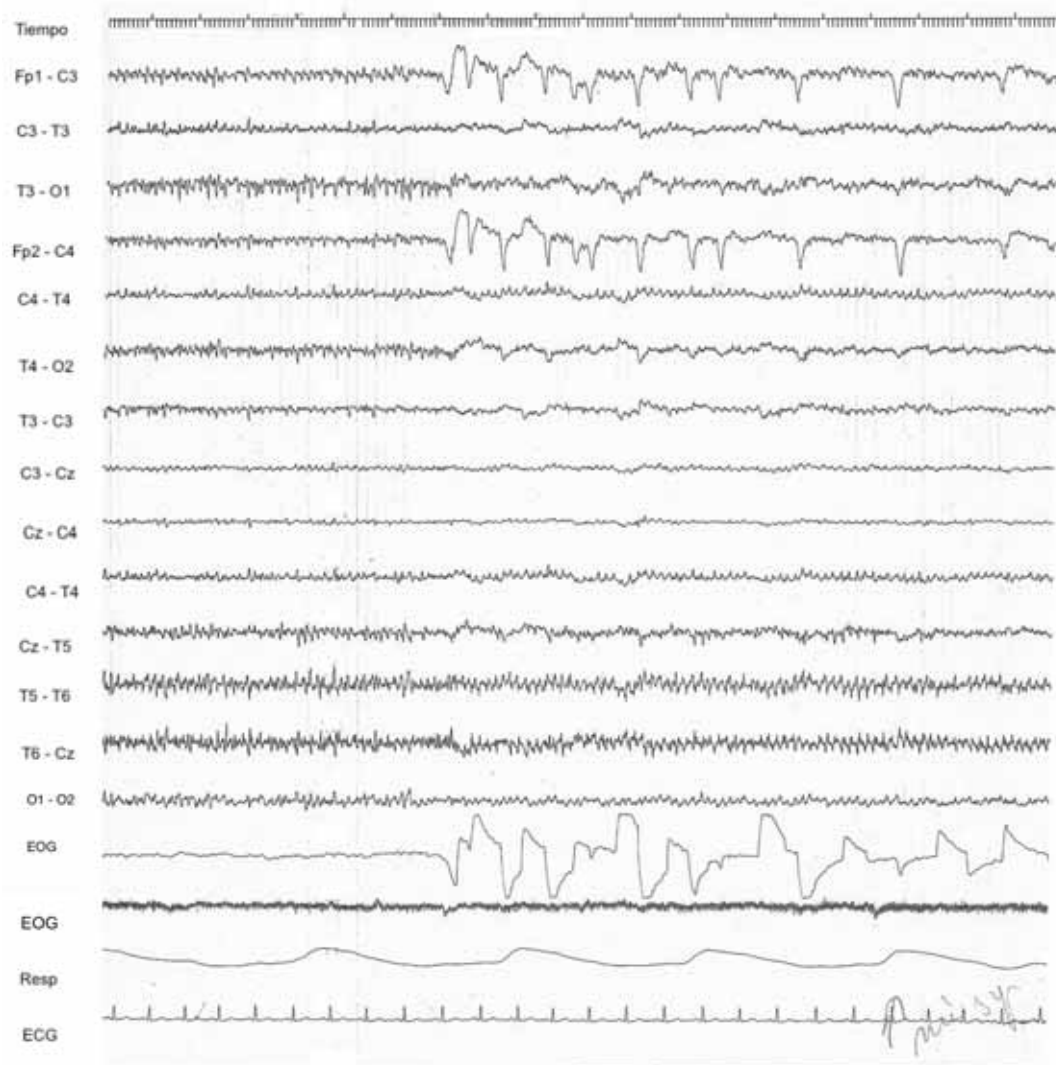


Fig. 1 Standard bipolar montage showing awake activity, with reactivity of alpha rhythm to eyes opening.

C.G.S.

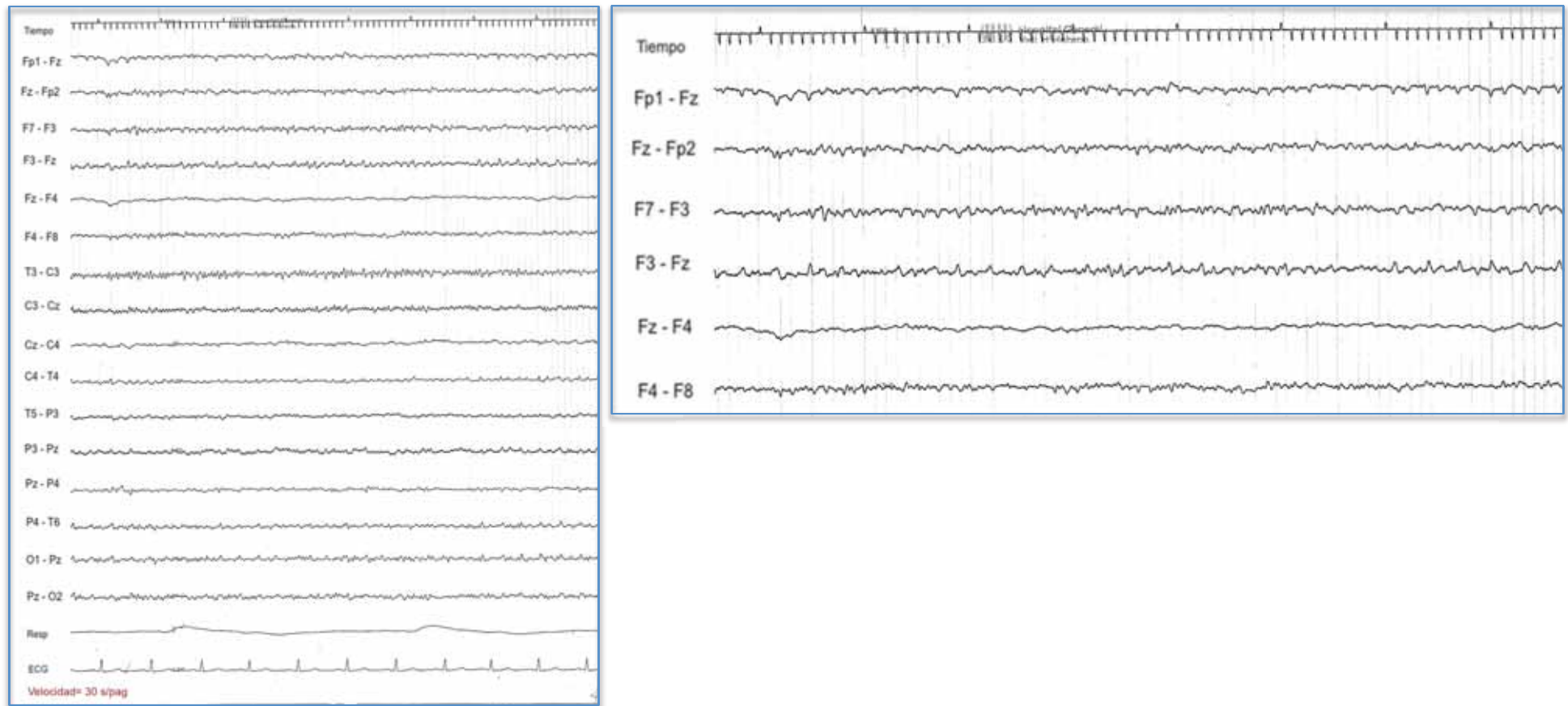


Fig. 2.1, 2.2 In the transversal montage we can see asymmetrical activity comparing left frontal with right frontal regions. Low voltage sharp waves are seen with left frontal predominance.



C.G.S.

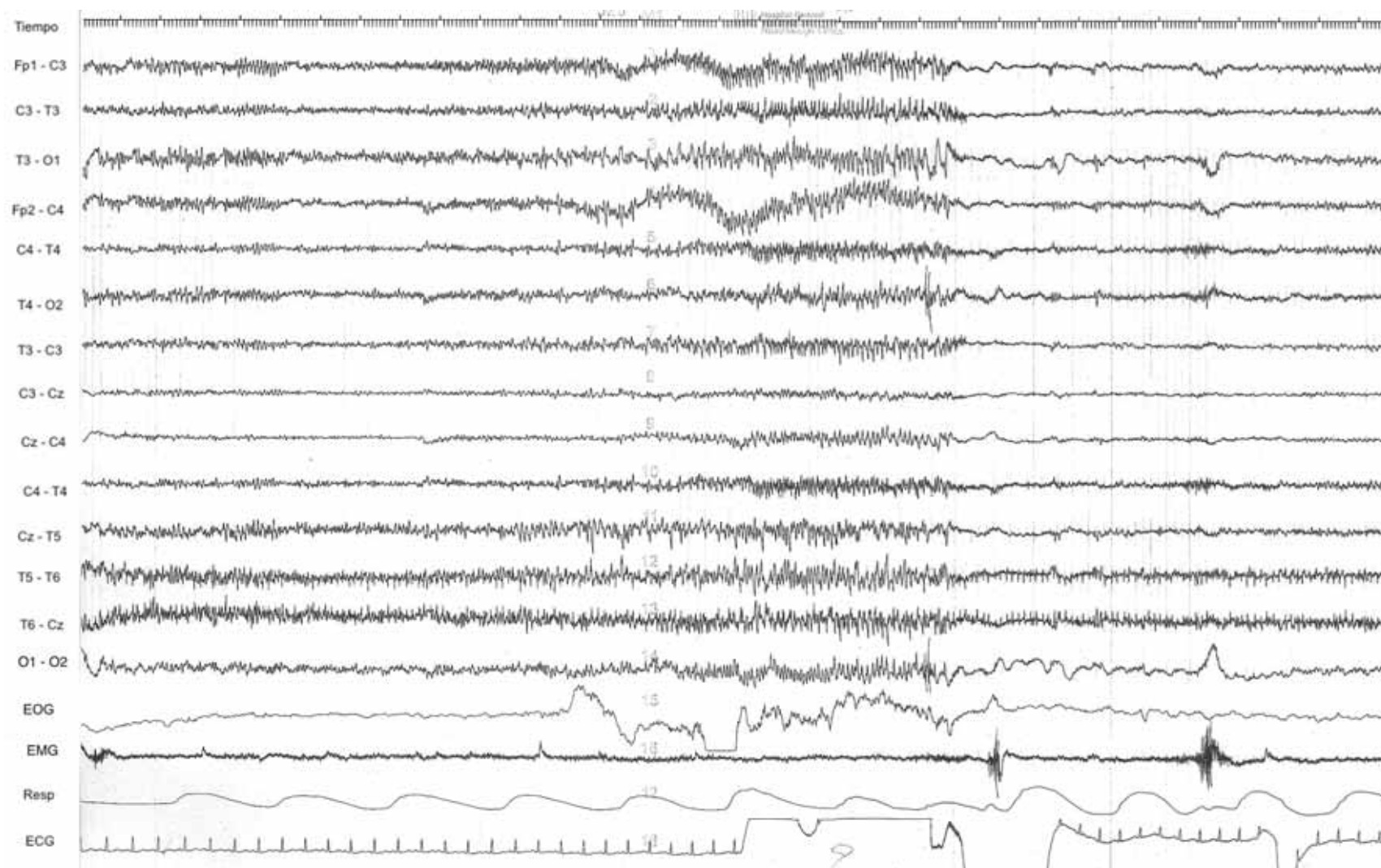


Fig. 3 Bipolar standard. Seizure with a low amplitude synchronized rhythm more expressive in left frontal regions, arising from sleep. Tachycardia and breathing irregularity after some seconds after onset.

R.M.C.

R.M.C.

R.M.C.

Patient with a TBI with normal CT who started having seizures at 21 years old orientated as generalized tonic-clonic seizures. She arrived in the emergency department after having several seizures without recovering consciousness. An EEG and MRI was performed, showing haemorrhagic chronic lesions in left frontal lobe and right protuberance, suggesting cavernoma malformation.

He presented three seizures during the EEG recording. Clinically opened his eyes, with groaning and facial clonic movements, raising his eyebrows and sometimes moving his mouth. We have observed a light up-ward movement of both arms individually. The patient remained unconscious between episodes.

EEG characteristics:

We started the recording within a seizure (Fig1). The ictal activity appears very widespread in both bipolar and referential montages. Looking carefully, in standard bipolar montage one can appreciate a left side predominance of a synchronized rhythm arising at seizure onset. (Fig 1.1, 1.2). The seizures were very long, up to 10 minutes of length.

Postictal alpha rhythm in posterior regions combined with marked frontal slowing supports the focal origin of the seizures.

R.M.C.

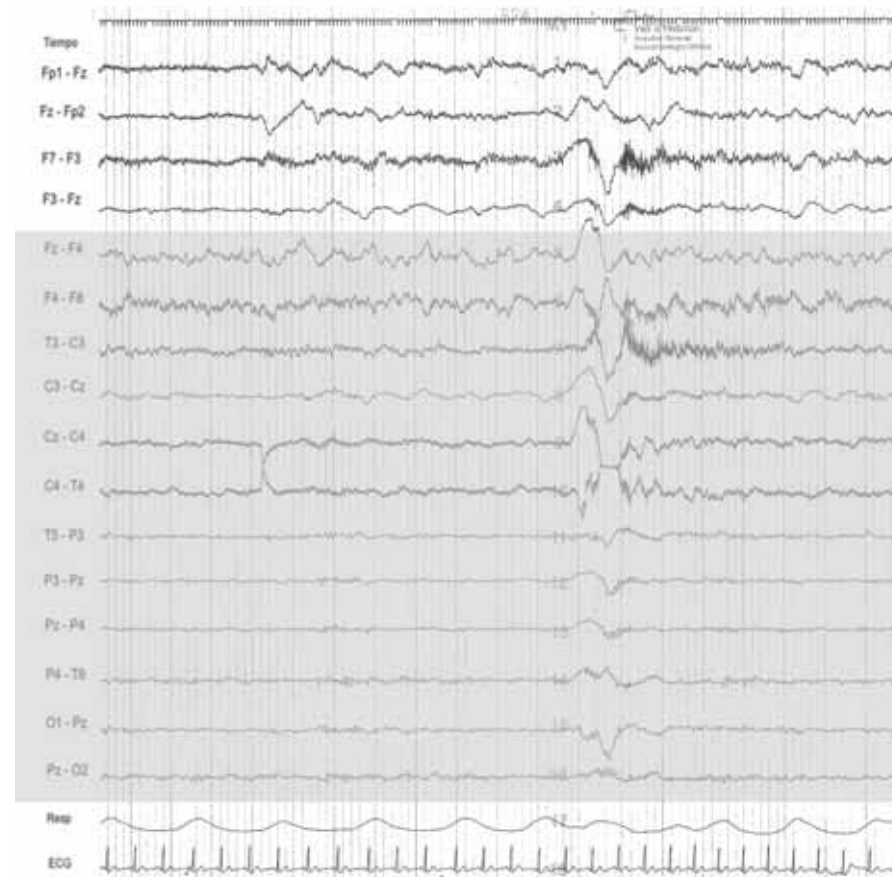
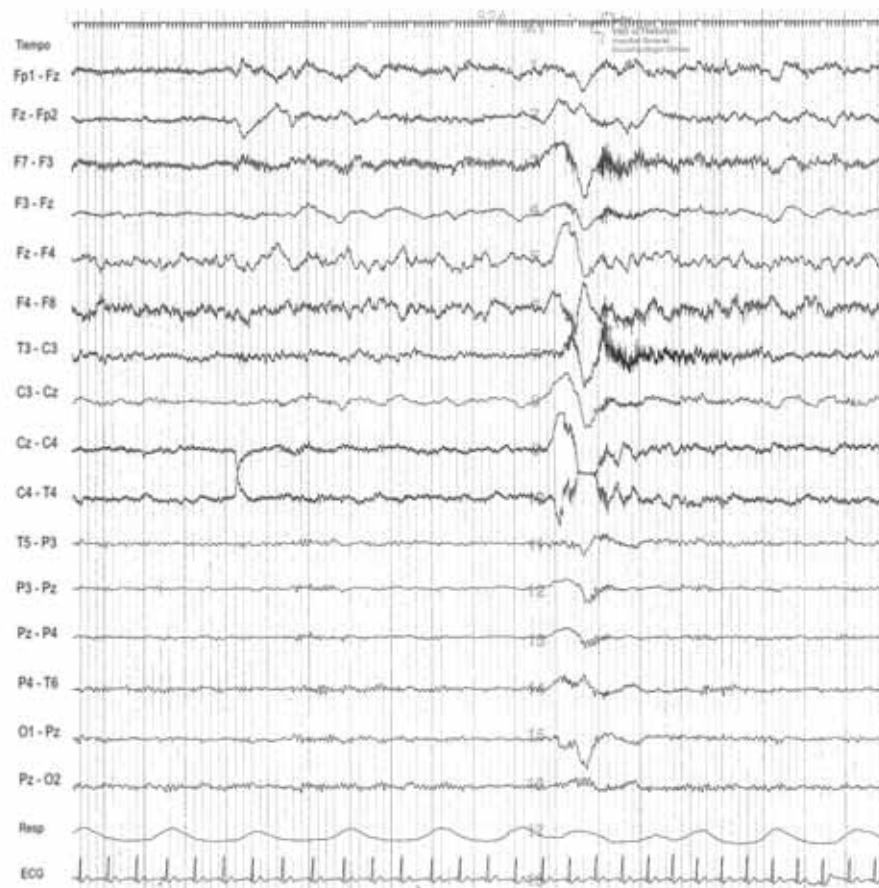


Fig. 1.1, 1.2 Transversal montage. A seizure is arising with a low amplitude synchronized rhythm with maximal expression in left frontal regions. Slight breathing irregularity and tachycardia.



R.M.C.

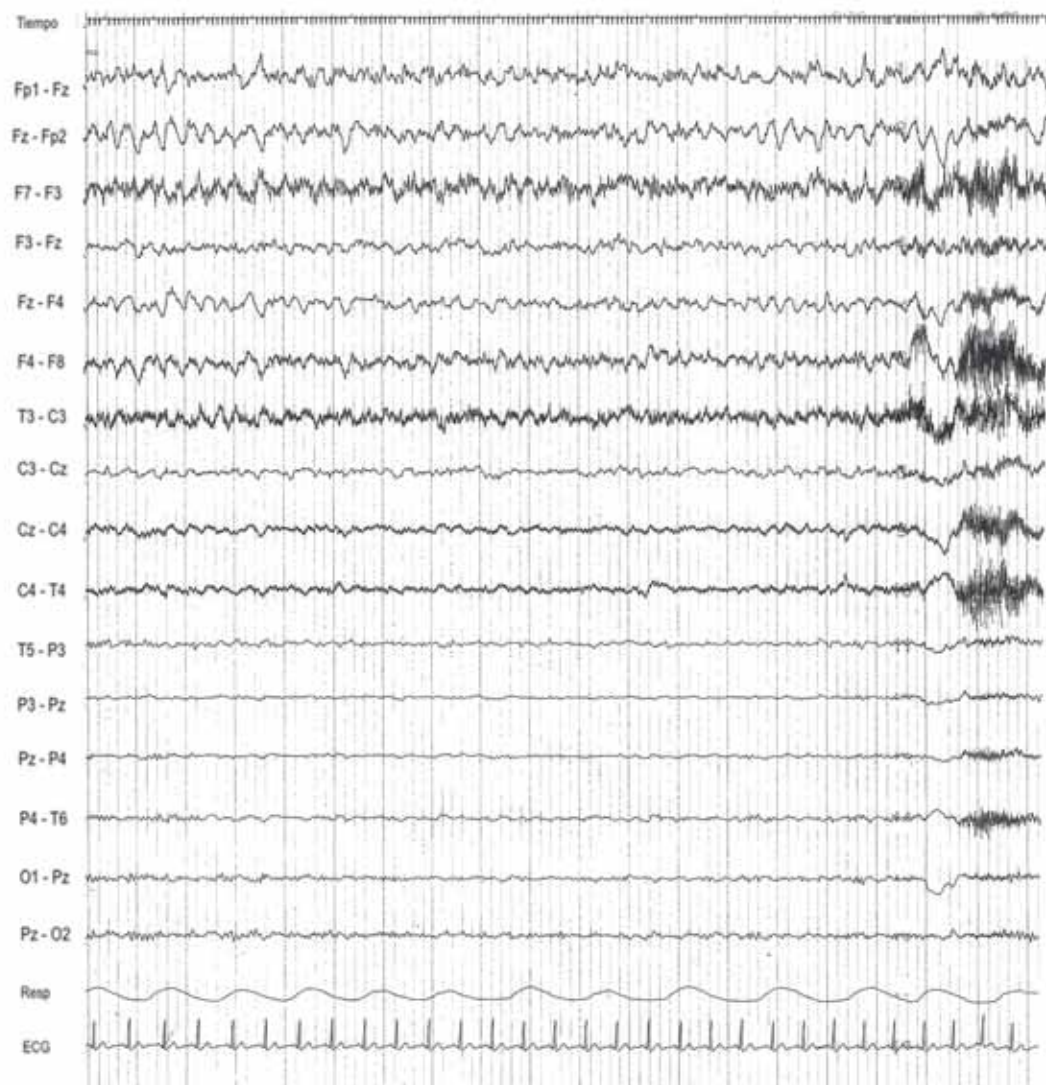


Fig. 2 Transversal montage. On-going seizure, after 3 minutes.

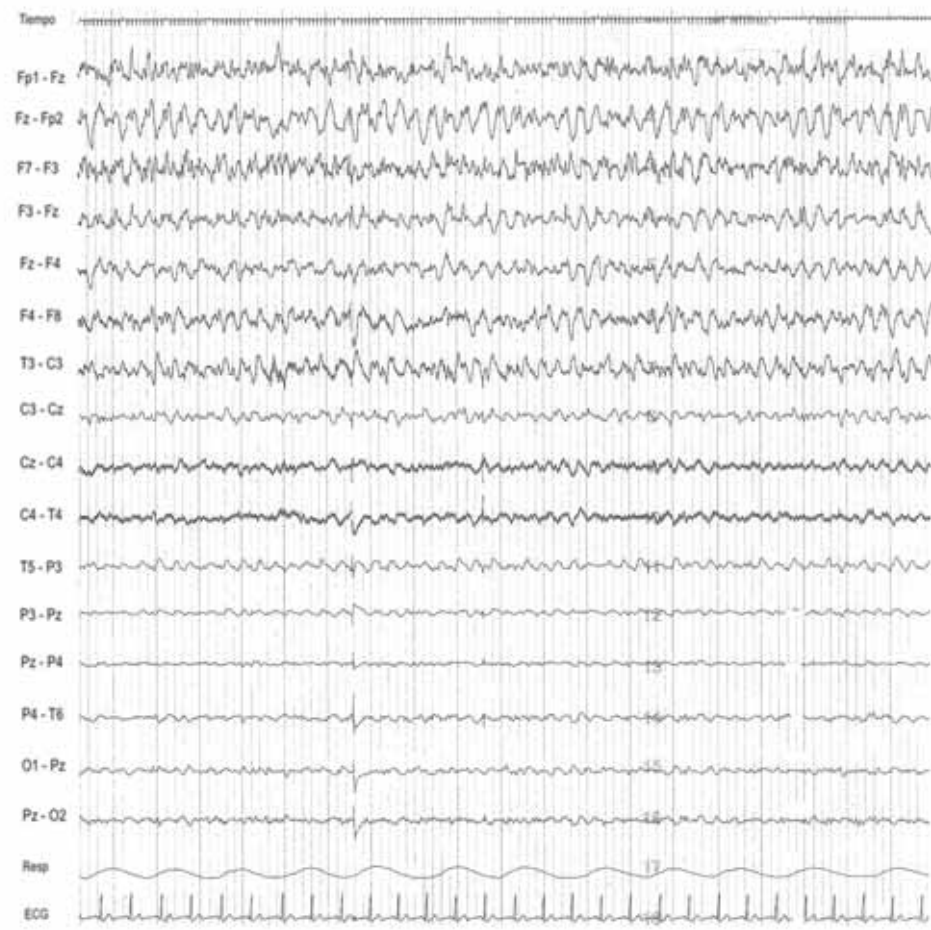


Fig. 3 Transversal montage. on-going seizure, after 5 minutes.

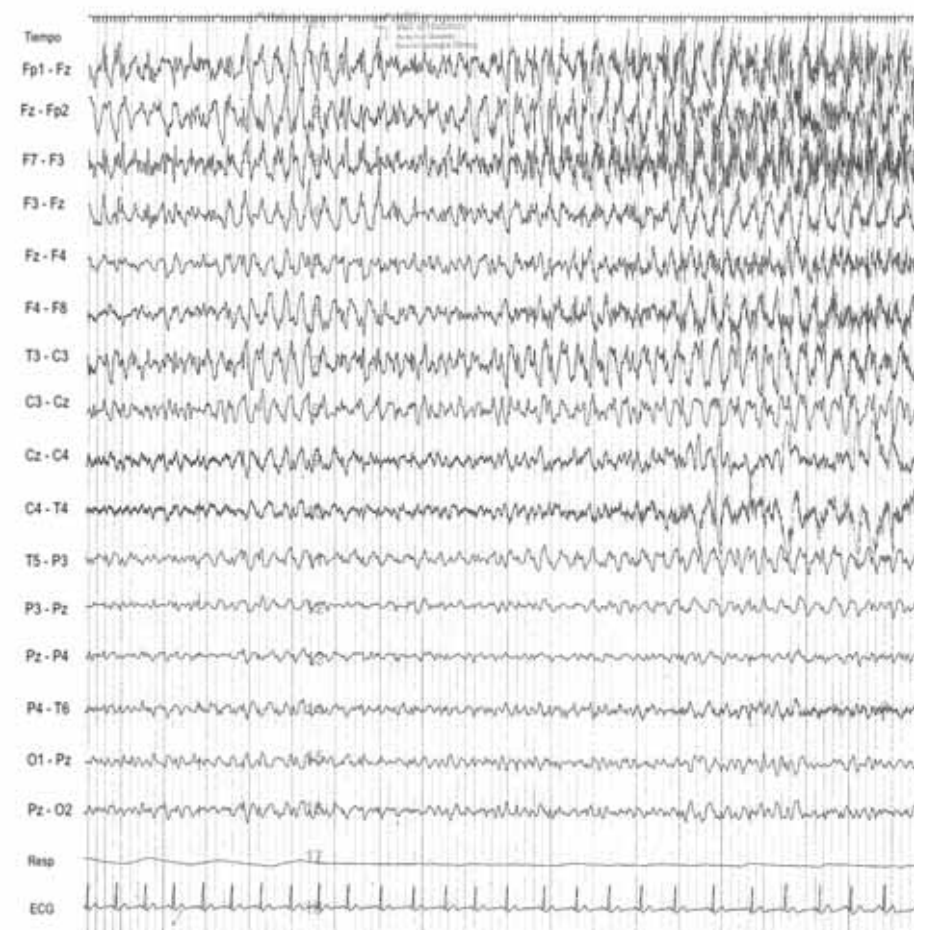


Fig. 4 Transversal montage. On-going seizure, after 6' 20" of onset.

R.M.C.

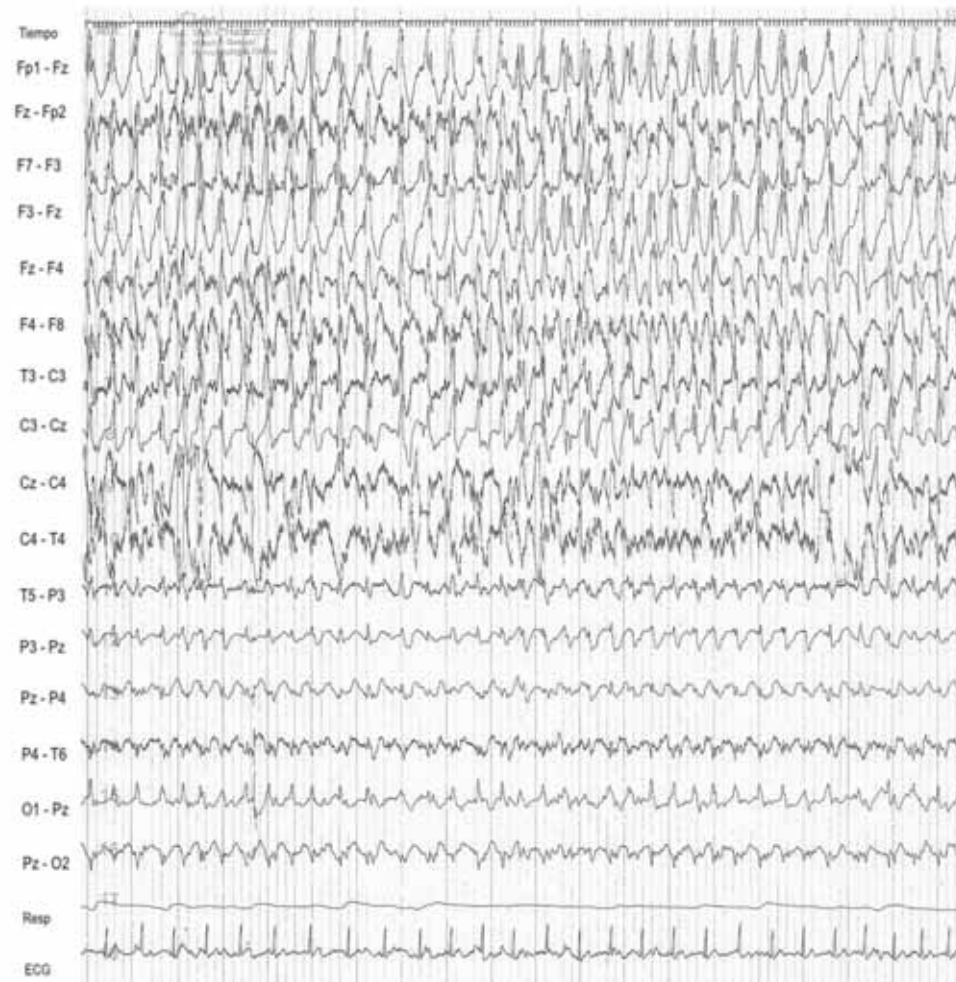


Fig. 5 Transversal montage. Same seizure after 9' after onset. Frontal predominance of the ictal activity during seizure.

R.M.C.

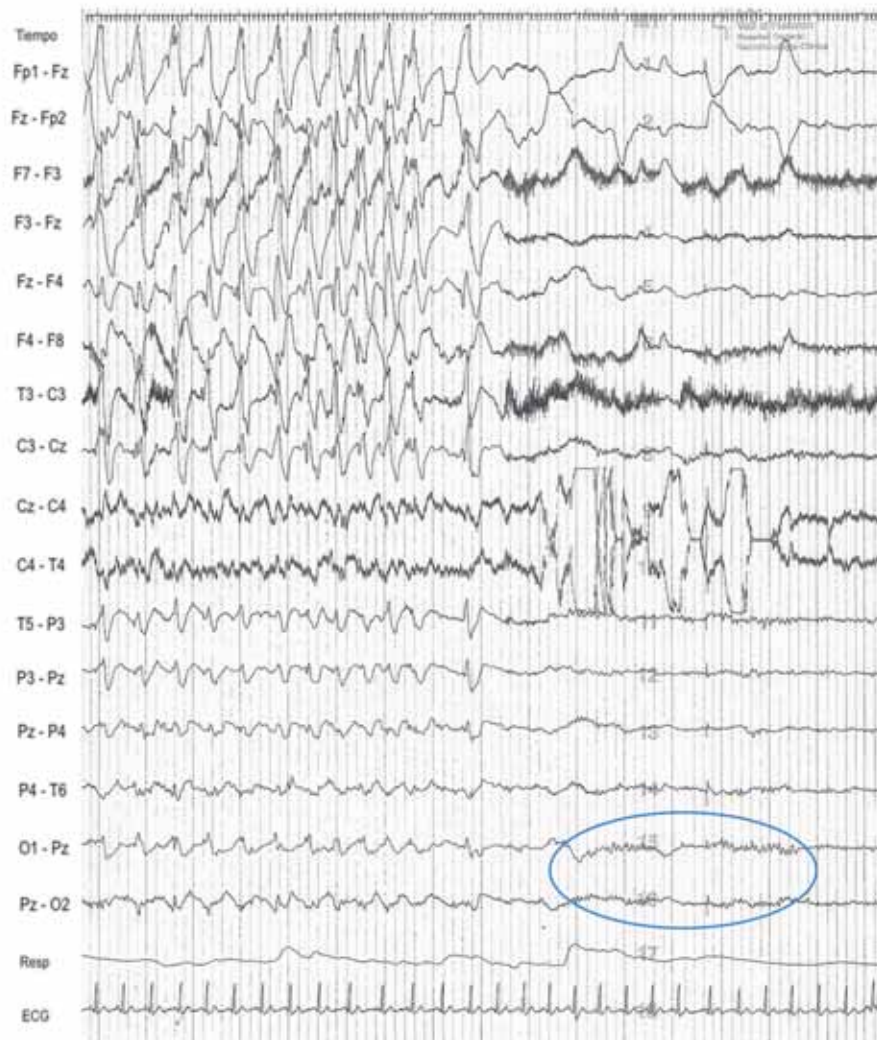


Fig. 6 Transversal montage showing seizure ending. Immediate basal activity, at alpha frequencies in both posterior regions and bi-frontal slowing, with left predominance.



R.M.C.

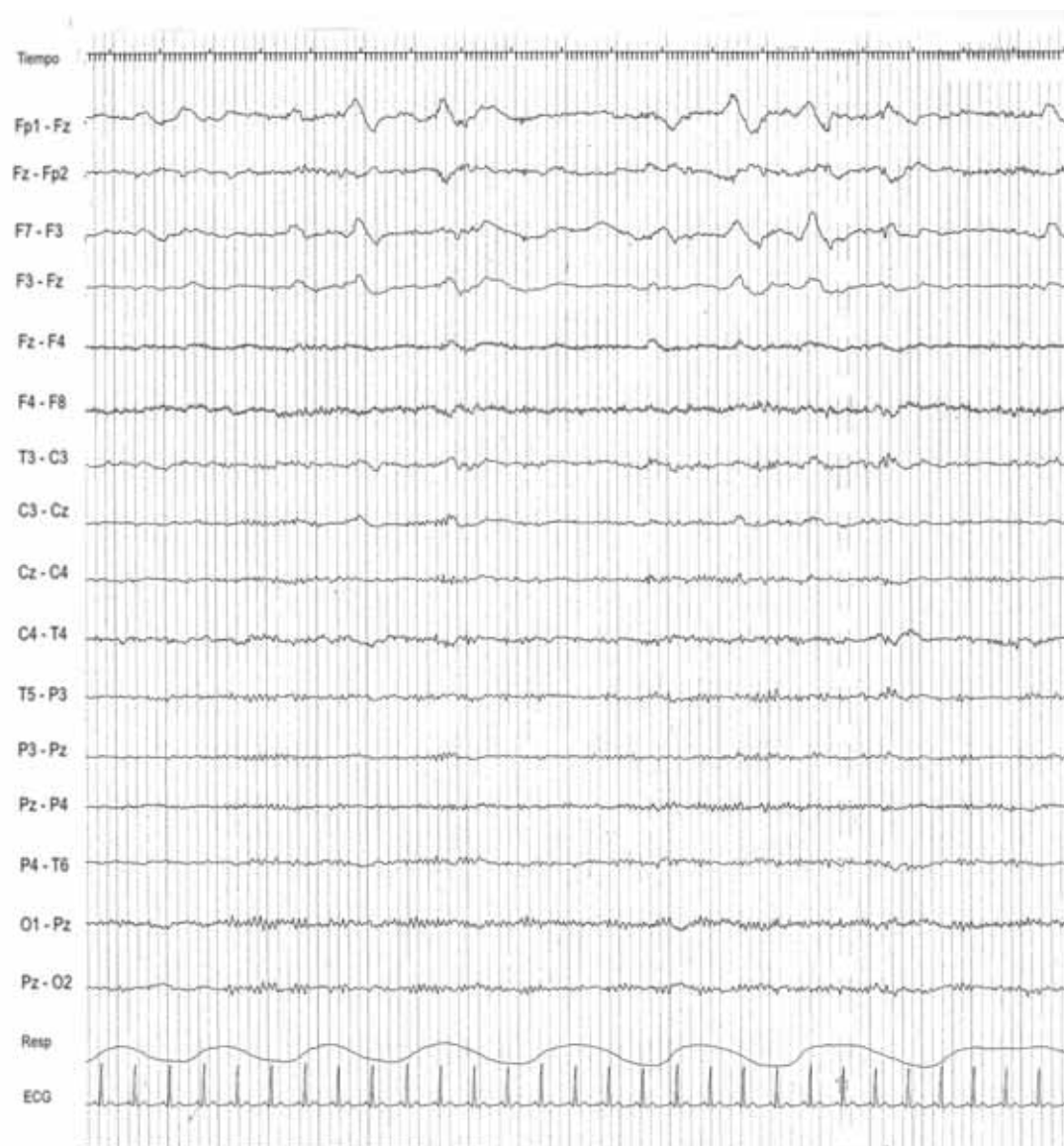


Fig. 7 Bipolar transversal montage. Post-ictal slowing with maximal expression in left frontal regions, Fp1, F7, F3.

A.S.A.

A.S.A.

A.S.A.

Patient who started having seizures at 25 years old. Eight years before he had had a TBI, and an MRI showed a right frontal lesion. He arrived with pain and movement of right arm, and afterwards impairment of consciousness. Afterwards he was aphasic and with right hemiparesis. The case was oriented as encephalitis, which was not confirmed. He presented several episodes, showing very agitated, with right arm movements and secondary generalization. Clinically this case was one of the most complicated ones, as the MRI showed a right residual lesion while the clinical events suggested a left origin. After the first type of seizures he presented different episodes with sweetening, abundant salivation and midriasis. EEG at the beginning of these clinical events showed slow waves more expressive in left frontal regions (postictal slowing). Following EEG recordings showed rhythmic activity, sometimes at theta frequencies and other times at delta waves very rhythmical, and was fortunately soon orientated as ictal activity. Due to the pharmacologic treatment refraction he received antiepileptic drugs and sedation in the intensive care unit. He remained having seizures after sedation, with midriasis and blinking and different EEG patterns (frequency and voltage) and he underwent sedation treatment again, with relapse of seizures after treatment. Due to the lack of pharmacologic treatment success electro-shock sessions were used and eventually an electrical and clinical improvement was observed. Two months after the debut of the frontal status awake and sleep activity was structured, and by this time he presented a left temporal seizure with secondary generalization.

EEG characteristics:

We recorded several seizures, with different electrical patterns, but with some details clue to identify the epileptic nature of those episodes: a very fixed and low voltage synchronized rhythm that recruits the rest of the brain activity and the rhythmicity of the patterns observed, in spite of its frequency.

A.S.A.

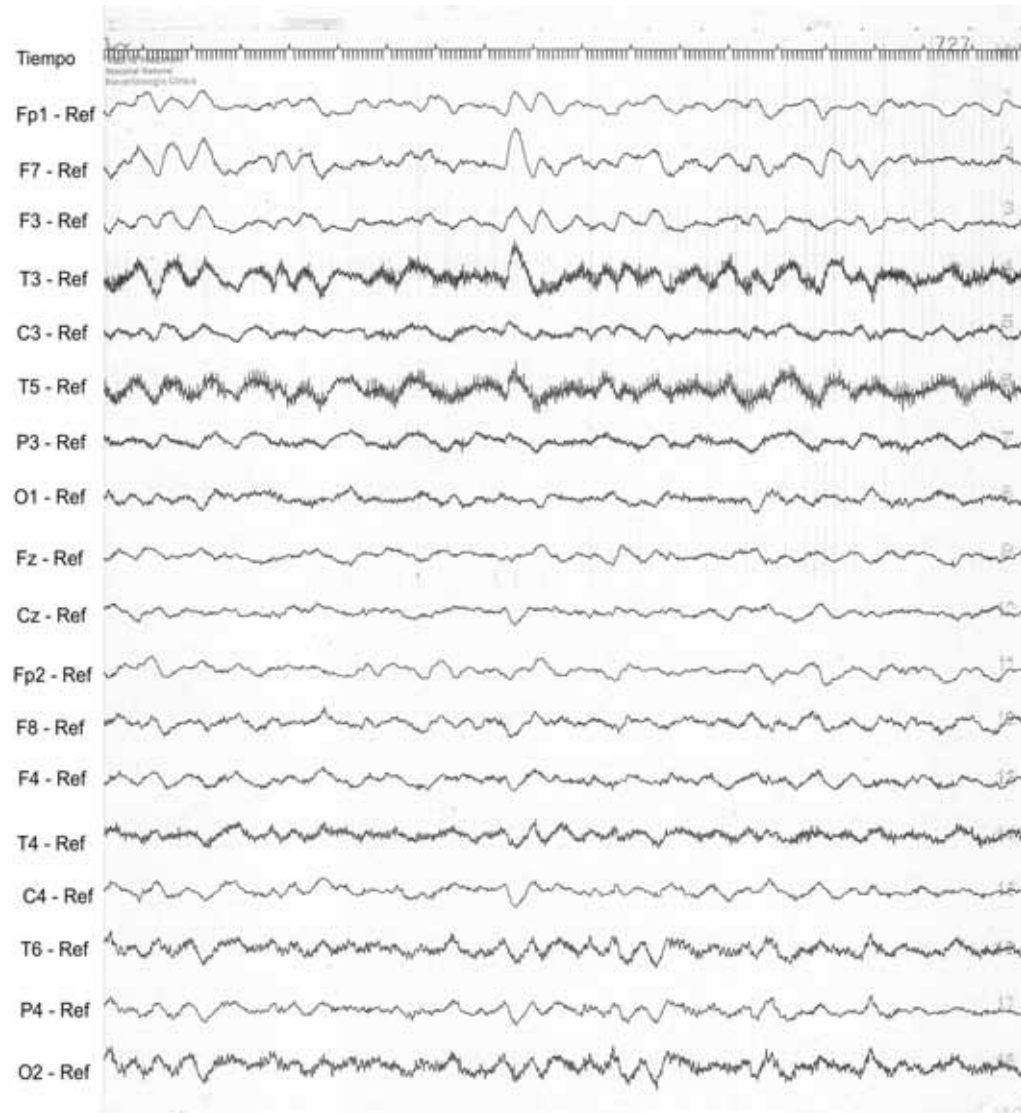


Fig1. Referential montage. Asymmetric slow waves with left predominance and alpha rhythm better structured in right posterior regions.

A.S.A.

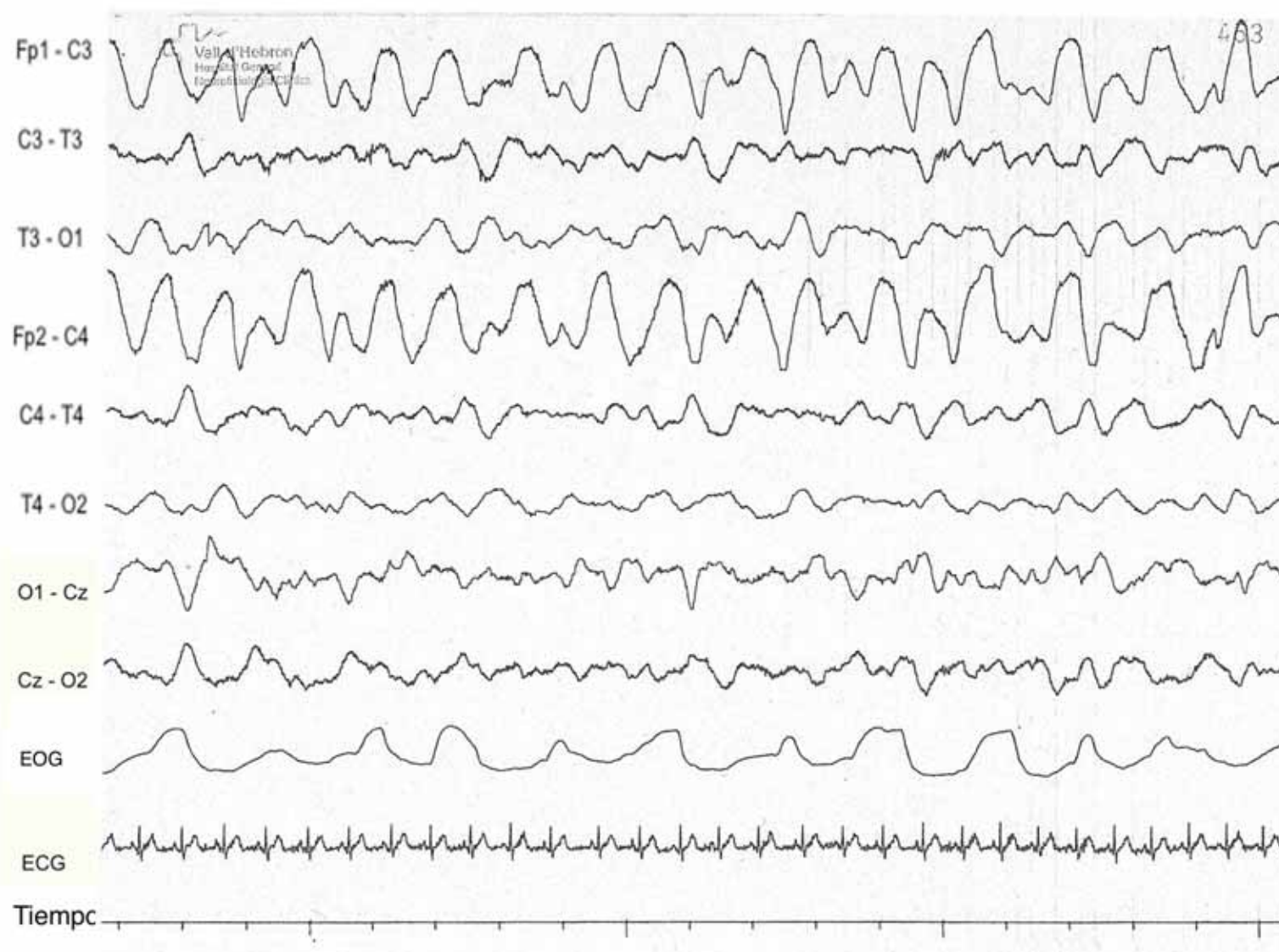


Fig. 2 We can see one of the different observed patterns during his stay in the neurology and UCI departments. Rhythmic slow waves with maximal expression over frontal regions.



A.S.A.

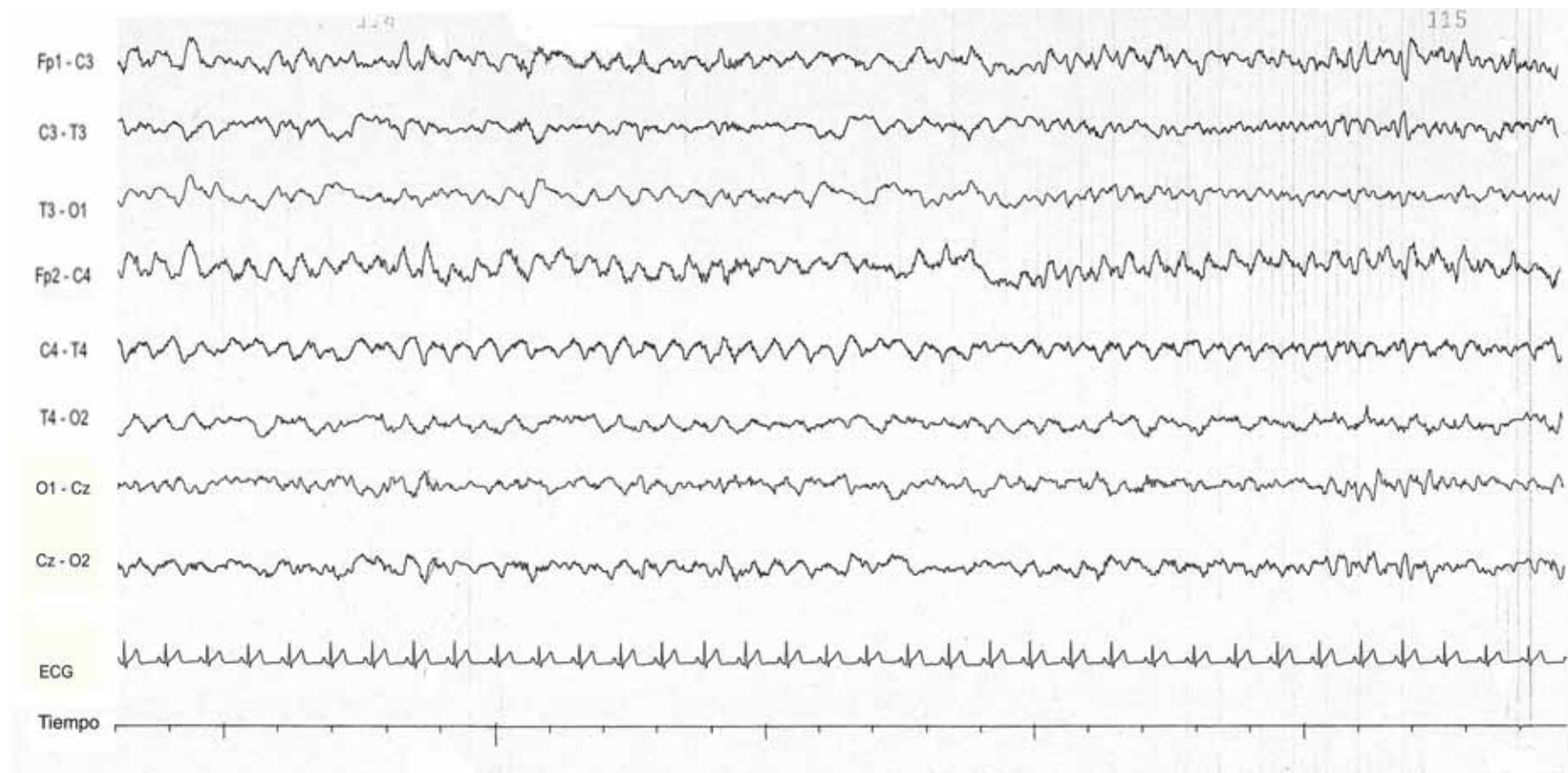


Fig. 3 Another seizure pattern, with subinvariant characteristics, arising again from left regions with alpha and theta frequencies and left predominance.

A.S.A.

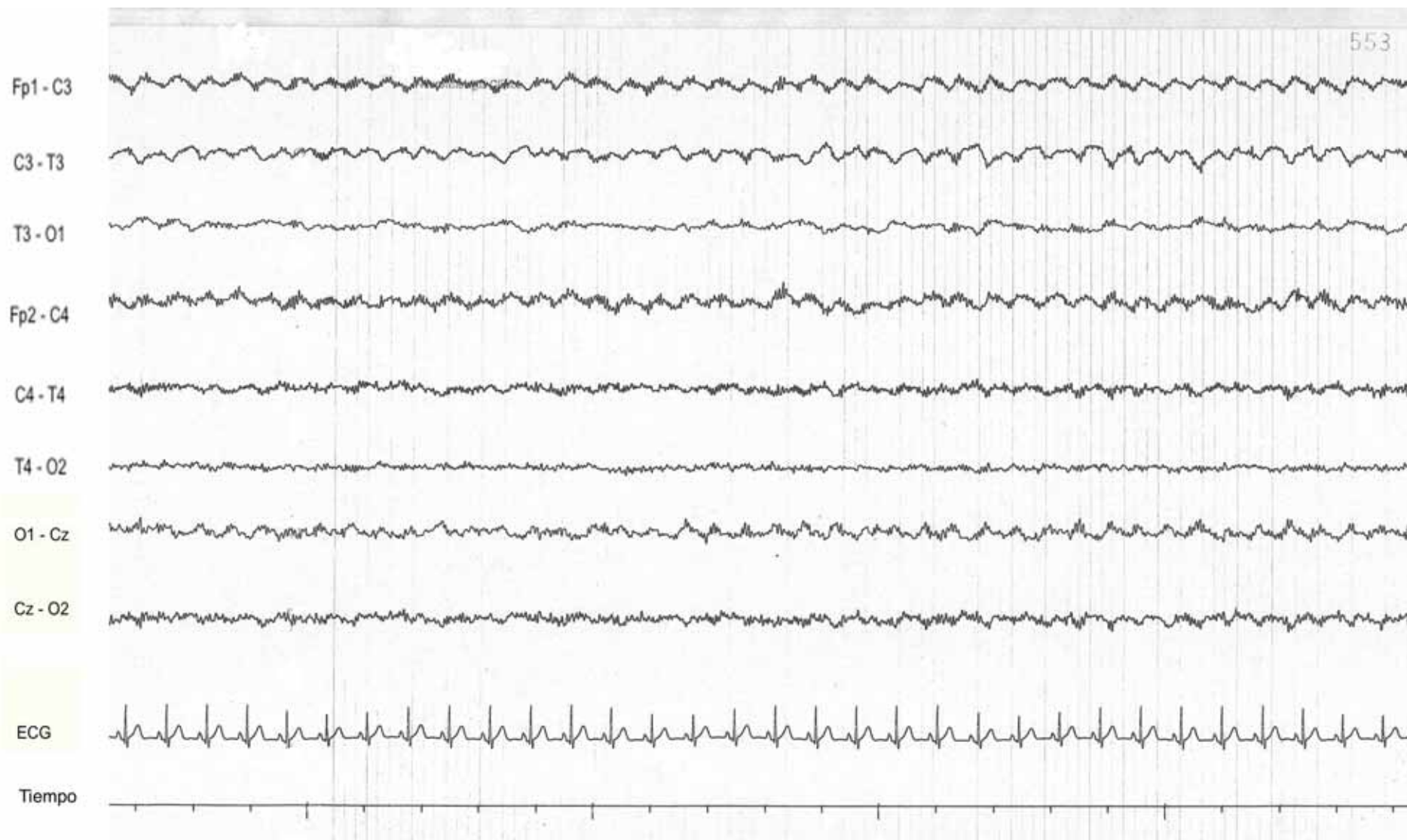


Fig. 4 Delta rhythmic activity with left side predominance during the seizures.

A.S.A.

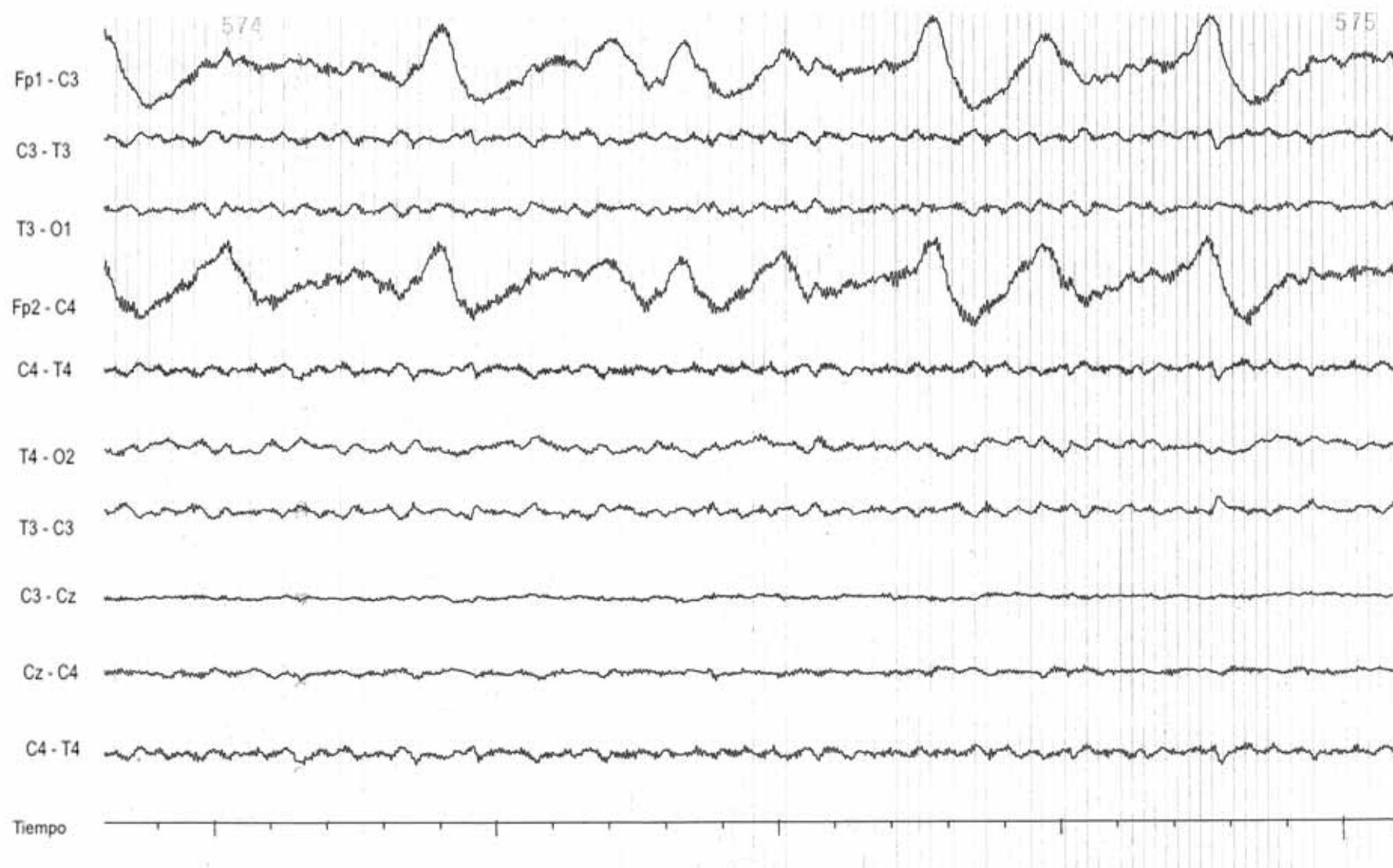


Fig. 5 Another delta high amplitude pattern with frontal predominance.

A.S.A.

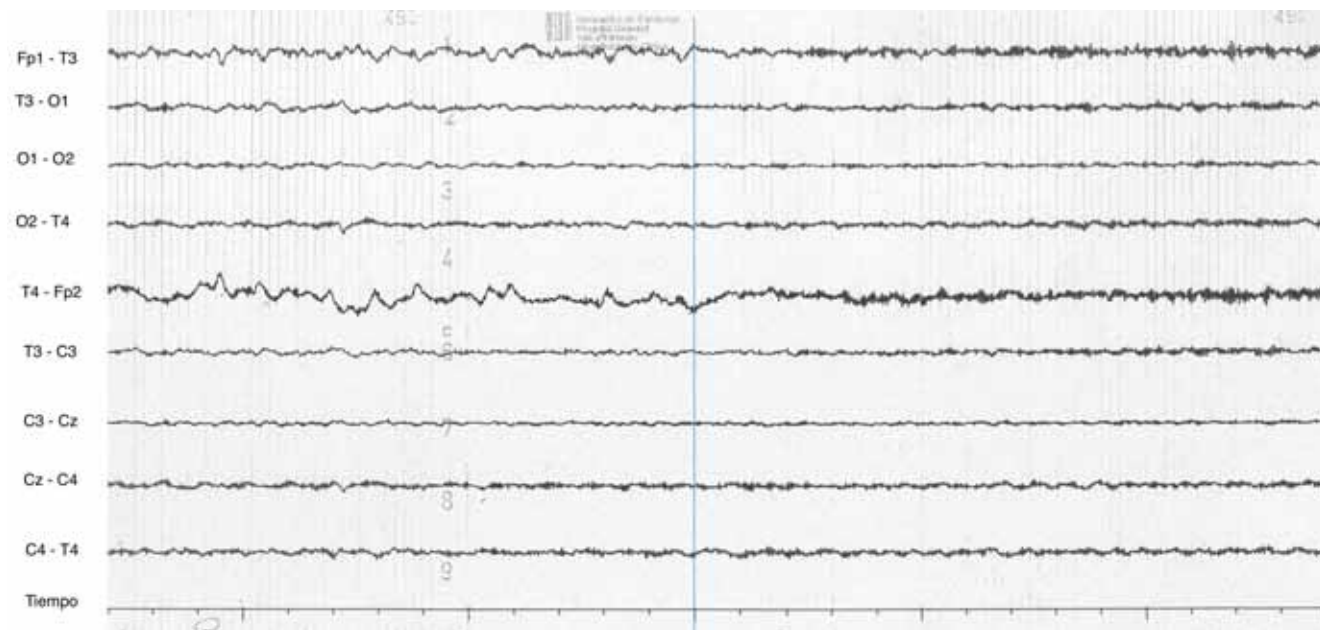


Fig. 6.1 Bipolar montage. Irregular slow waves predominantly in both pre-frontal regions that are blocked by a synchronized rhythm especially in both frontal regions, with maximal expression in Fp1.

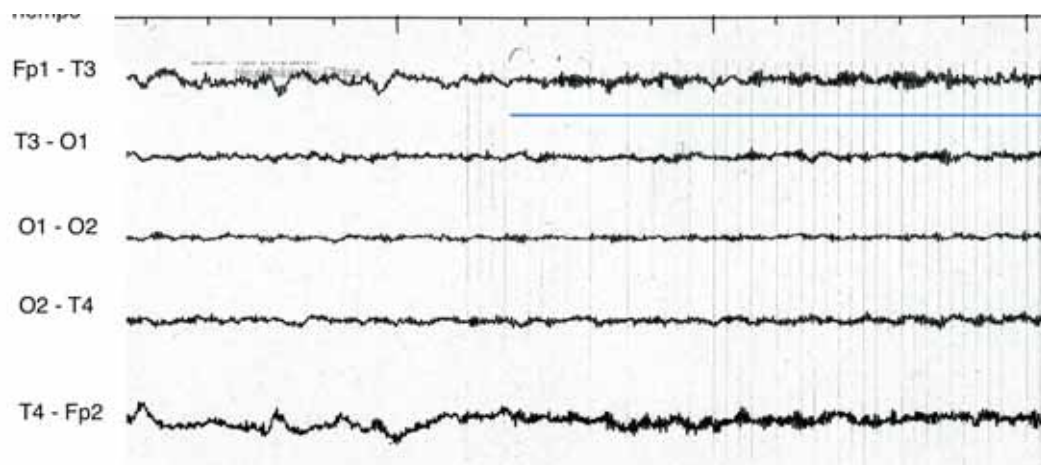


Fig. 6.2 Detailed view of the synchronized rhythm that recruits the rest of the activity at seizure onset with maximal expression in left frontal region.



A.S.A.

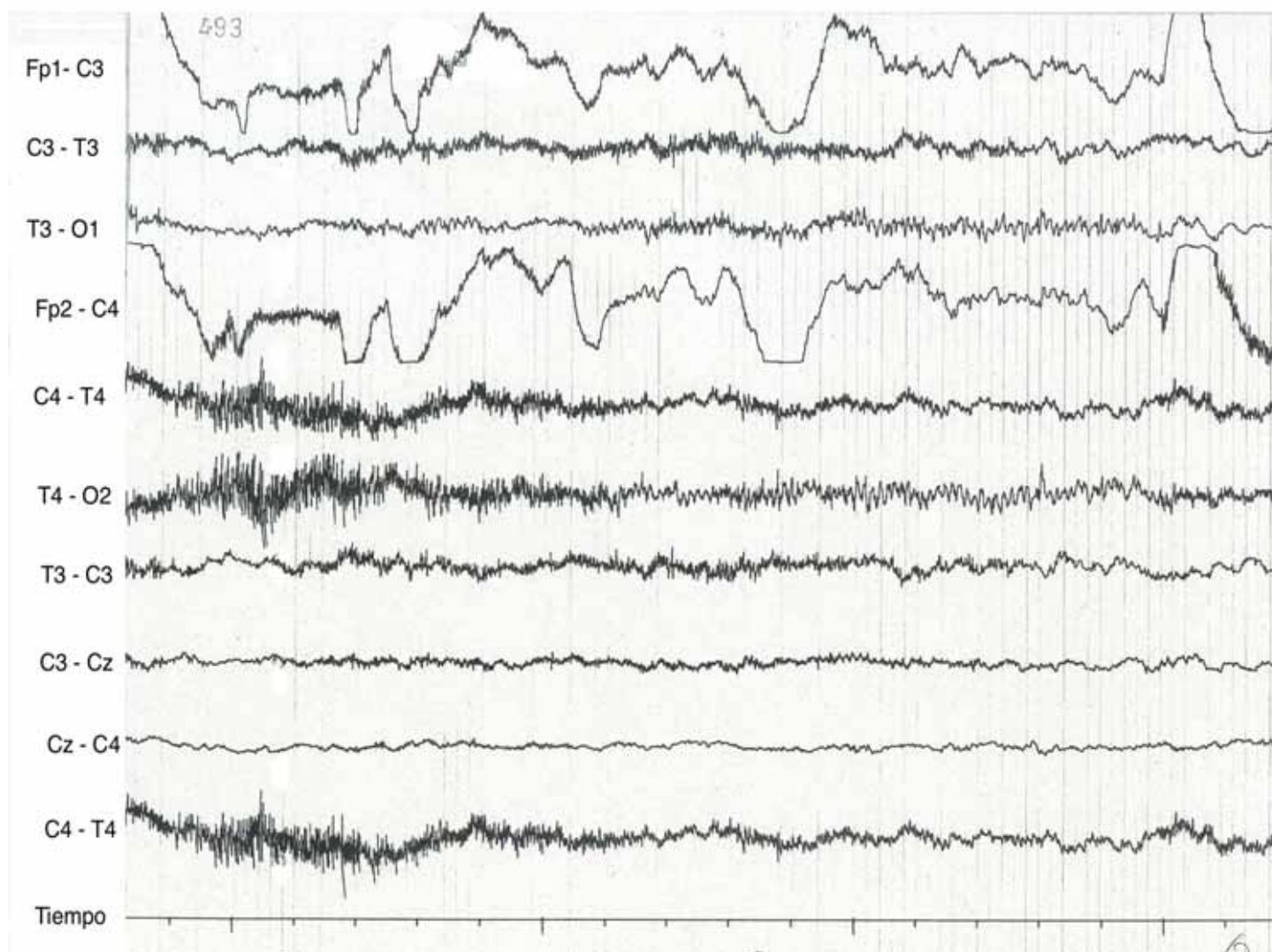


Fig. 7 After the electroconvulsive therapy, having solved the epileptic status situation. Alpha rhythm in posterior regions.



A.S.A.

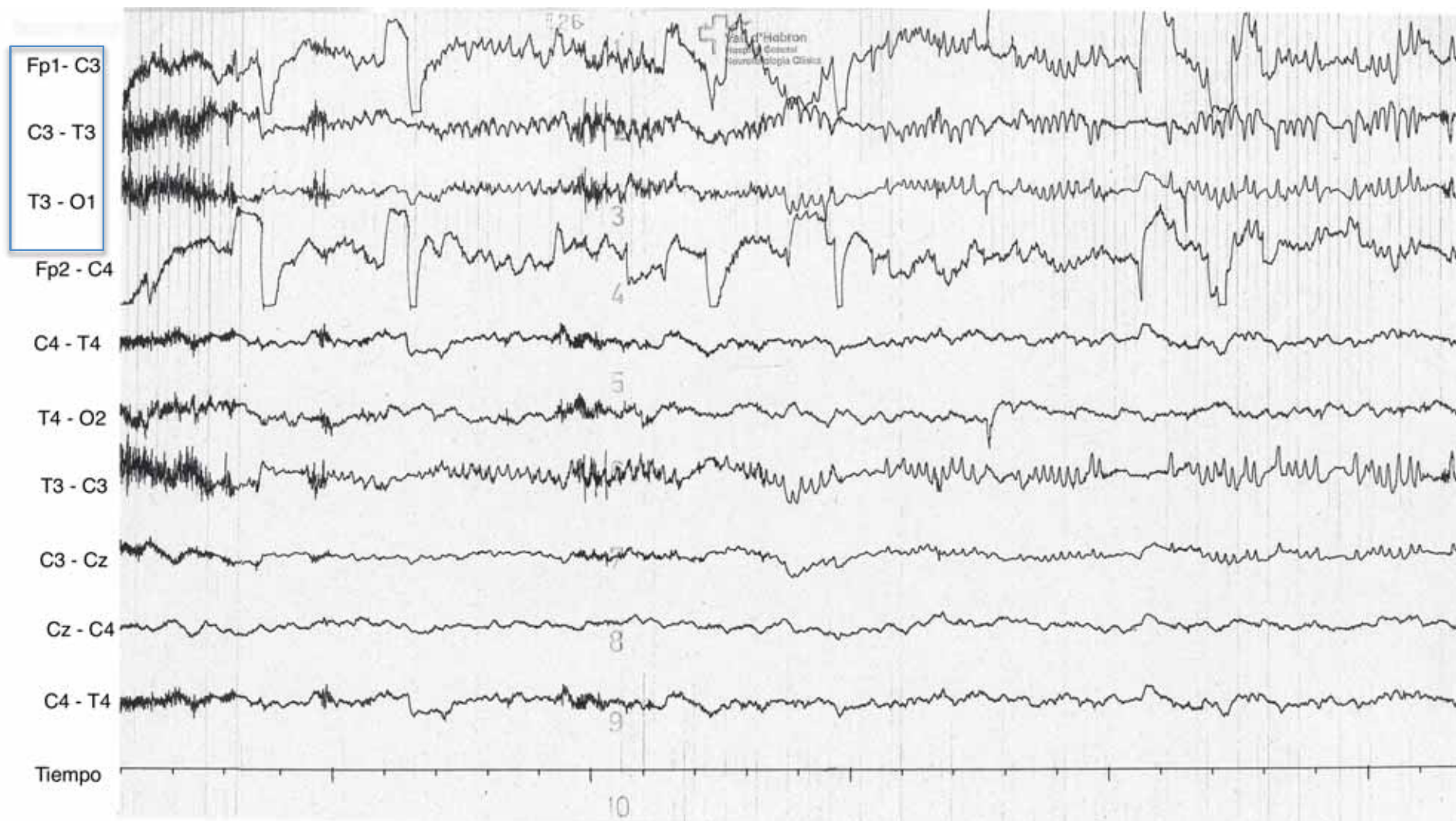


Fig. 8 In this context we recorded a left temporal seizure with secondary generalization. The seizure develops with more intensity, with increasing amplitudes and decreasing frequencies, from left temporal regions.

A.S.A.

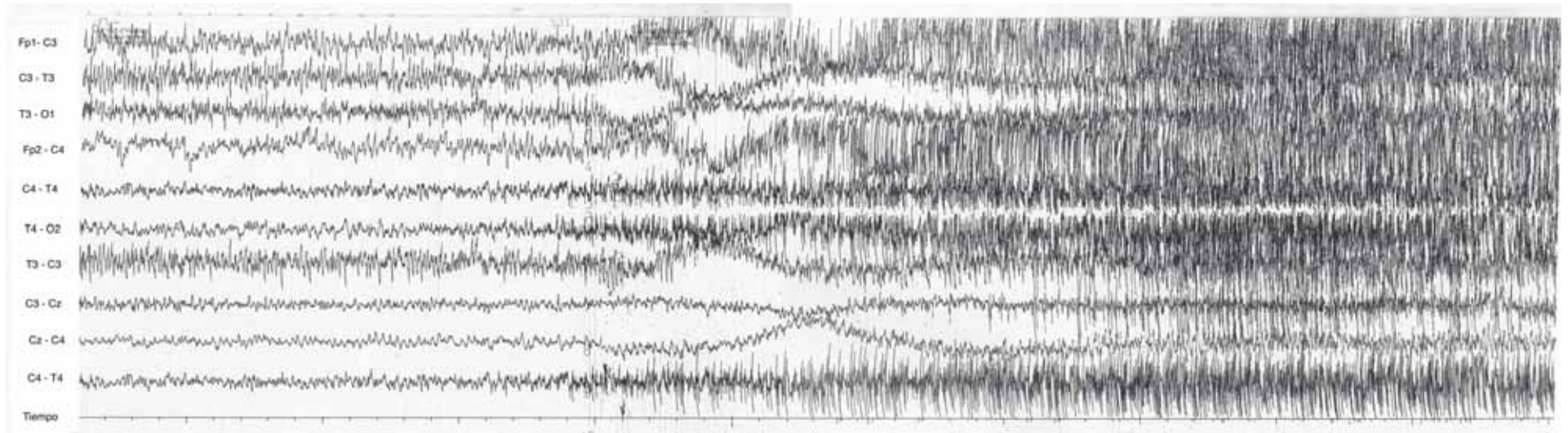


Fig. 9 On-going seizure, secondary generalization of the ictal activity

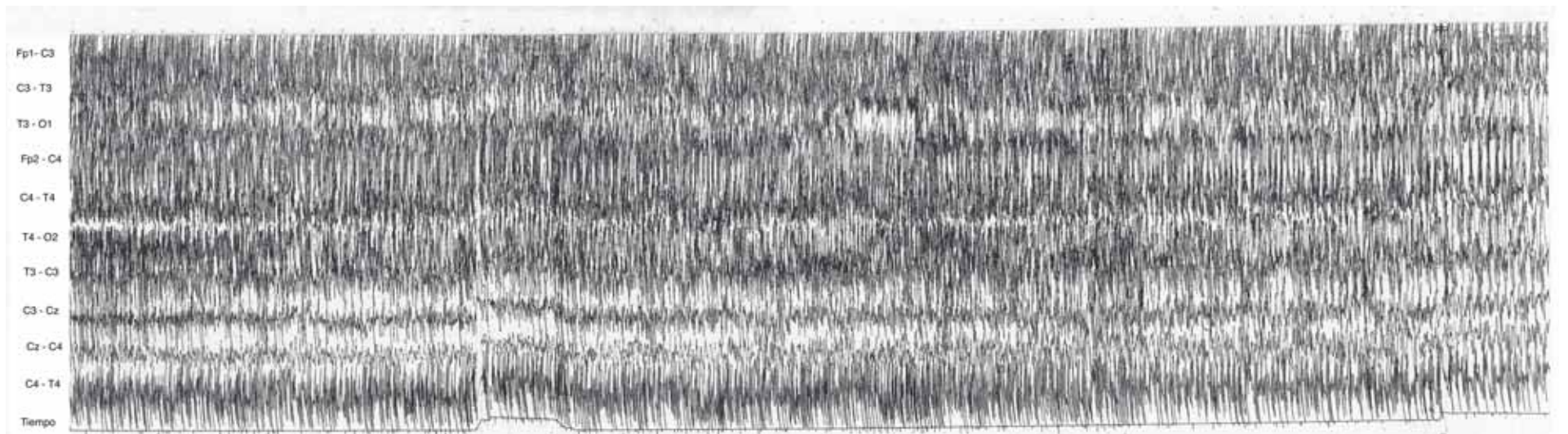


Fig. 10 Bipolar montage. Tonic phase of the secondary generalized tonic-clonic seizure



A.S.A.

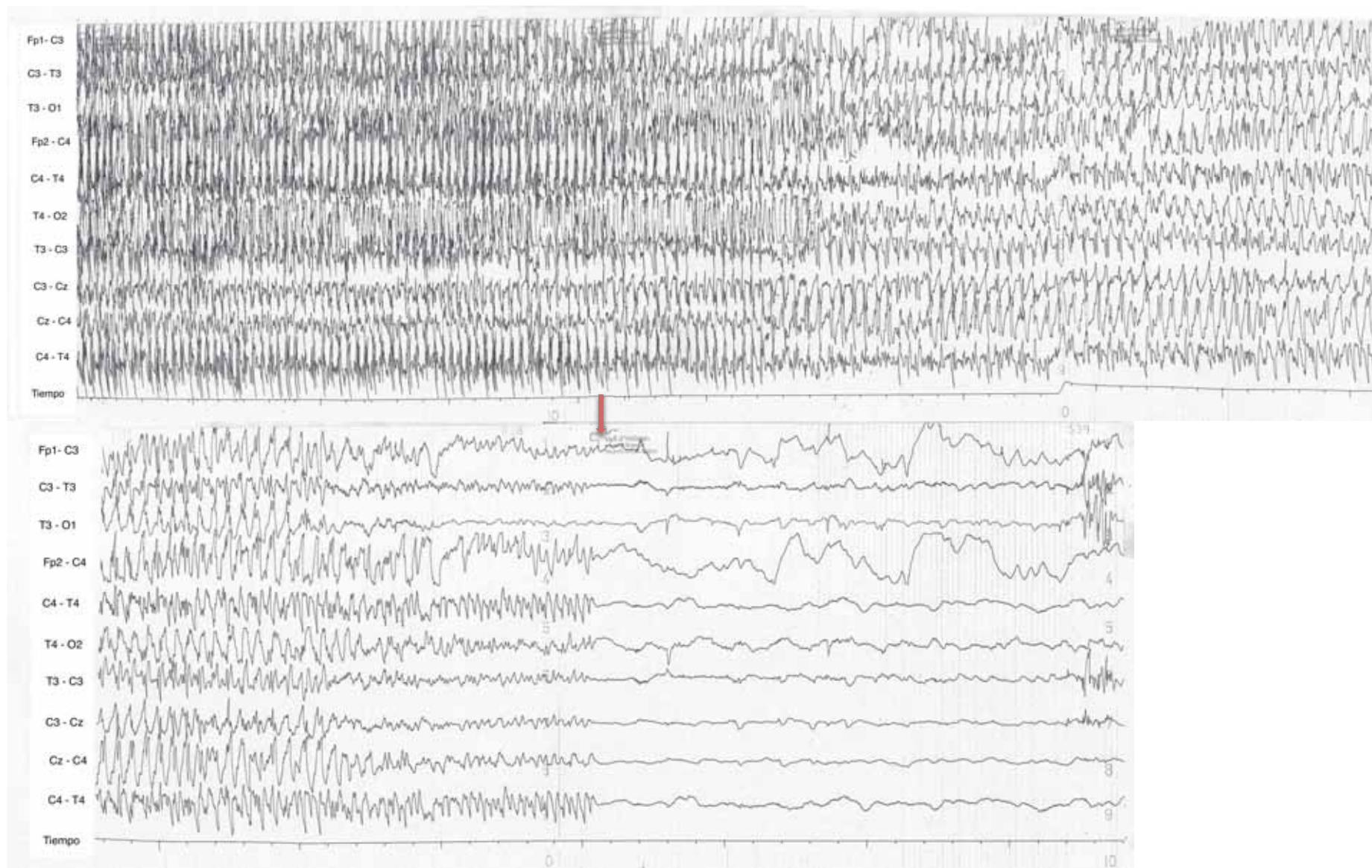


Fig. 11 and 12. Continuing seizure activity and seizure end. Marked and global attenuation as the main posth ictal characteristic

A.S.A.

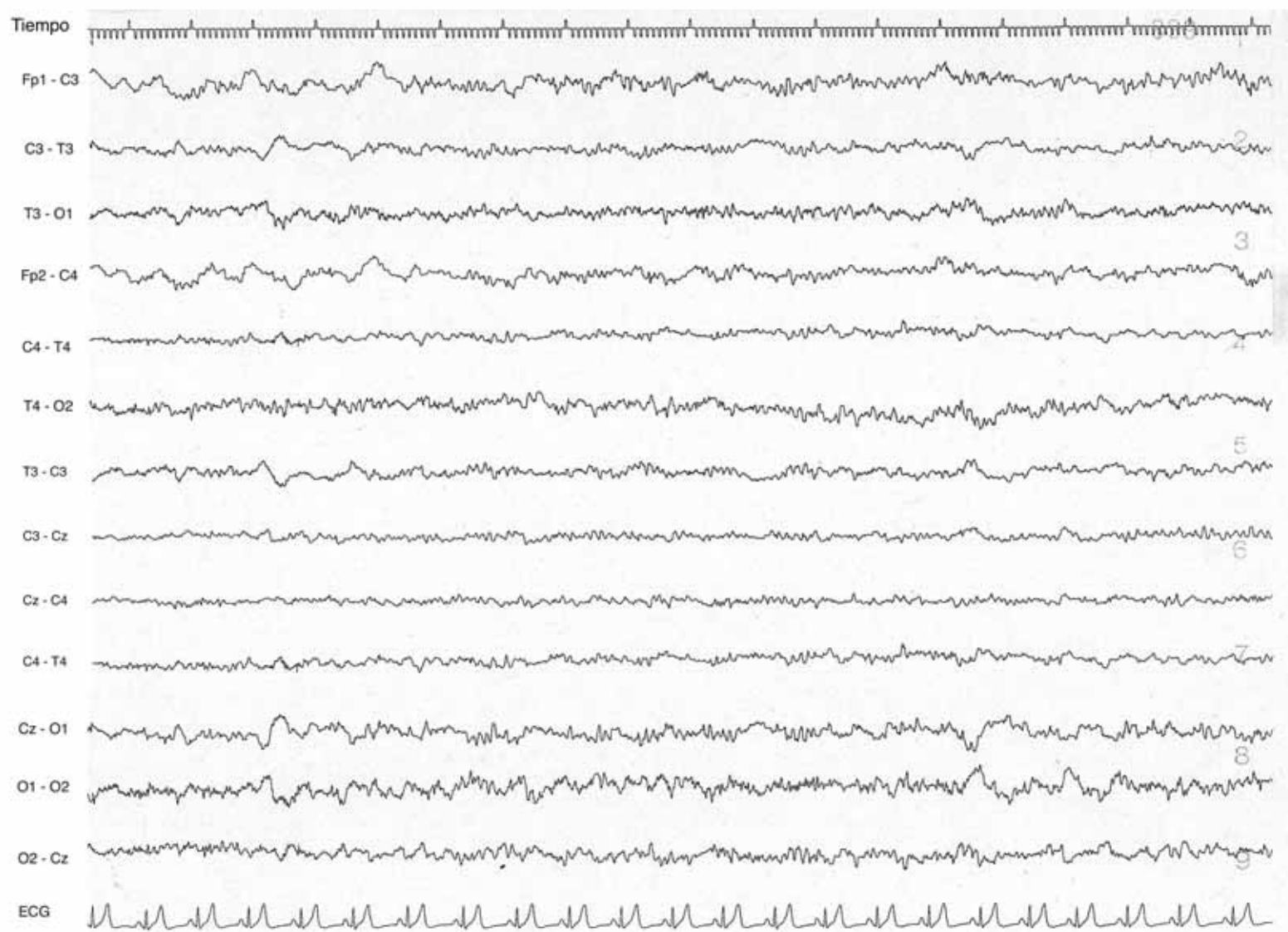


Fig. 13 EEG Recording 1 month later. Awake state.

M.A.R.M.

M.A.R.M.



M.A.R.M.

Patient without any pathologic antecedent of interest who started having seizures at 18 years old. She remember having a sick sensation and left numbness from sleep, and she was found without consciousness. She had three episodes the same and first night, and refers, since then, numbness sensation in left hand. MRI showed cortical development malformation with polymicrogyria in periventricular gray matter and a cystic lesion with corpus callosum dysgenesis.

EEG characteristics:

EEG recording show isolated sharp waves of less than 50  $\mu$ V in right front-central regions. Ictal activity arises from the same regions with a low amplitude synchronized rhythm, very well located in this case. We can see post-ictal slowing with anterior predominance and immediate alpha band activity in both posterior regions.

M.A.R.M.

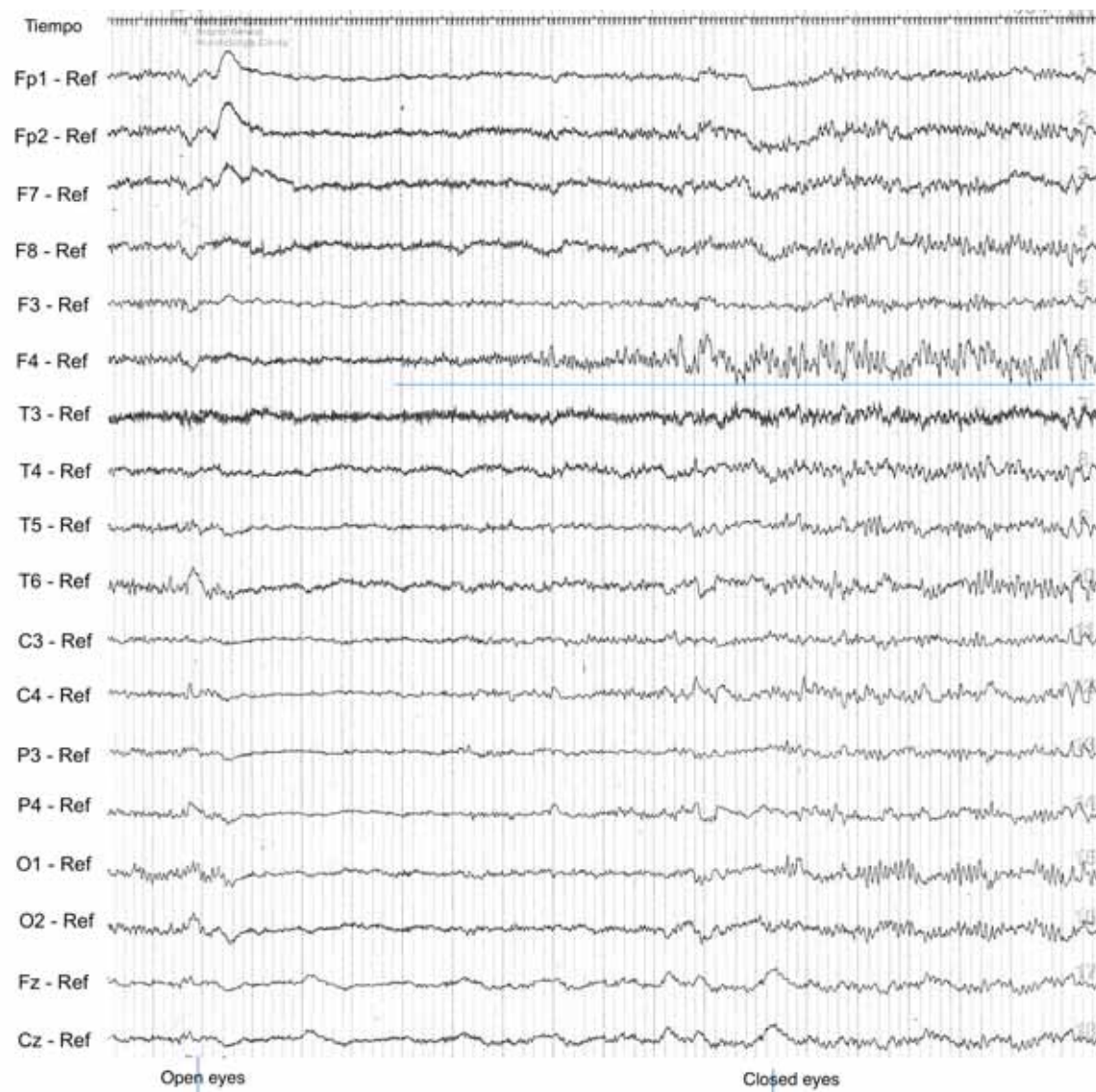


Fig. 1 Referential montage. Seizure arising with attenuation and low amplitude synchronized rhythm, independently from reactivity to eyes opening/closing with maximal expression in right front-central region, F4.

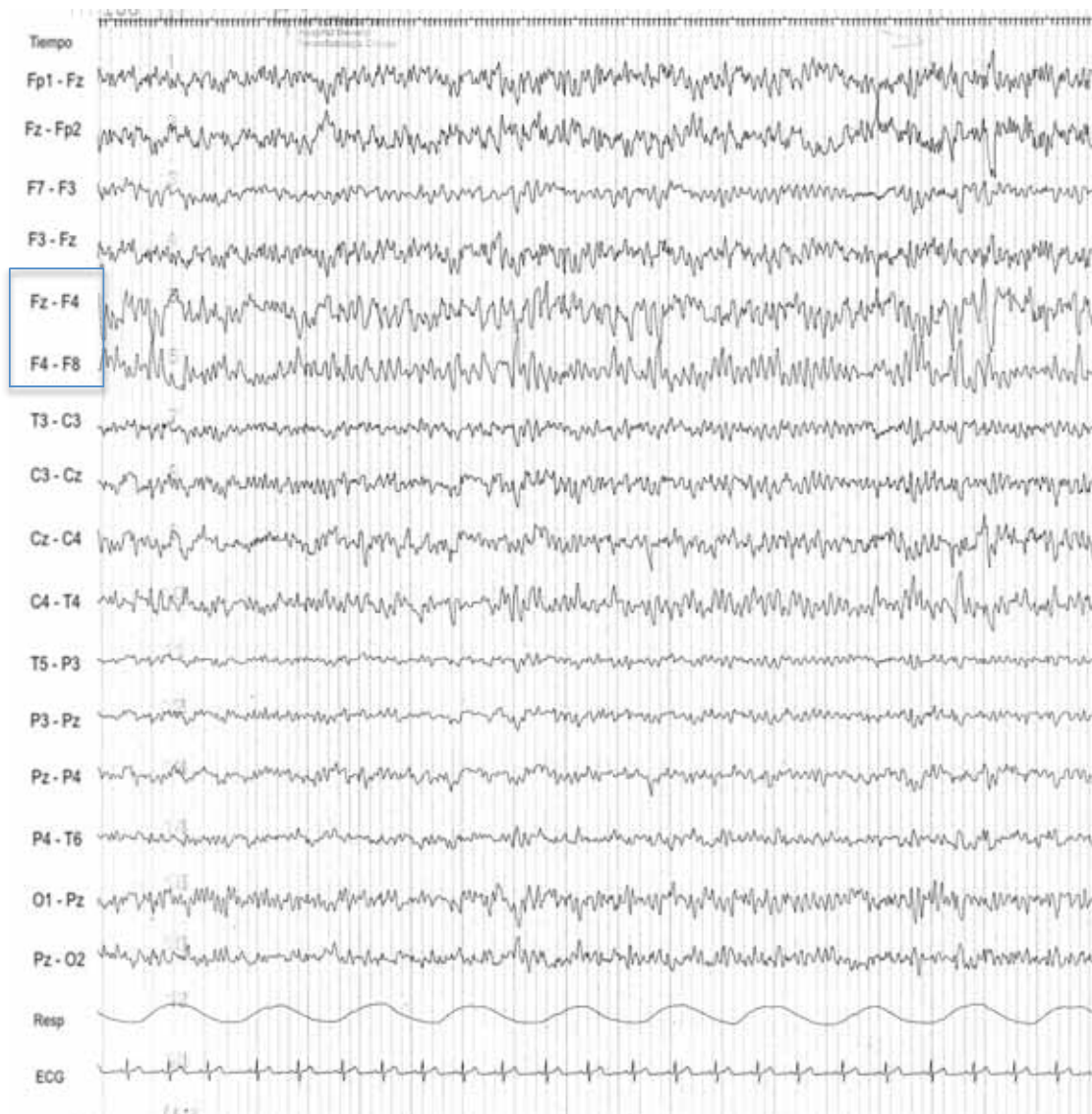


Fig. 2 Transversal montage. Increasing diffusion of the ictal activity from right front-central to central regions.

S.N.

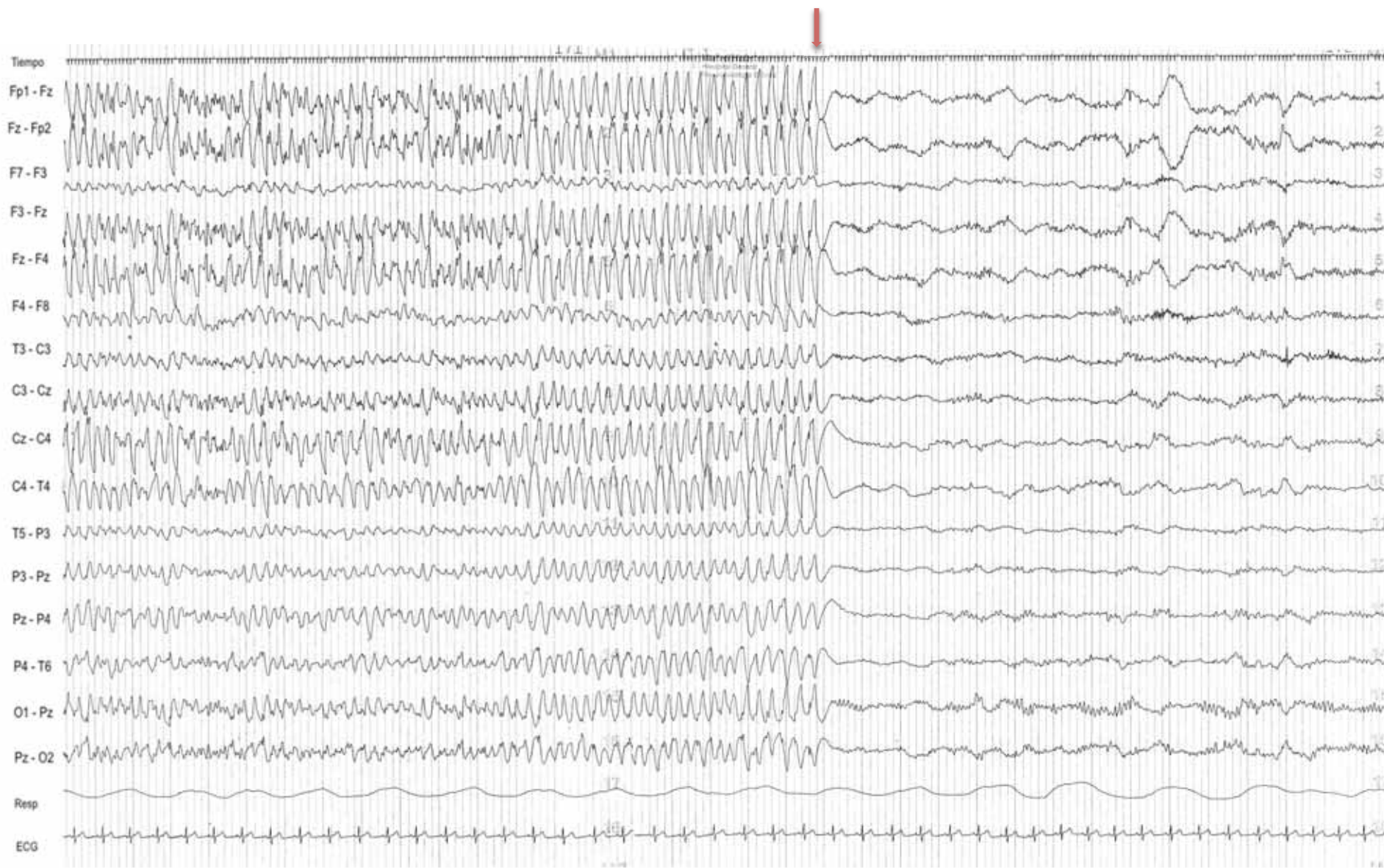


Fig. 3 Transversal montage. Immediate alpha basal activity after seizure ending, in both occipital regions while there is a prominent frontal post-ictal slowing.