

Are proprioceptive-induced reflex seizures epileptically-enhanced stretch reflex manifestations?

Anna Szűcs¹, György Rásonyi¹, Péter Orbay¹,
András Sólyom¹, András Holló², Zsuzsanna Arányi³,
József Janszky⁴, Lóránd Erőss¹, Anita Kamondi¹

¹ National Institute of Neurosciences, Budapest

² National Institute of Rehabilitation, Budapest

³ Semmelweis University, Budapest

⁴ University of Pécs, Medical School, Pécs, Hungary

Received December 17, 2010; Accepted February 29, 2012

ABSTRACT – In reflex seizures induced by proprioceptive stimuli, the activated network may be identified as a single anatomic-functional circuit; the sensory-motor network. These seizures may be considered as epileptically-enhanced stretch reflexes. Proprioceptive reflex epilepsies are a good example of the so-called “system epilepsies”. We present three cases discussing the clinical features of such epilepsies. [*Published with videosequences*]

Key words: proprioceptive-induced, stretch reflex, sensory-motor, long-loop, seizure, system epilepsy, neural systems

The definition of reflex epilepsies states that seizures are provoked by certain stimuli or, less commonly, mental processes. Individuals with reflex epilepsy may have seizures exclusively in response to specific stimuli without suffering spontaneous seizures. Alternatively, reflex seizures may coexist with spontaneously occurring seizures. They may clinically manifest as partial or generalised seizures and can similarly be associated with either focal or generalised ictal epileptic discharges at onset (Engel, 2001).

Common precipitating stimuli for reflex seizures may be visual (Binnie and Wilkins, 1998; Zifkin and Kasteleijn-Nolst Trenité, 2000),

somato-sensory, and proprioceptive; thinking, reading, eating, music, hot water (Grosso *et al.*, 2004), and startle (Zifkin and Andermann, 1998).

Reflex attacks induced by movement were reported more than 100 years ago (Gowers, 1901). Early reports described seizures induced by movement (Lishman *et al.*, 1962, Falconer *et al.*, 1963), but later work demonstrated the role of proprioceptive afferents (Chauvel and Lamarche, 1975). Thus, seizures originally described as “movement-, or gait-induced” (Iriarte *et al.*, 2001) are more accurately defined as “proprioceptive-induced” (Vignal *et al.*, 1998). Proprioceptive-induced



Correspondence:

Anna Szűcs
National Institute of Neuroscience,
Amerikai ut 57,
1147 Budapest, Hungary
<szucsan@gmail.com>

seizures are included as a reflex seizure type in the proposed classification of epilepsy syndromes (Engel, 2001).

Proprioceptive-induced seizures are provoked by passive or active movement. The seizures are usually simple partial attacks manifested as tonic or clonic motor movements of a limb; they may begin with sensory manifestations. Sometimes they occur in subjects with cerebral lesions and motor deficit. They have been described as transient phenomena during non-ketotic hyperglycaemia, resolving with metabolic correction (Brick *et al.*, 1989) and as self-induced attacks with proprioceptive self-stimulation (Guerrini *et al.*, 1992). The epileptic nature of these seizures has been confirmed by ictal EEG recordings (Arseni *et al.*, 1967) and video telemetry. Reflex drop attacks may occur with walking in patients with EEG vertex spikes, evoked by percussion of the sole of the foot (Tassinari *et al.*, 1988, Tedrus *et al.*, 2005).

We present here three cases in order to demonstrate the clinical features of such epilepsies.

Case I

Her partial epilepsy started at age 10 and she did not become seizure-free despite many antiepileptic drugs. Her left-sided lower limb sensory-motor seizures, frequently leading to falls, could be provoked by passive or active movement of the left leg, leading to the stretching of her sole and generally unexpected kinetic stimuli; slipping or lapse during walking. On her interictal EEG, Cz and C4 spikes were seen and could be provoked by movement, e.g. cycling. Scalp ictal EEG recordings and clinical seizure manifestations suggested the central, frontal or parietal region as the seizure-onset zone (*figure 1 A, B, C, D*). The patient did not agree to invasive monitoring which would have provided better localisation.

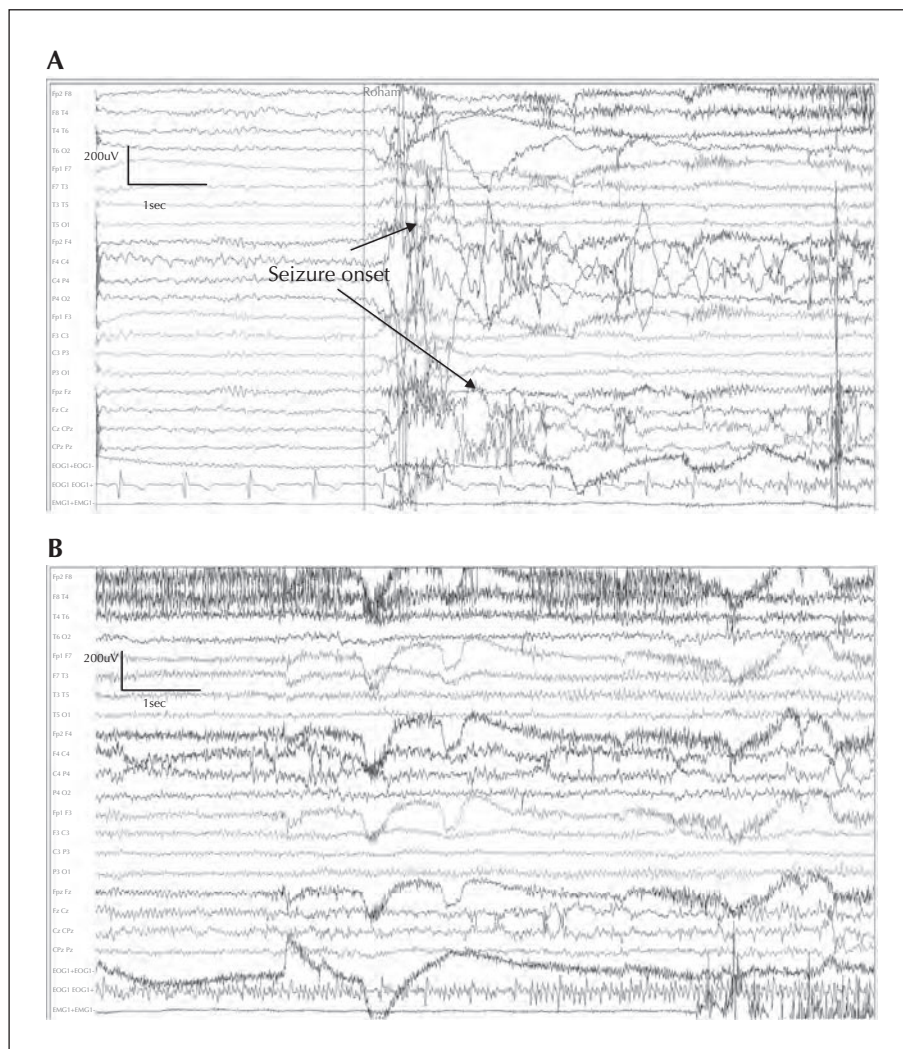


Figure 1 (A-D)– Patient 1. EEG sequence of a seizure provoked by movement of the left leg. The electrographic seizure starts at the Cz electrode. (EEG low pass filter: 0.3Hz; high pass filter: 70Hz).

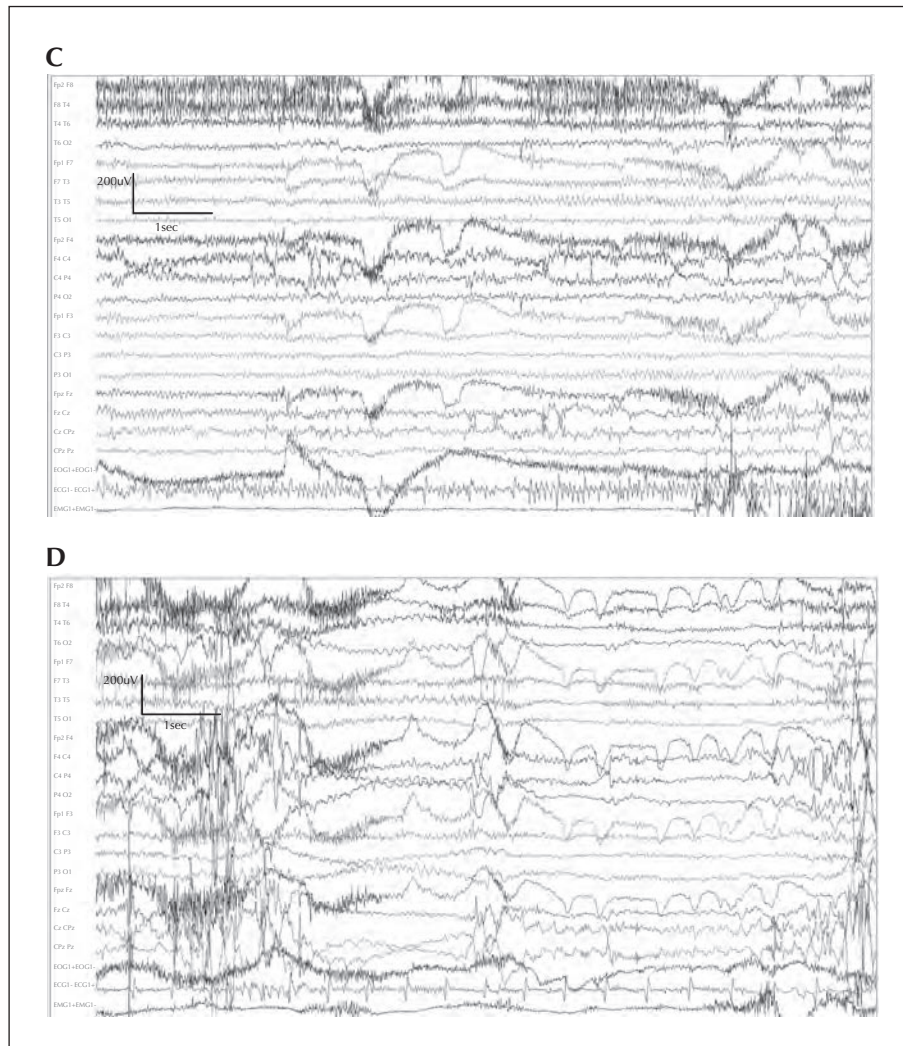


Figure 1 (A-D)– Patient 1. (Continued)

Her brain MRI and tibial nerve somato-sensory evoked potentials (SEPs) were normal.

On combined antiepileptic therapy, lamotrigine and topiramate, she had 1-2 seizures/month.

We consider this case to be partial epilepsy with reflex somato-sensory seizures, elicited by proprioceptive stimuli.

Case 2

Her epilepsy started at age 22. Her stereotyped left lower limb sensory-motor simple partial attacks lasted for 25-35 seconds and occurred several times a day. These attacks started with the strange feeling “*I do not feel my leg below my knee*”. Subsequently, a left leg cramp developed. Her left foot took an extended

position with rare clonus-like jerks. She could neither extend nor bend the knee, making her unable to stand or walk.

Brain MRI was normal.

Her seizures could be provoked by the movement of the left leg, but also by imaginative spatial experiences without movement, e.g. looking down the stairs or from a great height. Some of her motor seizures developed during sleep, when, according to her report, she had a dream with spatial experiences.

Her interictal EEG showed sharp waves and spikes with maximum amplitude at the centro-parietal electrodes, most frequently during non-REM sleep.

The ictal electrical activity appeared 6-7 seconds after a clinical seizure had started in Pz, involving sometimes also the Cz electrode. The ictal electrical activity, lasting only for 6-9 seconds on the scalp, was an 8-Hz

rhythm, gradually slowing down to 6 Hz and disappearing before clinical seizure offset (figure 2).

During a morning of video-EEG monitoring, the patient reported dreaming of a seizure. There was no clinical seizure during that night, but during REM sleep a 9-second EEG seizure pattern without obvious clinical manifestation was registered; a fast ictal rhythm starting in the Cz-Pz electrodes, rapidly involving the para-sagittal areas (figure 3).

She had rare seizures on carbamazepine and lamotrigine therapy.

We consider this case as partial epilepsy with sensory-motor seizures, elicited by proprioceptive stimuli of the leg (and also by “proprioceptive imagination”). The probable seizure-onset zone seems to be the central region.

Case 3

His falls induced by jogging started at age 21. When he ran, he fell stereotypically after 10-15 steps (see video sequence). He remembered his right leg becoming rigid, his right arm elevating, and falling on the right side without loss of consciousness. He was also able to provoke his falls by cycling. Brain MRI revealed a large left temporal arachnoidal cyst. Video-EEG monitoring showed clear left frontal interictal sharp waves and he could provoke his stereotyped reflex seizures, with no clear ictal EEG pattern identified during the violent movements. However, these events were stopped on carbamazepine treatment and he has been seizure-free for more than a year now.

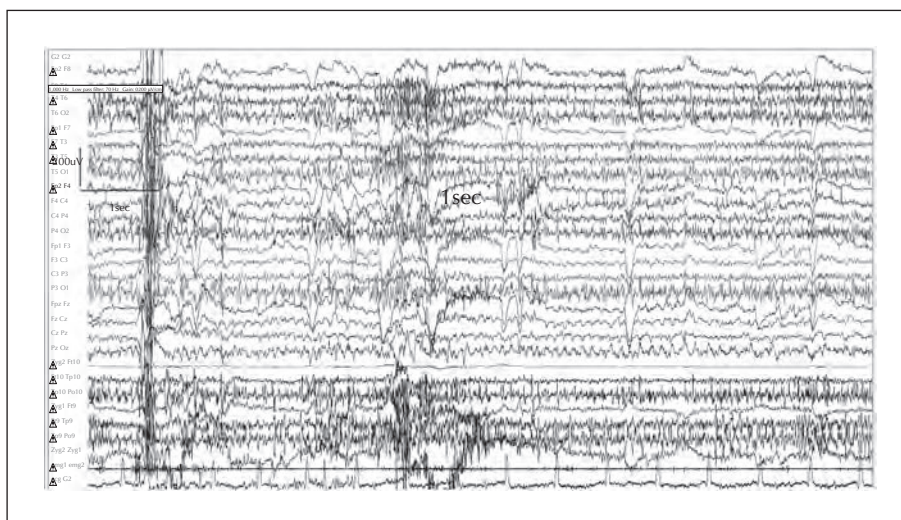


Figure 2 – Patient 2. EEG of a seizure provoked by movement of the left leg. The electrographic seizure starts at the Pz-Oz channel. (EEG low pass filter: 0.3Hz; high pass filter: 70Hz).

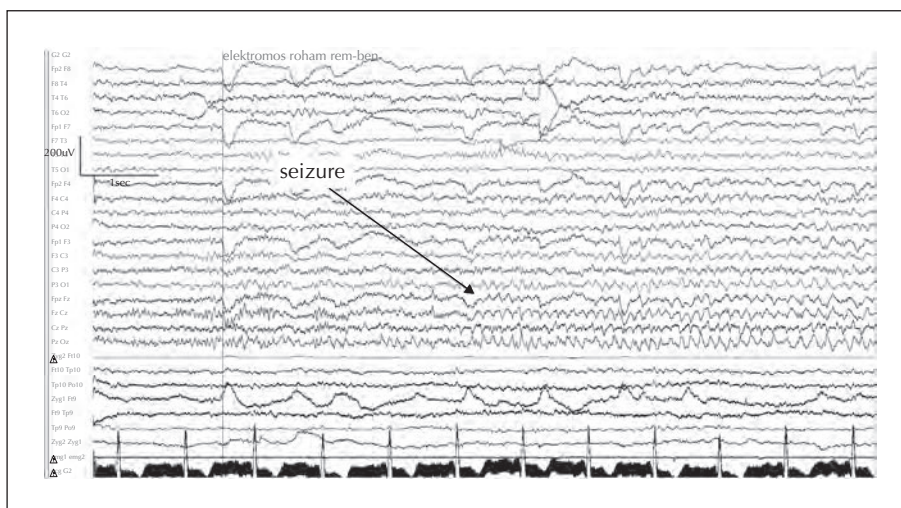


Figure 3 – Patient 2. EEG of an electrographic seizure during REM sleep. (EEG low pass filter: 0.3Hz; high pass filter: 70Hz).

Tibial nerve SEPs were normal but cortical magnetic stimulation revealed hyperexcitability of the motor cortex, evidenced by a motor threshold decrease of 25-40%.

Based on the frontal spikes, the cortical hyperexcitability, and the excellent and long-lasting response to carbamazepine, we consider this case to be proprioceptive-induced reflex epilepsy of unknown aetiology.

Discussion

Reflex seizures represent a variable group in terms of the provoking stimuli and the type of attacks. Although the provoking stimulus influences a specific brain region, most of these epilepsies are associated with generalised seizure types where the epileptic brain network is poorly identified. Thus, although the stereotyped evoking stimulus and seizures in these epilepsies suggest a specific and fixed epileptic network in each patient, it remains unclear in most cases, e.g. parietal and temporal seizures activated by hot water (Bebek *et al.*, 2001; Ilker *et al.*, 2010), focal seizures or periodic epileptic spasms activated by eating (Nakazawa *et al.*, 2002; Seneviratne *et al.*, 2003), and myoclonic jerks or focal seizures activated by reading (Salek-Haddadi *et al.*, 2009; Osei-Lah *et al.*, 2010).

Proprioceptive-induced reflex seizures appear to represent a specific group clearly suggesting the involvement of only a single anatomo-functional system; the sensory-motor network. The provoking stimulus and seizure seem to remain localised to the same functional brain network; stretching a limb results in a motor or sensory-motor attack of the same extremity. Classically, the rolandic sensory-motor area of the hemisphere or the supplementary motor area, contralateral to the clinical seizure onset, is involved. Although the motor event during proprioceptive-induced reflex seizures appears to be different from stretch reflexes, the actual process is similar; the movement of the limb leads to the stretching of the tendon, e.g. stimulation of the spinal reflex loop. The main difference is the epileptic enhancement and spreading of the reflex movements. With regards to physiology, the cortical control of stretch reflexes is realised by the so-called "long loop reflexes"; the proprioceptive information reaches the sensory-motor cortex that in turn sends modifying impulses to influence the segmental mono-synaptic reflex circuit. This superior reflex control is active during physiological movements, the cortex acting to precisely adapt movements to the spatial situation (Delwaide *et al.*, 1981; Kagamihara *et al.*, 2003; Scott *et al.*, 2003; Spieser *et al.*, 2010).

We presume that the specific feature of the long loop activated during a proprioceptive-induced reflex

seizure is the epileptic hyperexcitability of the involved cortical area.

To identify more closely which part of the cortex is affected by epilepsy in these patients, we performed SEP testing in two of our patients (Cases 1 and 3) to test the sensory cortex. The tibial nerve SEP responses were normal, no giant potentials were registered, and no focal seizure was provoked (Tedrus and Fonseca, 2004). The possible explanation for the normal result might be the small size of the epileptic cortex (Tedrus *et al.*, 2005).

We carried out cortical transcranial magnetic stimulation in Patient 3 to test the excitability of the motor cortex and observed marked hyperexcitability, evidenced by a significant decrease in motor threshold. This result supports our hypothesis that cortical hyperexcitability is the clue in the mechanism of proprioceptive-induced reflex seizures (Ferlazzo *et al.*, 2005).

The system-bound nature of proprioceptive-induced seizures supports the concept of the "network" or "system" epilepsies (Spencer, 2002); epileptic seizures remain in a closed anatomo-functional system showing their specific features (Halász, 2010a, 2010b).

Although epilepsies are classically defined by the presence of "unprovoked epileptic seizures", more and more seizure-precipitating stimuli are recognised (Rajna *et al.*, 2008), suggesting that for epilepsies not considered "stimulus-related", similar activating mechanisms might also be found.

Identifying and understanding such closed epileptic circuits may help to define and characterise brain networks as well as epileptic syndromes, and may contribute to presurgical evaluation. □

Legend for video sequence

Simple motor seizure of Patient 3 provoked by jogging.

Note the clumsiness and rigidity of his right leg as the first sign of the seizure.

Key words for video research on
www.epilepticdisorders.com

Syndrome: reflex epilepsy

Etiology: unknown

Phenomenology: reflex seizures

Localization: central motor; central sensory

References

Arseni C, Stoica I, Serbanescu T. Electro-clinical investigations on the role of proprioceptive stimuli in the onset and arrest of convulsive epileptic paroxysms. *Epilepsia* 1967; 8: 162-70.

- Bebek N, Gürses C, Gokyigit A, Baykan B, Ozkara C, Derwent A. Hot water epilepsy: clinical and electrophysiologic findings based on 21 cases. *Epilepsia* 2001; 42: 1180-4.
- Binnie CD, Wilkins AJ. Visually induced seizures not caused by flicker (intermittent light stimulation). *Adv Neurol* 1998; 75: 123-38.
- Brick JF, Gutrech GA, Ringel RA. Reflex epilepsy and nonketotic hyperglycemia in the elderly. A specific neuroendocrine syndrome. *Neurology* 1989; 39: 394-9.
- Chauvel P, Lamarche M. Analyse d'une 'épilepsie du mouvement' chez un singe porteur d'un foyer rolandique. *Neurochirurgie* 1975; 21: 121-37.
- Delwaide PJ, Toulouse P, Crenna P. Hypothetical role of long-loop reflex pathways. *Appl Neurophysiol* 1981; 44: 171-6.
- Engel J. A proposed diagnostic scheme for people with epileptic seizures and epilepsy: report of the ILAE Task Force on Classification and Terminology. *Epilepsia* 2001; 42: 796-803.
- Falconer MA, Driver MV, Serafetinides EA. Seizures induced by movement: report of a case relieved by operation. *J Neurol Neurosurg Psychiatry* 1963; 26: 300-7.
- Ferlazzo E, Zifkin BG, Andermann E, Andermann F. Cortical triggers in generalized reflex seizures and epilepsies. *Brain* 2005; 128: 700-10.
- Gowers WR. *Epilepsy and other chronic convulsive diseases: their causes, symptoms and treatment*. London: JA Churchill, 1901.
- Grosso S, Farnetani MA, Francione S, et al. Hot water epilepsy and focal malformation of the parietal cortex development. *Brain Dev* 2004; 26: 490-3.
- Guerrini R, Genton P, Dravet C, et al. Compulsive somatosensory self-stimulation inducing epileptic seizures. *Epilepsia* 1992; 33: 509-16.
- Halász P. The concept of epileptic networks. Part 1. *Ideggogy Sz* 2010aa; 63: 293-303.
- Halász P. The concept of epileptic networks. Part 2. *Ideggogy Sz* 2010bb; 63: 377-84.
- Ilker IH, Zeki G, Hidir UU, Zeki O. Hot water epilepsy: seizure type, water temperature, EEG findings and treatment. *Neurologist* 2010; 16: 109-12.
- Iriarte J, Sánchez-Carpintero R, Schlumberger E, Narbona J, Viteri C, Artieda J. Gait epilepsy. A case report of gait-induced seizures. *Epilepsia* 2001; 42: 1087-90.
- Kagamihara Y, Hayashi A, Masakado Y, Kouno Y. Long-loop reflex from arm afferents to remote muscles in normal man. *Exp Brain Res* 2003; 151: 136-144.
- Lishman WA, Symonds CP, Whitty CW, Willison RG. Seizures induced by movement. *Brain* 1962; 85: 93-108.
- Nakazawa C, Fujimoto S, Watanabe M, et al. Eating epilepsy characterized by periodic spasms. *Neuropediatrics* 2002; 33: 294-7.
- Osei-Lah AD, Casadei A, Richardson MP, Alarcon G. Focal reading epilepsy-a rare variant of reading epilepsy: a case report. *Epilepsia* 2010; 51: 2352-6.
- Rajna P, Sólyom A, Mezófi L, Vargyay E. Are seizure precipitating factors underestimated in refractory epilepsies? *Epilepsia* 2008; 49: 1812-3.
- Salek-Haddadi A, Mayer T, Hamandi K, et al. Imaging seizure activity: a combined EEG/EMG-fMRI study in reading epilepsy. *Epilepsia* 2009; 50: 256-64.
- Scott SH, Korbel T, Singh K. Primary motor cortex and feedback control: long-loop reflexes reflect joint mechanics and not joint motion. *Eng Med Biol* 2003; 4: 3840-2. Proceedings of the 25th Annual International Conference of the IEEE.
- Seneviratne U, Seetha T, Pathirana R, Rajapakse P. High prevalence of eating epilepsy in Sri Lanka. *Seizure* 2003; 12: 604-5.
- Spencer SS. Neural networks in human epilepsy: evidence of and implications for treatment. *Epilepsia* 2002; 43: 219-27.
- Spieser L, Meziane HB, Bonnard M. Cortical mechanisms underlying stretch reflex adaptation to intention: a combined EEG-TMS study. *Neuroimage* 2010; 52: 316-25.
- Tassinari CA, DeMarco P, Plasmati R, Pantieri R, Blanco M, Michelucci R. Extreme somatosensory evoked potentials (ESEPs) elicited by tapping of hands or feet in children: a somatosensory cerebral evoked potentials study. *Neurophysiol Clin* 1988; 18: 123-8.
- Tedrus GM, Fonseca LC. Benign focal epilepsy of childhood: epileptic seizure during somatosensory evoked potential: a case report. *Clin EEG Neurosci* 2004; 35: 94-6.
- Tedrus GM, Fonseca LC, Quagliato EM. Somatosensory evoked potential and EEG in children with focal idiopathic epilepsies with and without evoked spikes by tapping of the feet or hands. *Clin EEG Neurosci* 2005; 36: 194-8.
- Vignal JP, Biraben A, Chauvel PY, Reutens DC. Reflex partial seizures of sensorimotor cortex (including cortical reflex myoclonus and startle epilepsy). In: Zifkin BG, Andermann F, Beaumanoir A, Rowan A. *Reflex epilepsies and reflex seizures. Advances in neurology*. Vol 75. Philadelphia: Lippincott-Raven, 1998: 207-26.
- Zifkin BG, Andermann F. Proprioceptive-induced seizures. In: Zifkin BG, Andermann F, Beaumanoir A, Rowan A. *Reflex epilepsies and reflex seizures. Advances in neurology*. Vol 75. Philadelphia: Lippincott-Raven, 1998: 207-26.
- Zifkin BG, Kasteleijn-Nolst Trenité D. Reflex epilepsy and reflex seizures of the visual system: a clinical review. *Epileptic Disord* 2000; 2: 129-36.