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SOMATOSENSORY EVOKED POTENTIALS IN NEUROLOGY

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ABSTRACT

The authors present a views and opinions highlighting the role of somatosensory evoked potential and its application in neurology as a non-invasive technique studying the entire length of the afferent pathways, especifically the posterior cord, allowing the detection of subclinical disfunction. This study is very useful in diseases involving the myelin sheath, for monitoring sensory pathways function during surgical procedures has progressively become one of its most important applications.

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INTRODUCTION

Sensory evoked potentials, whether visual, auditory or somatosensory, are the electrical responses of the nervous system to an external stimulus capable of activating specific afferent pathways. This electrical response is constituted by voltage fluctuations in time, originating in neuronal populations in the temporal phase with the stimulus or event that originated it. (Hernandez Fustes, 2001). As an extension of the neurological examination, the evoked potentials (EP) allow us to evaluate several sensory pathways. The records of evoked potentials (EP) are a non-invasive means for studying the neural activity of the nervous system. It is interesting to consider that the sensory pathways are parallel to the motor pathways and relatively close to the areas linked to vegetative, conscious and cognitive processes; EPs can often represent an important, albeit indirect, resource for detecting and locating neurological dysfunctions within non-sensory systems, and can reveal nervous system dysfunctions not detected by conventional methods, (Manzano, 2007) help define the anatomical distribution and give an insight into the pathophysiology of a pathological process and, monitor changes in a patient's neurological status (Walsh, 2005).

The clinical utility of the EP depends on the possibility of demonstrating a dysfunction of the sensory system when history and physical examination are questionable, the ability to reveal the presence of a subclinical dysfunction in a system when there are signs and symptoms related to another area, the perspective of helping to define the anatomical distribution of a pathological process and the ability to monitor objective changes over time, during the course of the disease. (Chiappa, 1990). We present a views and opinions highlighting the role of somatosensory evoked potential (SSEP) and its application in neurology as a non-invasive technique studying the entire length of the afferent pathways, especifically the posterior cord, allowing the detection of subclinical disfunction. SSEP are used to evaluate both the central (spinal, cortical and subcortical level) and peripheral nervous systems. The findings may be helpful in showing that a lesion is present in the somatosensory pathways, helping to localize it, and providing a prognostic guide, the SSEP studies assess the entire length of the afferent pathways. Electrical, mechanical, thermal or air-jet stimuli can generate detectable responses. In the clinical setting, electrical stimuli are used, as they generate synchronous and easily controlled action potentials (Manzano, 2007; Cruccu, 2008).

Table 1. Indications of SSEP in Neurology

Indications	Diseases	References
Peripheral Disorders		
	Nerve entrapment or Monoradiculopathy	9, 13
	Isolated Radiculopathy	9, 13
	Proximal involvement in Guillain–Barre syndrome	5
	Chronic Inflammatory Demyelinating Polyradiculoneuropathy	20
Central nervous system Disorders		
	Multiple Sclerosis	9, 13
	Epilepsies	2, 4
	Lesions in the brainstem, diencephalon, or cerebral hemispheres	1, 6, 25
	Coma and Brain death	16, 17, 22
	Myelopathy	9
	Spinal cord tumors	9
	Chronic spinal cord injury	8
	Schizophrenia	17, 22
	Psychoses	11
Neurophysiologic Intraoperative Monitoring	Intracranial Vascular Surgery Epilepsy surgery Posterior fossa surgery Spinal surgery	16, 19, 21, 12 12 19, 21

The clinical interpretation of SSEP depends on the anatomofunctional relationship of the generators of the different waves. The absence of a component suggests that the path is compromised at the previous segment or at the level of its generator. The presence of an expected component, but with prolonged latency, suggests the existence of a compromised myelin pathway. Electrical stimulation, as it is currently used, allows the assessment of pathways related to thick peripheral fibers whilst electrophysiological assessment of peripheral nerves, plexuses and roots is performed in a more appropriate and informative way through electroneuromyographic studies**.** To establish a valid neurological diagnosis of lesions of the somatosensory system, confirmatory laboratory tests are often necessary in addition to the clinical features. For large fiber and dorsal column involvement, clinical neurophysiological tests like the recording of nerve action potentials and SSEP are standard procedures adding objective evidence to a diagnosis that might have become already likely by the patient's history and clinical sensory testing (Baumgärtner, 2012). In diseases involving the brain stem, SSEP is useful and sensitive if the lemniscal pathway is affected. In cortical myoclonus, potentials with markedly high amplitudes are often recorded, being known as giant potentials, in these situations, the findings are of clinical use, as they reflect an increase in cortical excitability. Giant potentials have been reported in patients with progressive myoclonic epilepsy, ceroid lipofuscinosis in late childhood and in some patients with photosensitive epilepsy (Berkovic, 1993; Báez Martín, 2001). Demyelinating diseases have been the focus of study with the evoked potentials, trying to find a neurophysiological biomarker for diagnosis, prognosis or therapeutic response. SSEP can still provide important information in selected patients with suspected multiple sclerosis and uncertain MRI findings. In multiple sclerosis with cerebral or spinal cord involvement, SSEP abnormalities are present in 90% of patients with a definitive diagnosis and in approximately 50% of patients with sensory signs or symptoms. (Chiappa, 1990) The potentials obtained from the lower limbs are more sensitive due to the greater extent covered by the salvo of potentials in the central nervous system. Abnormalities have also been described in adrenoleukodystrophy, adrenomyeloneuropathy and metachromatic leukodystrophy.

In degenerative diseases that present impairments of these pathways, abnormalities can be detected, as in cases of Friedreich's ataxia, hereditary cerebellar ataxias and hereditary spastic paraparesis (Kraft, 1999; Walsh, 2005; Lascano, 2017). In evaluating patients in a coma, SSEP are useful, as they do not change in metabolic and pharmacological states (Machado, 1994; Logi, 2003). The absence of cortical responses (N20) bilaterally is a reliable sign of poor prognosis. Patients who have unilateral preservation of these responses may experience functional recovery. Meta-analyzes of the bilateral absence of cortical responses to N20, recorded after 72 hours, can predict death or persistent vegetative state with a specificity of 99% in anoxic-ischemic coma and about 95% in traumatic coma. (Young, 2004). Most useful in the neurocritical care setting are median nerve SSEP, which interrogate the intact connectivity of peripheral sensory nerves to cortical projections, constituting a tool in the prognosis and monitoring of traumatic injuries of the brain and spinal cord (Carter, 2005). When bilaterally absent or alternatively normal following trauma, SSEPs may help detect patients with poor or good prognosis. For example, normal SSEPs after trauma are associated with a 57% chance of good recovery, whereas bilaterally absent SSEPs are associated with only a 1% chance of functional recovery. In addition, repeated SSEP measures may also help detect patients with brainstem herniation due to interruption of these functional connections, or with cerebral ischemia correlating with jugular bulb evidence of reduced oxygen content (Robinson, 2006). Changes in median SSEP may precede the rise of intracranial pressure 30% of the time (Amantini, 2009). SSEPs can provide prognostic information indicative of recovery of walking, hand and bladder function after spinal cord injury. In general, the evoked potentials have less interference from sedation or hypothermia than EEG (Rosenthal, 2012).

Important advances have been made in recent years with intraoperative neurophysiological monitoring, where SSEP play a fundamental role, with the aim of minimize neurological damage, to identify important neural structures and thus to avoid and/or limit significant postoperative impairments, the SSEP provide functional and localizing information about the dorsal somatosensory system and complement electromyography and motor

evoked potentials. While most frequently used on orthopedic spinal procedures (Nuwer, 2020) like scoliosis correction, SSEPs has proven useful for warning surgeons of impending brain damage on aneurysm clipping and other neurovascular interventions (Schrader, 2015), posterior fossa tumor surgery and in cardiac or aortic surgery with circulatory arrest (Hussain, 2015), in which, together with the EEG, has been used as a sort of "brain thermometer" with its disappearing after cooling the patient (usually around 20C) being interpreted as a sign brain metabolism is low enough to tolerate longer periods of circulatory arrest, and its reappearance with warming as a herald of appropriate brain function recovery.

SSEP can provide an objective and reproducible assessment of the neuraxis from the peripheral nerve to the cortex complementing information obtained from clinical and neuroradiologic examinations, and as such are useful in pediatric neurology. SSEP are useful in monitoring coma and surgical procedures, in detecting preclinical abnormalities, particularly patterns of abnormalities, and in localizing lesions within this sensory system (Fagan, 1987). Our goal is not to exhaust the topic, but to draw attention to a non-invasive complementary neurophysiological examination that can add evidence to the clinical diagnosis.

Conclusion

SSEP continues to be an important complementary exam within the neurophysiological arsenal available to the neurological clinic that is extended to neurosurgeons, intensivists, anesthesiologists and orthopedists. Important questions remain to clearly delineate the practical scope of EPs and their proper use. This includes standardization of techniques and nomenclature, precise location of neural generators, elucidation of various factors that affect determinations and establishment of normative values.

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