THE INFLUENCE OF MILD TRAUMATIC BRAIN INJURY ON EPISODIC MEMORY -A CROSS-SECTIONAL STUDY

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Abstracts: Mild traumatic brain injury (mTBI) causes an alteration in the brain function without any evident structural changes. With this study an attempt was made to determine cognitive impairments pertaining to specific areas of the brain involving working and episodic memory as no significant data is available regarding the same.

The objective was to assess the cognitive deficits and audio-visual reaction time in subjects who had suffered mTBI with a GCS of 15/15 admitted in neurosurgery ward.

A cross sectional study from February to July 2019 was carried out on 12 patients in neurosurgery department, statistical analysis was done using SSPS version 20 and Unpaired T test was performed. The following tests were conducted-

1.STAI (for perceived anxiety)
2.Delayed free verbal Recall (episodic memory)
3.Audio-Visual reaction time (working memory)

Mean ± SD

- STAI state form 38.69 ± 8.68; (higher than normal)
- 3-word recall trial one 1.5± 0.512 and trial two 1.66 ± 0.557; (lower)
- Visual time on AVRT 301.5 ± 101.25ms; (higher)
- Auditory time on AVRT 286.1 ± 95.9 ms; (higher)

Both episodic and working memory showed deviation from normative findings. As the functional alterations in the pathway of formation and retrieval of memory involving the decoupling of the dorso-lateral pre-frontal cortex (DLPFC) causes

- alterations in freely recalling words due to disruption in the process of encoding,
- altered problem solving and processing speed leading to increased reaction time

further aided by the increased amount of anxiety post trauma

Key Words: STAI; AVRT; delayed word recall

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Introduction: Traumatic brain injury is broadly defined as an alteration in brain function or any other evidence of brain pathology caused by an external force [(1)]. Various classifications based on severity, anatomical features of the injury, mechanism (closed or penetrating head injury), level of consciousness etc are available [(2)].

In this study, we have focused on grading TBIs according to the Glasgow Coma Scale. A GCS of 13 or above is categorized as mild, 9–12 as moderate, and 8 or below as severe [(3)] Culotta et al on the basis of their findings suggested separating patients with GCS 13–14 into a different category from patients with a GCS 15, thus effectively redefining minor head injury [(4)]. For the purpose of

this study we have restricted our research pertaining to only those patients who present with mild traumatic brain injuries with a GCS score of 15/15.

The prevalence of TBI in India is steadily increasing, according to a study by the department of epidemiology, NIMHANS Bangalore, in India an estimated 16 lakh people sustain head injury each year with 2 lakh deaths [(5)] showing a peak incidence between 15-24 years of age. Causes include falls, vehicle accidents, and violence [(6)]

Memory impairment affects 54% to 84% of individuals with TBI [(7)]. A number of studies report that mild traumatic brain injury (mTBI) participants have reduced cognitive performance, even in the long-term after injury, on tasks that assess attention and memory [(8),(9),(10),(11),(12)] while a few studies state complete recovery and no cognitive impairments in majority of the cases [(13),(14)]

Since no clear answer regarding these paradigms are present with us, this study was undertaken to help aid researchers form a directed opinion and avoid pending complications. Also, to form rehabilitation modules for patients afflicted with mTBI.

Aim-

To assess the cognitive deficits and audio-visual reaction time in subjects who have suffered mild traumatic brain injury with a GCS of 15/15 admitted in neurosurgery ward of the hospital.

Material and Methods:

a) **Ethical clearance**- Approval from the institutional ethics committee of the university was taken before starting the study on patients in March 2019.

b) **Consent**- A voluntarily written informed consent from each participant was obtained.

c) **Study design**- Cross sectional study

d) **Period-** Period from February 2019 to July 2019

e) **Study population**-

Patients attending the neurosurgery OPD at the hospital with a history of traumatic head injury and getting admitted to the IPD for further evaluation.

f) **Sample size estimation**-

Based on the pilot study conducted using State Trait Anxiety Inventory, effect size was 28

- Expected reduction-(mean)-d = 28
- SD = σ= 40
- Power = 80%
- α error= 0.05;

One sided Zα=1.65

- β error=0.2;

Zβ=0.84

$$n = [(Z\alpha+Z\beta)\,\sigma/d]^2 = 11.79 \cong 12$$

g) **Criteria for selection of the study group**-

- **Inclusion criteria-**

Both male and female patients with a mild head injury and a GCS score of 15/15 belonging to the age group from 30 to 55 years (middle aged)

- **Exclusion criteria-**

1) Patients with H/O Dementia as per DSM 4 criteria.
2) Any Psychiatric history
3) With H/O visual, hearing disabilities or communication abnormalities.
4) Patients who are on medication (sedatives, antipsychotics etc.) which affect memory.

A structured Performa was used to collect socio-demographic and nationality information from all participants

Study procedure-

State Trait Anxiety Inventory (STAI) was used for each patient to evaluate the perceived anxiety levels, there were two separate self-report scales given to each candidate for measuring "STATE" and "TRAIT" anxiety that evaluated respectively how the respondent felt "at that moment" and "generally". A cut-off point of scores >40 was selected for both S-and T-STAI as being anxious.

Next, we gave 3-word recall test for each patient to test for delayed free verbal recall, as a test for episodic memory, each patient was given a set of 3 words to remember, these words were repeated to the patient twice and the patient was said to remember them for further recounting. 2 trials of the same were conducted and 1 point was given for each word spontaneously recalled without cueing.

The audio-visual reaction time was conducted to assess the concentration, alertness, cognitive accuracy and muscle coordination. The apparatus provided both auditory (low- and high-pitched sounds) and visual (red and green) stimuli. The response was given by the subject by pressing a key with his index finger. Time taken by the subject to give a response was displayed with an accuracy of one millisecond and was recorded as his auditory or visual reaction time [15], [16] . Three readings of the reaction time were taken for each stimulus by randomly varying the fore period (range 0 –10 seconds). The best response of three readings was taken for statistical analysis

Statistical Analysis

The analysis of the results was done using SSPS software and reported as Mean ± SD values. Unpaired t-test was used to compare results from normative values and a "*P*" value of less than 0.05 was considered significant.

Result:

The following results were obtained, with the demographic data of the patients recorded as follows

Table I demographic data, HTN- hypertension, DM- diabetes mellitus, ALC DEPENDENCE- alcohol dependence, TB – tuberculosis

Sex	***Male***		***Female***	
	100% (12/12)		*0.00%*	
Age	***35-40***	***40-45***	***45-50***	***50-55***
	33% (4)	*17% (2)*	*17% (4)*	*33% (2)*
Level of education	***<12***	***=12 YRS***		***>12 YRS***
	33% (4)	*9% (1)*		*58% (7)*
Cause of injury	***Fall***	***Violence***	***Rta***	***Other***
	25% (3)	*0%*	*33% (4)*	*42% (5)*
Loss of consciousness	***YES***		***NO***	
	25% (3)		*75% (9)*	
Post traumatic amnesia	***YES***		***NO***	
	33% (4)		*66% (8)*	
Confusion	***YES***		***NO***	
	50% (6)		*50% (6)*	
Under alcohol influence	***YES***		***NO***	
	9% (1)		*91% (11)*	
Time between injury and initial assessment	***<24 HRS***	***24-48 HRS***		***>48 HRS***
	50% (6)	*33% (4)*		*17% (2)*
Icd 10 co-morbidities associated	***Htn***	***Dm***	***Alc/drug dependence***	***Tb***	***Thyroid disorder***
	42 % (5)	*17 % (2)*	*50% (6)*	*0 %*	*9% (1)*

The STATE TRAIT ANXIETY INVENTORY scores-

Table 2- data for STAI test in head injury patients; statistically significant P-value (<0.05)

	SCORE (mean± S.D)	*P value*
STATE form	38.69 ± 8.68	***0.03***
TRAIT form	41.19 ± 9.34	*0.07*

Table 2 shows data for STAI-STATE and TRAIT tests, showing high levels of state anxiety at the time of testing *(P-value = 0.03),* similarly, the trait anxiety inventory, which represents the self-reported anxiety level experienced on a daily basis also shows increased perceived levels of anxiety, although the *P value* for TRAIT test was *P=0.07* (significant *p value* <0.05)

THREE WORD RECALL-

Table 3- scores for 3-word recall test, significant p value<0.05

	Score (mean ± SD)	*P value*
Trial 1	1.5± 0.512	***0.046***
Trial 2	1.66 ± 0.557	***0.05***

Table 3 gives scores for 3-word recall recording two separate trial scores, the test scores showed improvement with the subsequent trial, but the scores were lower than normative scores (>2), both trials showed significance as *p values ≤ 0.05*

AUDIO-VISUAL REACTION TIME-

Table 4- mean (S.D) scores for AVRT with significant p values reported for each category

Auditory and Visual time (msec)			
Stimulus		Time	
Auditory time	Tone	Left	273.7 ± 86.4
		Right	284.5 ± 97.5
	Click	Left	305.4 ± 103.6
		Right	281.1 ± 92.3
Visual time	Red	Left	321.3 ± 112.4
		Right	285.2 ± 89.3
	Green	Left	297.0 ± 106.1
		Right	302.5 ± 97.2

Table 5 - mean (SD) score for AVRT with significant p values

	Mean ± SD	*p value*
Auditory time	286.1 ± 95.9	***0.03***
Visual time	301.5 ± 101.25	***0.043***

Table 5 records mean ± SD scores for Audio-Visual Reaction Time with values ranging from 273ms to 321ms for different stimuli and significant *P-values.*

Discussion:

The findings from this study suggest that traumatic brain injury, even of a mild degree has long term effects on different aspects of memory.

Mild traumatic brain injuries are characterized by immediate physiological changes conceptualized as a multilayered neurometabolic cascade where affected cells almost always recover, although in some circumstances some may degenerate and die [(17)].

Specific areas within the brain are responsible for different kinds of memory functions, involving complex interaction between the biochemistry of neurons and their electrical activity in specific anatomical structures. The neural circuits are dynamic, reflective of the pliability of memory itself. episodic memory (a kind of declarative memory) and working memory are under the management of the prefrontal cortex [(18), (19)].

Perceived anxiety measured by STAI test on analysis showed moderate levels of state test anxiety at the time of testing. STAI scores are commonly classified as “no or low anxiety” (20-37), “moderate anxiety” (38-44), and “high anxiety” (45-80) [(20)]. Similarly, the trait anxiety inventory, which represents the self-reported anxiety level experienced on a daily basis also shows increased perceived levels of anxiety. although the p value for TRAIT test was p>0.06 (significant p value<0.05).

These findings are in accordance with the fact that symptoms of anxiety, depression, and irritability often occur in the aftermath of a TBI and affect mood centers, including the hippocampus, amygdala, and prefrontal regions of the brain [(21)]. Studies have implicated that such psychological factors are potential contributors to poor recovery after mTBI [(22)] and may lead to development of anxiety disorders due to reduced GABAergic

inhibitory transmissions and hyperexcitability of the basolateral amygdala causing long lasting anxiety like behaviour in the future [(23)].

Delayed free verbal recall was measured by the 3 word recall test for which two separate trial scores were recorded, the test scores, the test scores showed improvement with the subsequent trial which may suggest improved concentration due to increased familiarity with the test, but the scores were lower than normative scores (>2) and both trials showed significance as P-values ≤ 0.05.

This is in keeping with the previous research done which suggests that the reduced ability of individuals with TBI to freely recall words appeared to be related to differences in the process of encoding the words which was subsequently related to alterations in the prefrontal cortex, responsible for episodic memory and its discrepancy [(24), (25)].The dorsolateral part of the prefrontal cortex appears to be decoupled from other active brain regions specifically when strategic control is required [(26)], thus functional alterations in the pathway of formation and retrieval of memory may be responsible for these findings.

Cognitive accuracy and muscle coordination were assessed with the help of the Audio-Visual reaction time, and the subjects showed decreased cognitive abilities as the normative data documented mean Reaction Time to detect visual stimuli as approximately 180–200 ms, whereas for sound as around 140–160 ms. [(27)]

Due to mTBI, frontal lobes and their related circuitry (e.g. subcortical white matter, basal ganglia, and thalamus) are particularly rendered vulnerable [(28)] Working memory and planning deficits may be associated with the focal injury to the dorsolateral prefrontal cortex (DLPFC) or diffused axonal injury DAI affecting the projections between the lateral frontal and posterior regions [(29)] if not structurally then functionally, leading to increased reaction time and poorly coordinated goal oriented activities.

The results and evidence of our study support previous research done which suggests that TBI predominately affects the frontal lobes, regardless of the mechanism of injury and subsequent pathophysiology [(30)], and this may result in deficits in a range of cognitively demanding tasks including executive control, working memory, episodic memory and problem solving as well as processing speed [(31), (32), (33), (34)]

Conclusion: From the results obtained in the above study, we conclude that the effects of mild traumatic brain injury on memory are significant, both the episodic and working memory showed impairment and deviation from normative findings

These inferences were drawn on the basis of the following results obtained-

- After injury, increased amount of anxiety was reported in the patients due to hyperactivity of the mood centers of the brain and decreased activity of the GABAergic receptors, which may lead to a poor recovery and further cause other cognitive impairments
- Cognitive functions like delayed recall, concentration, cognitive accuracy and muscle coordination, showed mild to moderate impairments. Such cognitive abilities are controlled by higher centres in the brain and a functional discontinuity or aberration in the dorsolateral prefrontal-subcortical circuit may be the cause for these discrepancies after injury.

This study also aims to prove and provide basis for early detection of such cognitive problems, as early detection will lead to early and effective rehabilitation. Cognitive rehabilitation therapy (CRT) is a term that describes treatments designed to improve patients' participation in cognitive demanding activities, either by restoring cognitive functions or teaching compensatory skills [(35)].

Conflict of interest- nil

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