Case Report

RIGHT MEDIAN NERVE STIMULATION IN TRAUMATIC BRAIN INJURY: EVALUATION OF IMPROVEMENT USING CLINICAL SCALES AND PET SCAN

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ABSTRACT

Electrical stimulation may serve as a catalyst to enhance central nervous system functions and the right median nerve has been chosen as a portal to electrically stimulate and help arouse the central nervous system for persons with reduced levels of consciousness. The mechanisms of central action include increased cerebral blood flow and raised levels of dopamine. Right median nerve stimulation (RMNS) is a safe, inexpensive, non-invasive therapy and may help in facilitating recovery from coma. It does not have any reported side effects and might be used for all those patients who are in coma or vegetative state. We present a case of Traumatic Brain Injury in which we used position emission tomography (PET) in addition to clinical scales, to identify the changes in brain metabolism following RMNS therapy.

KEYWORDS: Coma, Traumatic brain injury, Electrical Stimulation, Right median nerve stimulation, RMNS, Position emission tomography, PET

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INTRODUCTION

Brain injury is a leading cause of mortality, morbidity, and socioeconomic losses worldwide and in India too. Despite the improvements in emergency treatment, persistent coma is still a major clinical problem. There is more than 20 years of experience in the USA of using nerve stimulation for acute coma after traumatic brain injury. There is a much longer period of experience by neurosurgeons in Japan with implanted electrodes on the cervical spinal cord for persons in the persistent vegetative state (PVS). [1, 2, 3, 4]

Electrical stimulation may serve as a catalyst to enhance central nervous system functions and the right median nerve has been chosen as a portal to electrically stimulate and help arouse the central nervous system for persons with reduced levels of consciousness. This is because increased awareness and a better pattern of speech and abilities to calculate have been observed after right median nerve stimula-

-tion(RMNS). In the majority of individuals, whether right-handed or left handed, Broca's motor/speech planning area lies in the left fronto-temporal region. Broca's area has been shown to become more active in position emission tomography (PET) when a subject moves, or even contemplates moving his hand, a process mimicked by stimulation of the right median nerve. Additionally, the cortical representation of the hand is disproportionately large compared to other parts of the body. The mechanisms of central action include increased cerebral blood flow and raised levels of dopamine. We present a case in which we used PET in addition to clinical scales, to identify the changes in brain metabolism following RMNS. [3,5,6]

CASE SUMMARY

A 26 years old male came to our hospital with alleged history of fall in the bathroom. At the time of admission his Glasgow Coma Score (GCS) was E1M2V1. A Non Contrast Computed Tomography (NCCT) study of his head was done which revealed bilateral basifrontal contusion (left>right) and left temporal hemorrhagic contusions with extra dural haematoma. Further, he underwent left fronto-temporo-parietal craniotomy and evacuation of hematoma. Post operative NCCT head scans showed hypodense region in the left posterior temporal and occipital region suggestive of an infarct in the left Posterior Cerebral Artery (PCA) territory and post operative changes. He was tracheostomised for better toileting of lung secretions. After about 21 days of surgery, once his vitals were stable, he was put on right median nerve stimulation (RMNS) for a period of 3 weeks, for approximately 8 hours per day. The electrodes were placed just above the right wrist joint, on the palmar aspect of distal forearm (lateral side). The parameters of RMNS were chosen as per the previous studies. Asymmetric biphasic pulses at amplitude of 20 mA (milliamps) with a pulse width of 300 microseconds at 40 Hz (pulses/second) for 20 sec on and 40 sec off were used. The stimulator was developed and manufactured by Medicaid System, Chandigarh, INDIA.

The outcome measures were Glasgow Coma Scale (GCS) and JFK Coma Recovery Scale-Revised (JFK-CRS-R). The JFK-CRS-R scale was developed by Giacino et al and the basic structure is similar to GCS. It includes similar visual, motor and verbal subscales as the GCS. There are in addition three other subscales: an auditory function scale, a communication scale and an arousal scale. Its total score ranges between 0-23. It also denotes minimally conscious state and emergence from minimally conscious state. [7]

PET scan protocol

Brain PET/CT was performed pre and post right median nerve stimulation. The scan was done after I.V. injection of 5 m Ci of 18F-FDG (Fluorodeoxyglucose), using a full-ring dedicated Discovery 600 PET/CT scanner with 16 slice CT. Images were acquired at 60 minutes and reconstructed using ordered subset expectation maximization (OSEM) standard iterative algorithm and reformatted into Transaxial, Coronal and Sagittal views. The images were also quantitatively analysed on dedicated neurology software -Cortex ID.

RESULTS AND TABLES

Clinical scales

	GCS	JFK-CRS-R
Pre RMNS	E4M3Vt	8/23
Post RMNS	E4M6Vt	17/23

As mentioned in the table above, his GCS and JFK-CRS-R scores before the stimulation were E4M3Vt and 8 out of 23 respectively. After 3 weeks of stimulation his GCS improved to E4M6Vt and JFK-CRS-R bettered to 17.

PET scans interpretation

The baseline scan was acquired prior to the stimulation and showed generalized hypometabolism in the cerebral hemispheres both in cortical and subcortical structures, more marked on the right side. Post stimulation the scan was acquired using the same parameters as that of baseline scan. The post stimulation scan showed better generalized metabolism in comparison to the baseline scan, more marked improvement in the right cerebral region and some improvement in the left parieto-temporal region. Even the quantitative scores and visual interpretation on the Cortex ID software showed improvement in comparison to the baseline study.

Fig. 1: Pre RMNS PET scan.

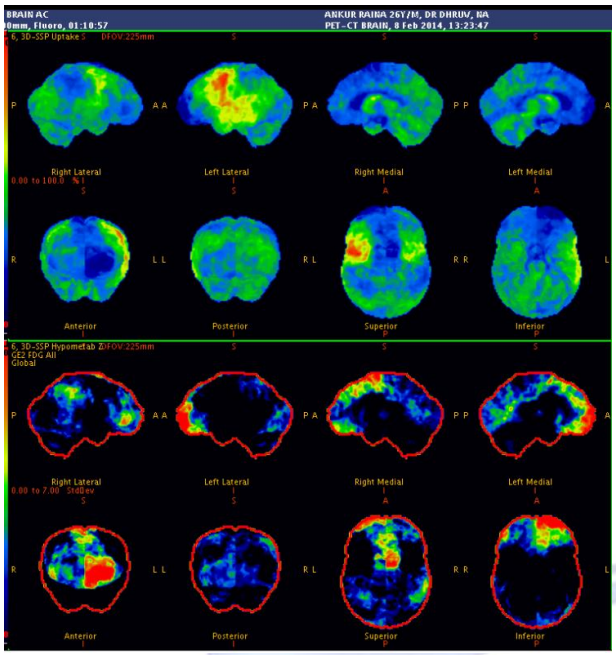
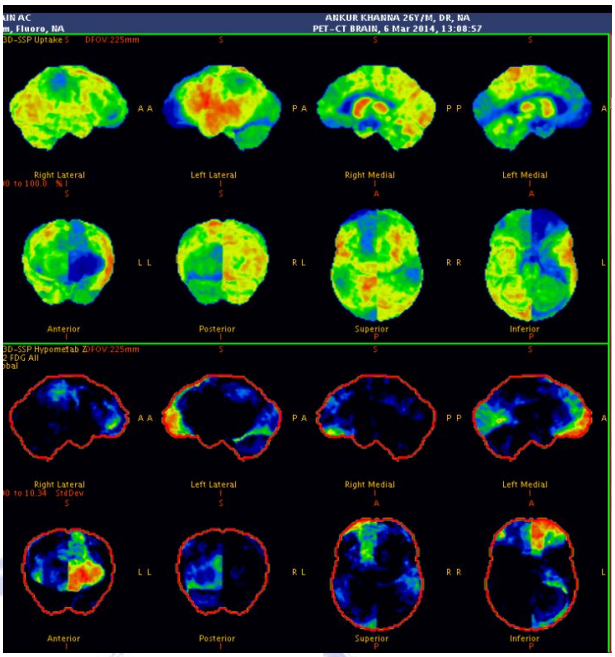


Fig. 2: Post RMNS PET scan.



*Pre RMNS (Fig. 1) and post RMNS (Fig. 2) PET scan images: Fig. 2 shows marked improvement in cerebral glucose metabolism on right side and also in the scores on cortex ID (not shown in the figures)

DISCUSSION

In this study we found significant improvement in Glasgow Coma Scale (GCS) and JFK Coma Recovery Scale-Revised (JFK-CRS-R) following right median nerve stimulation (RMNS). We also observed increased brain metabolism after RMNS, more marked in the right cerebral hemisphere and also in the left parieto-temporal region. This improvement in right sided brain metabolism as compared to left hemisphere is contradictive of what normally one would assume with RMNS. The rationale for better metabolism could be part of the natural recovery process of the injury or right hemisphere might have more intact neurons (capable of improvement) rather than the left hemisphere (the side of surgical intervention) comprising of a lot of gliotic scarred neural tissue. We studied only a single case; however, there is need for larger trial to reach further conclusion.

Cooper et al. have explained in detail the mechanism behind the action of right median nerve stimulation for improving consciousness. The concept of electrical stimulation in traumatic brain injury is based on the hypothesis that electric currents applied through peripheral routes may reach central areas, activating the neuro-endocrine system to improve functioning after traumatic cerebral damage. It is proposed that the peripheral stimuli go to the Ascending Reticular Activating System (ARAS), which further connects with the intralaminar nuclei of the thalamus and then stimulates the cortical layer one. The locus coeruleus (releasing norepinephrine), and the forebrain basal nucleus of meynert (releasing acetylcholine), are also involved and stimulate the cortical layer 1, thus enhancing arousal.[6, 8, 9] The efficacy of right median nerve stimulation in patients with prolonged coma after trauma, stroke, and hypoxic brain damage has been suggested by many researchers.[10, 11, 12] Liu et al. used RMNS to awaken consciousness of 6 patients (2 with brain trauma, one with aneurysm rupture, one with hemorrhagic stroke, and two with hypoxic encephalopathy). All patients underwent SPECT (Single Photon Emission Computed Tomography) scan for cerebral perfusion evaluation and neurotransmitter quantification before and after the stimulation. Four patients recovered from consciousness within 35 days. There was no obvious clinical improvement in two patients. Brain perfusion increased in all cases after stimulation. The elevation of neurotransmitter in CSF was found in 5 out of 6 cases. They concluded that median nerve stimulation elevates the cerebral blood flow and may influence the patient's consciousness. Young patients (<40 years old) had better results than

older patients.[13]

CONCLUSION

RMNS is a safe, inexpensive, non-invasive therapy and may help in facilitating recovery from coma. It does not have any reported side effects and might be used for all those patients who are in coma or vegetative state. We believe a functional investigation like PET scan, might help us in understanding the mechanism of RMNS better.

Conflicts of interest: None

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