Section: PMR

Original Research Article

PROGNOSTIC IMPORTANCE OF TIBIAL NERVE SOMATOSENSORY EVOKED POTENTIALS IN TRAUMATIC BRAIN INJURY

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Abstract

Background: TBI increases long term mortality and reduces life expectancy. **Objective:** To study changes in Tibial nerve Somatosensory Evoked Potentials in patients with Traumatic Brain Injury within 1 month and at 3 months after the traumatic event. **Material and Methods:** The study was conducted among 21 patients with Traumatic brain injury (TBI) of less than one month duration seen in the Department of Physical Medicine and Rehabilitation of Christian Medical College, Vellore. Duration of study was one and half year. **Results:** 3 patients had grade I, 5 patients had grade II and 13 patients had grade III initial Tibial SSEPs. 4 patients had grade I, 6 patients had grade II and 11 patients had grade III Tibial SSEPs. Of the3 patients with grade I SSEP, Second SSEP remained grade I in 2 patients and there was worsening to grade III in 1 patient. Among the 4 patients with initial grade II SSEPs, second SSEP remained same in 3 patients and SSEP of 1 patient worsened to grade III. Of the 13 patients in grade III SSEPs, 9 patients continued to grade III, 3 patients improved to have grade II SSEPs and 1 patient improved to have grade I SSEPs at 3 months. Among 11 patients with grade 2 and 3 SSEPs initial Median SSEPs, 3 patients improved to have better grades(27%) and among 18 patients with initial. Among 18 patients with grade 2 and 3 SSEPs initial Tibial SSEPs, 4 patients improved to have better grades (22%) and among 8 patients with initial Tibial SSEPs of grade 1 and 2, two patients worsened to lower grades(25%). **Conclusion:** Tibial SSEPs improved in 22% and worsened in 25% patients. Initial Tibial SSEPs co-related with MMSE and 3 month Tibial SSEPs co-related with MBI scores. There was no co-relation with other outcomes. Absent SSEPs predicted bad outcome, and this was statistically significant.

INTRODUCTION

Traumatic Brain Injury (TBI) is defined as "an alteration in brain function, or other evidence of brain pathology, caused by an external force". Alteration in brain function can be one of the following clinical signs: any period of loss of or a decreased level of consciousness, any loss of memory for events immediately before or after the injury, neurological deficits (weakness, loss of balance, change in vision, dyspraxia, paresis/ plegia, sensory loss, aphasia), or any alteration in mental state at the time of the injury (confusion, disorientation, slowed thinking).[1]

TBI can be classified as

Mild Traumatic Brain Injury

1. Confused state or loss of consciousness < 30 minutes
2. Initial Glasgow Coma Scale of 13 – 15
3. Post traumatic amnesia lasts < 24 hours

Moderate traumatic brain injury

1. Loss of consciousness of 30 minutes to 24 hours
2. Initial Glasgow Coma Scale of 9 – 12
3. Post traumatic amnesia lasts 24 hours to seven days

Severe Traumatic Brain Injury

1. Loss of consciousness of greater than 24 hours
2. Initial Glasgow Coma Scale of 3 – 8
3. Post traumatic amnesia period of greater than seven days.[2,3]

Several studies have analysed the utility of Somatosensory Evoked Potentials done in the acute phase of Traumatic Brain injury for prognostication. In these studies, bilateral absent Somatosensory Evoked Potentials have been found to have a strong association with poor outcome or nonawakening after coma. However, few studies have studied Somatosensory Evoked Potentials in the sub-acute or the late phases after the event, the changes in

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these potentials over time and the prognostic significance of the same.

In the current study, we have done Somatosensory Evoked Potentials in the sub-acute phase that is within one month following the Traumatic Brain Injury and subsequently at 3 months. We have compared the potentials obtained at these time intervals with various outcome measures and also analysed the changes in them over the time interval defined.

MATERIALS AND METHODS

The study was conducted in the Department of Physical Medicine and Rehabilitation of Christian Medical College, Vellore. The study was approved by the Institutional Review Board of the Institution.

Inclusion Criteria

21 patients with Traumatic brain injury (TBI) of less than one-month duration seen in the Department of Physical Medicine and Rehabilitation of Christian Medical College, Vellore. Duration of study was one and half year. Patients seen as outpatients in Brain Injury Clinic and those admitted for neurorehabilitation were included in the study after obtaining informed consent.

Exclusion Criteria

Patients with

1. Neurological impairment before head trauma and peripheral neuropathy
2. Focal lesions preventing the impulse from reaching the cortex
3. Subdural or extradural collections which impede the recording of the cortical response were excluded from the study.

Methodology

Neurological examination was done in all patients, which included Glasgow Coma scale, speech, cranial nerve, motor, sensory, cerebellar functions and gait assessment.

Outcomes measures

Cognitive functions were assessed using

1. Mini-Mental Status Exam (MMSE)
2. Rancho Los Amigos scale (RLA)

MMSE allows objective assessment of mental status. MMSE assess orientation to time and place, memory, attention, ability to name objects, follow verbal and written commands, write a sentence spontaneously and copy a complex figure. Scores range from 0 to 30.[4]

Rancho Los Amigos scale defines eight levels of cognitive functioning from "no response" to "purposeful and appropriate." It helps to identify the type of injury, severity, and cognitive functioning.[5]

Functional status and disability were assessed using

1. Modified Barthel Index (MBI)
2. Disability Rating Scale (DRS)

Modified Barthel Index establishes the degree of independence of the patient during his routine activities. Scores range from 0 to 100.[6]

Disability Rating Scale uses a continuous 30-point scale. It reflects change in arousal and awareness and in the cognitive functional and psychosocial areas.

DRS scores have been correlated with 10 clinical levels of disability.

DRS Score 0 is no disability, 1 is mild, 2-3 is partial, 4-6 is moderate, 7-11 is moderately Severe, 12-16 is severe, 17-21 is extremely Severe, 22-24 is vegetative state, 25-29 is extreme Vegetative State and 30 is death.[7]

Glasgow Outcome Scale (GOS) was used for overall assessment. GOS is one of the most widely used outcome scales. GOS is a five level classification scale.

1. Dead
2. Vegetative state
3. Severe disability (Able to follow commands/ unable to live independently)
4. Moderate disability (Able to live independently; unable to return to work or school)
5. Good recovery (Able to return to work or school).[8]

Glasgow Outcome Scale Extended (GOS-E) is a modification of the GOS. It has eight categories of outcomes, including dead, vegetative state, lower severe disability, upper severe disability, lower moderate disability, upper moderate disability, lower good recovery, and upper good recovery.[9]

SSEP recording

Tibial nerve was stimulated using surface electrodes.

Stimulus intensity and rate

Monophasic square pulses of 0.2 milliseconds duration and 25 mA in intensity were given at 3Hz frequency.

Recording Parameters

Recording electrode impedances was kept below 5,000 ohms. Ground electrode was placed on the stimulated limb, proximal to the stimulation site. Recording amplifier filters were set at 30-3,000 Hz. Signal averaging with 500 stimulus trials was done.

Electrode Locations

SSEPs were recorded using standard EEG electrodes. Scalp electrode sites were determined using the international 10-20 system.

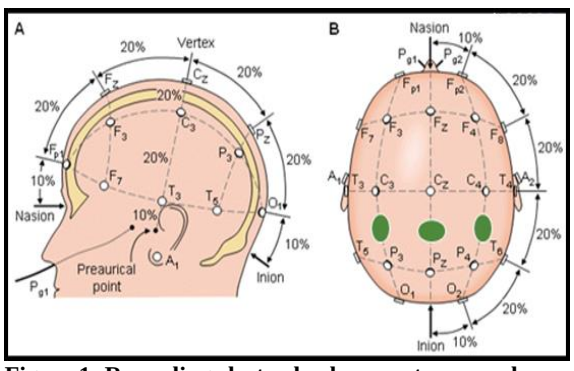

Figure 1: Recording electrode placement over scalp

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Three channel recording was done for Tibial SSEPs. For Tibial SSEP studies, E1 and E2 refer to electrodes in the popliteal fossa, 2 cm and 5 cm above the popliteal crease in the midline respectively. E3 and E4 refer to electrodes over the lumbar spine. Cz' is in the midline, 2 cm behind the vertex (Cz) location. FPz is used as noncephalic reference electrode.

Tibial SSEP

1. Stimulus location

Posterior Tibial nerve was stimulated at the ankle, with the cathode midway between the Achilles tendon and medial malleolus. Anode was placed 3 cm distal to the cathode.

2. Montages/ Channels

Channel 1: E1 - E2
Channel 2: E3 - E4
Channel 3: Fpz-Cz

Channel 1 records the stationary popliteal potential. Channel 2 records the stationary lumbar potential (LP), widely distributed over lower thoracic/ upper lumbar spine. Channel 3 records the subcortical far field potentials, P37 and the cortical near field potential N45.

Recording of the waveforms

Evoked potential waveforms were named by the polarity of their peak (N or P to indicate negative or positive), and the time to maximal amplitude in milliseconds after stimulation. Wave forms were analysed for peak latencies and interpeak latencies.

For Tibial SSEPs, peak latencies of popliteal fossa potential, lumbar potential, P37 and N45 were measured. Interpeak latencies for PF to LP, LP to P37 and PF to P37 were measured.

Patients were assessed clinically using the scales included in the study. SSEP studies were done first within one month of the event and then 3 months after the event. Outcome measures were obtained at 3 months as well.

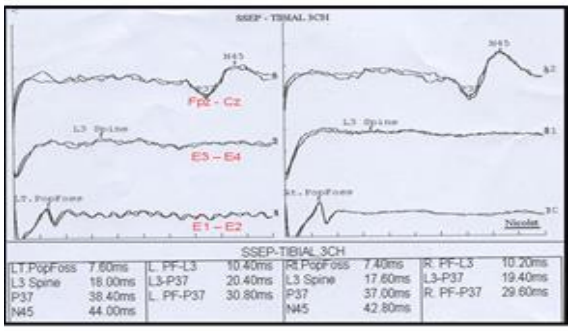

Table 2: SSEP Tibial recording

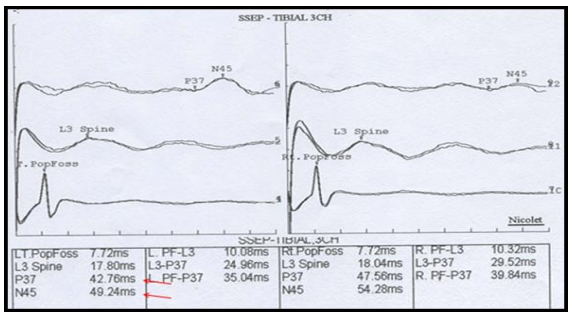

Figure 3: Tibial SSEPs recording showing prolonged latencies on both sides

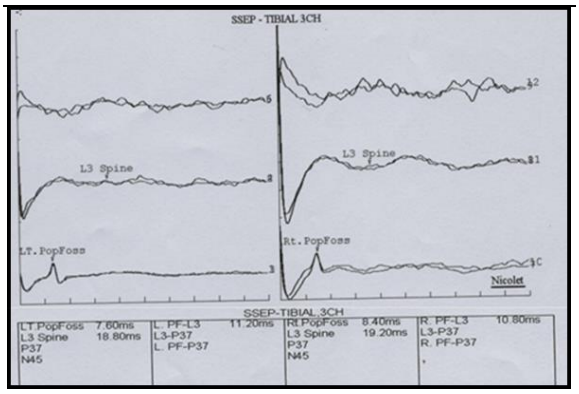

Figure 4: Tibial SSEPs recording showing bilateral absent cortical potentials

Statistical Methods

Descriptive statistics, including mean, standard deviation and range were done for continuous data. Univariate analysis of the data for SSEP and outcome scales was done for correlation using chi square test. p value less than 0.05 was considered as significant.

RESULTS

4 patients had grade I, 6 patients had grade II and 11 patients had grade III Tibial SSEPs.

Tibial SSEPs

Of the3 patients with grade I SSEP, Second SSEP remained grade I in 2 patients and there was worsening to grade III in 1 patient. Among the 4 patients with initial grade II SSEPs, second SSEP remained same in 3 patients and SSEP of 1 patient worsened to grade III. Of the 13 patients in grade III SSEPs, 9 patients continued to grade III, 3 patients improved to have grade II SSEPs and 1 patient improved to have grade I SSEPs at 3 months.

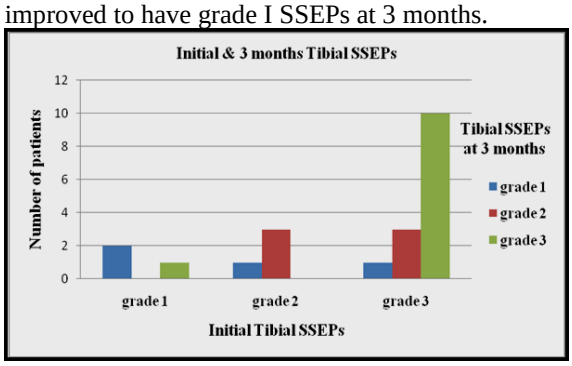

Figure 5: Changes in Tibial SSEP after 3 months

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Among 18 patients with grade 2 and 3 SSEPs initial Tibial SSEPs, 4 patients improved to have better grades (22%) and among 8 patients with initial Tibial SSEPs of grade 1 and 2, two patients worsened to lower grades(25%).

Initial Tibial SSEPs and clinical outcomes

Clinical outcome scores showed improvement at 3 months compared to the initial values, but there was no statistically significant difference in outcome of the patients with the three initial Tibial SSEP grades, except for MMSE (p - 0.02).

3 months after injury patients with grade 1 and 2 Tibial SSEPs, had better outcome than those with grade 3 Tibial SSEPs, which was statistically significant for MBI (p – 0.037).

SSEPs and GOS

3 months after the event, based on the Glasgow outcome scale (GOS), 10 patients (47.6%) had good recovery, 7 (33.4%) had moderate recovery, one patient had severe disability (4.8%) and 3 (14.3%) were in vegetative state.

Favourable outcome includes the categories of moderate disability and good recovery. Unfavourable outcome includes the categories of death, vegetative state and severe disability.

There was no co-relation between initial Tibial SSEPs and GOS at 3 months. There was no co-relation between Tibial SSEPs 3 months after the TBI and the outcome based on GOS.

There was no significant correlation between the changes in Tibial SSEPs after 3 months with the clinical improvement. In the case of Tibial SSEP, 15 patients continued to have the same grade, 4 patients improved to a better grade and 2 patients worsened to have more abnormal grades of SSEP.

Table 1: Baseline characteristics of patients at initial assessment

Parameter	Mean (SD)	Range
Age	33.4 years	9 - 60 years
Duration of injury	19.33 days (6.12)	6 - 30 days
GCS (sum of Visual and Motor components)	7.90 (0.77)	6 – 9
Mean Rancho Los Amigos score/ level	3.1 (0.63)	2 – 4
Mean Disability Rating Scale score	21.76 (1.95)	16 – 24

3 patients had grade I, 5 patients had grade II and 13 patients had grade III initial Tibial SSEPs.

Table 2: Initial and 3 month Tibial SSEPs

	Initial	**3 months**
Tibial SSEPs		
Absent on both sides	13 (61.9%)	11 (52.4%)
Absent on one side	3 (14.3%)	2 (9.5%)
Absent one side and prolonged on other side	-	1 (4.8%)
Prolonged on one side and normal on other side	1 (4.8%)	1 (4.8%)
Prolonged on both sides	1 (4.8%)	2 (9.5%)
Normal	3 (14.3%)	4 (19%)

Table 3: Number of patients in each grade of SSEPs

	Number of patients	
	Initial	**At 3 months**
Tibial SSEPs		
Normal (grade I)	3	4
Impaired (grade II)	5	6
Absent (grade III)	13	11

4 patients had grade I, 6 patients had grade II and 11 patients had grade III Tibial SSEPs.

Table 4: Changes in Tibial SSEPs over time

		Second Tibial SSEP - No of patients			
		Grade I	**Grade II**	**Grade III**	**Total**
First Tibial SSEP - No of patients	Grade I	2	0	1	3
	Grade II	0	4	1	5
	Grade III	1	3	9	13
	Total	3	7	11	21

Table 5: Grades of initial Tibial SSEPs and clinical outcomes

	RLA (1)	**DRS (1)**	**MMSE (2)**	**RLA (2)**	**MBI (2)**	**DRS (2)**
Grade I	3.67	23.00	29.00	8.00	99.67	.33
Grade II	3.00	22.00	21	7.4	76.2	3.4
Grade III	3.00	21.31	15.54	6.69	64.15	7.62
Kruskal wallis test	3.039	1.93	7.85	2.06	3.94	4.68
Sig	.219	.38	.02	.35	.13	.09

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Table 6: Grades of Tibial SSEPs at 3 months and clinical outcomes

	RLA (1)	DRS (1)	MMSE (2)	RLA (2)	MBI (2)	DRS (2)
Grade I	3.75	22.00	27.00	8.00	99.75	.50
Grade II	3.00	20.33	21.83	7.67	77.00	3.50
Grade III	2.91	22.45	14.18	6.36	59.36	8.55
Kruskal wallis test	5.82	4.28	2.26	.67	4.37	5.88
Sig	.054	.617	.133	.414	.037	.053

Table 7: SSEPs grades and clinical outcome based on GOS at 3 months

	Glasgow outcome scale		Pearson chi square value (sig)	Likelihood ratio (sig)
	Favourable	Unfavourable		
First Tibial SSEPs				
Grade I	3	0	3.04 (0.21)	4.40 (0.11)
Grade II	4	0		
Grade III	8	5		
Second Tibial SSEPs				
Grade I	4	0	1.44 (0.48)	1.35 (0.24)
Grade II	5	1		
Grade III	7	4		

DISCUSSION

21 patients with TBI were included in the present study. They were assessed within the first one month and at 3 months after the TBI.

On initial assessment, 67% of the patients were in vegetative state and remaining 33% were in severe disability categories on the DRS score. 76% patients were in either generalized or localized response state and remaining 24% were in confused agitated categories on the RLA scale. MBI and MMSE could not be assessed because of low sensorium in most of the patients. 15% patients had normal initial Tibial SSEPs. 3 months after the TBI, patients improved and the clinical outcomes ranged from total assistance to purposeful, appropriate behaviours/ stand by assistance categories on RLA, and no disability to vegetative state categories on the DRS score.

In our patients, SSEPs abnormalities evolved after traumatic brain injury during the study period. Out of 18 patients with either grade II or III initial Tibial SSEPs, 4 patients improved to better grades after 3 months, whereas, out of 8 patients with either grade I or II initial Tibial SSEPs, 2 patients worsened to lower grades subsequently.

The possible causes for this could have been associated spinal cord injuries in these patients which can be seen in patients with TBI. This could not have been picked up by the SSEP median recording technique in our study, as the cervical electrode recordings are not routinely done in our Electrophysiology laboratory. .

Three months follow up was of short duration considering that some patients can have slow recovery. Long term follow up studies would be helpful.

The outcome measures in the study assessed mainly the physical disabilities due to the short duration of follow up. Long term studies with assessment of neurocognitive profiles will be more informative on the overall outcome.

Studies with large sample size, assessing SSEPs at early, acute and sub-acute phases after traumatic brain injury, analyzing multiple factors/ outcomes and having long term follow up will provide more informative data about the role of SSEPs in traumatic brain injury.

CONCLUSION

Tibial SSEPs improved in 22% and worsened in 25% patients. Initial Tibial SSEPs co-related with MMSE and 3 month Tibial SSEPs co-related with MBI scores. There was no co-relation with other outcomes. Absent SSEPs predicted bad outcome, and this was statistically significant.

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