

MRI AND MOTOR EVOKED POTENTIALS AS A PREDICTOR OF EARLY RECOVERY AFTER ACUTE BRAIN PARENCHYMAL INJURY

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ABSTRACT

BACKGROUND

MRI and motor evoked potentials have been widely used in assessment of patient's diagnosis, but their assessment in predicting outcome of acute brain parenchymal injury has been limited.

The aim of this study was to measure Motor Evoked Potentials (MEP) intraoperatively and to predict the outcome and early recovery after trauma involving acute brain parenchymal injury.

MATERIALS AND METHODS

A retrospective descriptive study done between 2015 and 2017, at a tertiary trauma care centre, database of 32 patients who have been monitored intraoperatively with motor evoked potentials has been collected. Among them 23 patients came under a, b, c of Association Impairment Scale (AIS). Preoperative and postoperative AIS data, MRI reports, surgical data and use of steroids have been obtained for study. Axial T2 MRI have also been obtained.

RESULTS

AIS at discharge was significantly predicted by MEP ($p < .001$). AIS improved by an average of 1.5 grade (median= 1) in patients with AIS a, b, c with electable MEPs, while the improvement in those without elicitable MEPs was 0.5 grades (median= 0, $p < .05$). MEP status was well correlating with MRI grade.

CONCLUSION

MEPs predicted neurological improvement in patients with AIS grades a, b and c in patients with acute brain parenchymal injury. MEP prediction was well correlating with MRI grading.

KEY WORDS

MRI Grading, Acute Brain Parenchymal Injury, Evoked Potentials.

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BACKGROUND

Neurophysiological monitoring in the intraoperative period (IOM) is widely being used with Motor Evoked Potentials (MEP) and Somatosensory Potentials (SSEP) in patients with brain parenchymal injury.⁽¹⁻²⁾ At present, scientific studies are demonstrating the value of IOM in spinal fusion and deformity, but the use of MEP in acute brain parenchymal injury has been lacking. There is a good amount of literature supporting prognostic value of early neurophysiologic monitoring in preclinical models of acute brain parenchymal injury. There are several studies detailing the use of MEP in intraoperative period in brain surgeries, but they have not given any correlation between MEP and the clinical outcome of the patient after the surgery and their correlation with MRI grade.⁽²⁻³⁾ Recent studies have also demonstrated correlation of MEPs with chronic injuries, but did not investigate the role of IOM in acute injury groups.⁽⁴⁻⁵⁾ The role of intraoperative EEG findings in assessment of future prognosis has also been largely unexplored.

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Aims and Objectives

The purpose of this study was: 1) To find correlation of MEPS and clinical examination findings in acute brain parenchymal injury patients; 2) Assessment of role of MEPS as a prognostic marker for acute brain parenchymal injuries; 3) To find correlation between acute magnetic resonance imaging findings and MEPS.

MATERIALS AND METHODS

A retrospective descriptive study was performed to evaluate the diagnostic and prognostic value of MEPS for acute brain parenchymal injury patients admitted to a level 1 trauma centre between January 2015 and December 2017. Patients were identified using a database obtained from Department of Neurosurgery at a level 1 trauma care centre specialised in handling brain parenchymal injuries. We retrospectively identified 131 patients from database with a principal diagnosis of acute brain parenchymal injury. Of them, 32 met inclusion and exclusion criteria.

All of these patients were acute brain parenchymal injuries. Inclusion criteria was set as: (1) Age ≥ 18 , (2) Utilising intraoperative MEPS during surgical decompression and (3) Documented AIS grading at the time of admission before surgery and during follow-up after the surgery. Exclusion criteria was considered to be (1) Cases for which pre-op AIS grading was not mentioned and (2) Cases complicated intraoperatively by hypotension. AIS grading was selected as a measure of neurological outcome based on current guidelines for the classification of brain parenchymal

injuries.¹¹⁻¹³ AIS grades were obtained on all patients included in this study, both at the time of discharge and before the surgery during time of admission.

Intervention Parameters: Imaging Workup and Initial Management

Twenty-seven patients underwent MRI brain prior to surgery. MRI was performed on a 3 Tesla scanner. 14 axial grading of MRI images was performed with the help of basic (Brain and Spinal injury centre) score. Grading was performed by radiologist who was blinded to the clinical status of the patients. Briefly, based on the most severely affected axial T2 MRI image at the injury epicenter, grades were assigned as follows: Grade 0 injury was defined as no parenchymal signal abnormality, grade 1 injury was defined as T2 hyperintensity approximately confined to the grey matter, grade 2 injury was defined as T2 hyperintensity involving grey and some but not all of the white matter, grade 3 injury was defined as T2 hyperintensity involving both grey and white matter and grade 4 injury was defined as grade 3 injury with the addition of foci of T2 hypointensity consistent with macroscopic intracerebral haemorrhage. 5 patients were excluded due to non-availability of MRI images prior to decompression surgery. Mean Arterial Pressure (MAP) goal of greater than 85 mmHg was targeted according to our institutional protocol. Earlier high-dose methylprednisolone was used, but later steroids were not used because of deleterious effects.

Intervention Parameters

All patients taken into consideration for surgery underwent surgical decompression with a total of 32 procedures in 32 patients. IOM including baseline MEP and SSEP were performed on all the patients prior to positioning and surgery.

Intervention Parameters: IOM

Cadwell's cascade elite neuromonitoring equipment for Neurophysiologic monitoring of Transcranial Electrically Stimulated MEPS (TCMEPS), SSEPS and free-running/evoked electromyography (EMG) were used. Subdermal needle electrodes were placed in Trapezius, Deltoids, Biceps, Triceps, Thenar, Hypothenar and foot flexor/ foot extensor muscles bilaterally for TCMEPS monitoring. Cadwell TCS-1 double train stimulator (pulse with 50 ms, 2 trains of a total of 9 pulses, 1.7 ms interstimulus, interval 13.1 ms intertrain interval), constant voltage ranged from 100 to 1000 v was used for stimulation. Subdermal needle electrodes inserted at C1/C2 were used for transcranial stimulation. For EMG activity monitoring, subdermal needle electrodes placed for TCMEPS were used for cerebral monitoring bilaterally. A needle electrode in the right shoulder served as a ground. SSEPS/ TCMEPS/ EMGS were amplified using differential amplifiers, averaged and computer monitored.

Propofol 120 mcg/kg/min, Fentanyl 100 mcg/h with Sevoflurane 1.0% (0.5 MAC) was used as Anaesthesia protocol and a map goal was set as > 85 mmHg. Baseline measures for both SSEPS and MEPS were documented while prepositioning. Changes were also documented after position change to prone. Final readings were taken with quantification/ comments on significant changes in

SSEPS/TCMEPS from baseline. Presence or absence of MEPS was verified by two-blinded physicists based on operating room neurophysicist's assessment. MEPS with weak signal were considered present as long as they were reproducible with a constant stimulation voltage.

Statistical Methods

For statistical analysis one-way ANOVA was used. This is an extension of the Wilcoxon Rank-Sum Test used to compare population location parameters (mean, median etc.) among two or more groups including independent samples. It is based on the ranks of the data and for non-normal data were reported as median [Interquartile Range [IQR]]. Means of 2 continuous normally distributed variables were compared by independent samples student's t-test. Mann-Whitney U test were used, respectively, to compare means of 2 and 3 or more groups of variables not normally distributed. Analysis of the data was done using a software SPSS system 16.0.

RESULTS

57.4 (range 22 - 86 yrs.) is the mean age in the cohort and AIS grades at admission were a (n= 12), b (n= 5), c (n= 6) and d (n= 9). Descriptive demographics for this cohort are entered in Table 1. Of note, approximately 19 of the 32 patients received high-dose methylprednisolone. No clear relationship was found between administration of high-dose methylprednisolone and MEPS or AIS recovery. All patients were treated with surgical decompression and stabilisation with intraoperative MEPS.

Descriptive Demographics Variable	n= 32	MEP Absent n= 13	MEP Present n= 19	p value
Male	26 (81.25)	10	16	0.21
Female	6 (18.75)	3	33	0.14
Mean age	57.4 ± 17.65	49.5 ± 16.6	63.1 ± 16.3	0.52
Mean MAP goal	121.78 ± 41.9	135.5 ± 36.4	110.59 ± 43.60	0.43
Mean ISS score	22.83 ± 13.27	29.7 ± 16.9	19.4 ± 9.71	0.69
No steroids	13	5	11	0.26
Mean ICU LOS	15.42 ± 19.39	26 ± 24.5	8.65 ± 5.92	0.67
Mean Hospital LOS	26.12 ± 26.81	33.92 ± 29.9	20.90 ± 21.45	0.25
Mortality	1	1	0	0
Table 1. Descriptive Demographics with Variables reported as Mean ± Standard Deviation				

Change of AIS grades from before surgery and after surgery have been entered in Table 2. MEPS significantly predicted the presence of AIS at discharge (p < .001). Patients with present intraoperative MEPS had higher AIS grades after surgery in comparison to those subjects with absent MEPS. When looking at the entire patient population (Initial AIS a-d grades), the amount of recovery in AIS grade was not significantly different between patients with absent MEPS in comparison with patients with present MEPS (p=.158). In the group of severe brain parenchyma injury (AIS a, b, c), AIS of patients with elicitable MEPS improved by an average of 1.5 grades (median= 1) as compared to the subjects without elicitable MEP, who on an average only

improved by 0.5 grades (median= 0). No difference was found between the hospital stay between these two groups.

Variable	AIS-A (n= 12)	AIS-B (n= 5)	AIS-C (n= 6)	AIS-D (n= 9)
1 Grade Improvement	0	2	5	3
2 Grade Improvement	3	1	1	0
3 Grade Improvement	1	0	0	0
4 Grade Improvement	1	0	0	0
No Improvement/ Regression	7	2	0	6

Table 2. Incidence of Recovery by Initial AIS Grade

P < 0.001

All severe brain parenchyma injury patients (AIS a-c) that had present intraoperative MEPS converted at least 1 AIS grade from before surgery to after surgery. Among those who did not have elicitable intraoperative MEPS (n= 13), 8 subjects did not show conversion of AIS grades. No significant difference in time to surgery was found for patients with and without MEPS. Patients with absent MEPS had significantly higher basic scores when compared to the patients with present MEPS. All subjects that had a basic score of 4 did not change in their AIS grade before and after surgery.

DISCUSSION

We have evaluated the prognostic value of IOM in the present study for predicting early neurological recovery after acute brain parenchymal injury.^(1-6,7) Results show that presence or absence of intraoperative MEP status is highly predictive of AIS conversion in severe brain parenchymatous injury after the surgery. Further, we found strong electro-radiologic correlation, as intraoperative axial MRI grade (basic score) were found highly correlating with intra-op MEP status.^(8,9,10-12)

We applied basic score to our subjects and found that patients with positive MEPS were found to have significantly lower basic scores (p < .001). MEP status was found to be dividing into 2 basic MRI patterns. Patients (80%) without elicitable MEPS had T2 signal abnormality with both grey matter and white matter (basic 3 and 4) and 94% patients with preserved MEPS had varying degrees of white or grey matter injuries MRI (basic 0 - 2); 22 in our cohort with intramedullary haemorrhage on axial T2 (basic 4) did not recover. All these patients did not have elicitable MEPS. The use of MEP in brain parenchyma may also provide prognostic value that can guide patient/ family counselling and post-operative treatment. MEPS may even be used to guide medical management. Future studies are required to evaluate the use of MEPS in the intensive care setting.⁽¹³⁻¹⁶⁾

This is a retrospective descriptive study and is subject to the basis inherent with such studies. AIS grades are used rather than international standards for neurological classifications of grading brain parenchymal injury. AIS grades provide less detailed information to evaluate postsurgical changes. Length of stay can be varied for a variety of reasons, many of which are not a reflection of clinical outcomes. Finally, the most compelling finding in this study is the relationship between elicitable MEPS and brain parenchymal injury outcome.⁽¹⁷⁻¹⁹⁾ However, this is limited by a relatively small number of patients (32

patients). A prospective study with large sample size is needed to further validate these findings. Even with these limitations, this study has successfully established a relation between MEPS and neurological outcome after acute brain parenchymal injury.⁽¹⁷⁻¹⁹⁾

CONCLUSION

Intraoperative elicitation of MEPS is found to be strongly associated with at least partial sparing of brain parenchymal tissue on axial T2 MRI. Future studies regarding role MEPS in the ICU setting should be undertaken and perhaps after establishment of strong relationship, they could even be used to guide medical management. Significant findings like a relationship between MEPS and potential for recovery after surgery for brain parenchymal injury during the acute hospitalisation. The present data needs more evaluation. Prospective studies should be done to further validate these findings.

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