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Original Research Article

# An Observational Study on Influence of Pre-Existing Diseases on Vestibular Rehabilitation of Vertigo in Patients with Head Injuries

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**Abstract**

**Background:** A symptom complex of Vertigo, dizziness, and imbalance occur in patients following concussion. Multiple factors play role in their recovery following rehabilitation. The causes may be peripheral or central.

**Aim and Objectives:** To study the influence of pre-existing diseases on the vestibular dysfunction recovery in patients with head injuries. Objectives were to observe the factors which predispose, promote and perpetuate the rehabilitation of vertigo. The objectives were to record the predisposing and promoting factors of vertigo, undertake bedside equilibrium tests and caloric test for peripheral and central causes of vertigo.

**Materials:** 83 patients with head injuries were included who presented with vertigo. Patients with pre-existing diseases like hypertension, diabetes and thyroid hormone dysfunction were included. All the patients were assessed using a Dizziness handicap index with subscales to assess the physical, functional and emotional aspects. Vestibular rehabilitation was done and DHI scores were evaluated at the end of 12 weeks.

**Results:** Out of 83 patients 61 (73.49%) were males and 22 (26.50%) were females. Male to female ratio was 2.3:1. Patients aged 18 to 27 years were 12 (14.45%), Patients aged 28 to 37 years were 36 (43.37%), Patients aged 38 to 47 years were 21 (25.30%), and Patients aged 48 to 57 years were 14 (16.86%). The mean age was 38.75±3.15 years. The head injury severity as per Head Injury Severity Scale (HISS) was minimal in 24 (28.91%), 26 mild in (31.32%) and 33 moderate in 33 (39.75%) of patients**.** There were 44 (53.01%) patients with ore-existing diseases and 39 (46.98%) patients without pre-existing diseases. There was no statistical significant predilection of any age group to gender or degree of head trauma ($p>0.05$)

**Conclusions:** Vertigo after concussion brain injury was common. All the patients responded to vestibular rehabilitation from 3rd week onwards. By 12th week the patients without pre-existing diseases with central vestibular dysfunction and fixed peripheral vestibular dysfunction were either resolved or greatly improved. The patients with pre-existing diseases responded rather slowly and the DHI indices/scores were more compared to the patients without pre-existing diseases.

**Keywords:** Hypertension, Thyroid Hormone Dysfunction, Rehabilitation.

## Introduction

Traumatic brain injury was defined as a non-degenerative and non-congenital mechanical injury to the brain from an external source, leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness. Mild concussion injury to brain in Head injuries was proportionate to the rise in the motor vehicle accidents in India [1]. But they are not reported as large proportion of patients does not need active treatment [2]. Nearly half of them continue to suffer from certain symptoms labeled as "Post-Concussion Syndrome". Dizziness (vertigo) was reported as the second most common squeal following brain concussion [3]. Vertigo is ill defined; the description varies from "giddiness" to unsteady gait to rotary vertigo attacks. Damage to brain and /or cochlea following head injuries can cause vertigo. The damage to brain could be due to direct compression of brain (coup) and /or impact of brain against the inner table of skull (countercoup) factors [4]. In certain cases the rotational forces also play their role in causing in axonal shearing [5]. Diffuse axonal injury (DAI) to the brain most probably causes the post-concussion syndrome [6]. Perfusion changes, bio-chemical changes and local inflammation subsequently, interfere with axonal connections to the cerebellum and brainstem producing symptoms of dizziness secondary to concussion [7]. Extensions of these pressure effects to the labyrinth of inner ear are called as Labyrinthine Concussion (LC) [8]. Some authors presumed cochleovestibular nerve traction injury which resulted in labyrinthine dysfunction causing vertigo [9]; supported by travelling wave theory of Labyrinthine concussion of Schucknecht [10]. To support this view the histopathological report by Ishai *et al.* [11] who demonstrated, temporal bone specimens of head injury patients with moderate to severe degeneration of spiral ganglion cells. Knoll *et al*. [12] found moderate to severe degeneration of the membranous vestibular labyrinth in patients dying of head injuries without temporal bone fractures; also with mild to severe otolithic maculae degeneration was noted in 25% of cases. Few studies have showed Vestibular hydrops in 25% of their cases [12]. Various bed side clinical tests are done to evaluate status of equilibrium in patients. The commonly used tests are Romberg's test, Unterberger's test, head shaking test, positional test, positioning test, walking in straight line. They all test the function of horizontal Semi Circular Canal (SCC) which gives vestibular input from horizontal rotations of the head. The most commonly tested reflex has been the vestibule-ocular reflex (VOR) of the Horizontal SCC [13]. While these examinations are helpful, they lack the sensitivity/specificity and objectivity for discreet analysis of vestibular function. Consequently, the vestibular peripheral end organ is often ignored. Caloric tests in patients after head injuries have demonstrated abnormalities 14 to 90% of patients [13,14,16]. The functions of other SCCs (posterior and anterior), the Utricle and Saccule have been less evaluated [17]. Equilibrium tests after head injuries especially after concussions are reported as central vestibular dysfunction, but they become normal in most patients of them within 6 months [18]. Among the central disorders causing disequilibrium and sensation of vertigo the frequent one was concussion itself [19] The cause of vertigo was presumed to be Diffuse Axonal Injury (DAI) of the central vestibular pathways. The test useful in diagnosing central vestibular pathway disruption are pursuit tracking, saccade testing, optokinetic testing, gaze, near point convergence, and inability to suppress nystagmus (spontaneous nystagmus or induced by caloric testing). Among these tests performed on patients with post concussion, abnormal findings were reported in 5 to 45%. The incidence of oculomotor abnormalities was found to be a proxy of post concussion

vertigo and they were positive in 90% of the patients which could also be due to DAI [20]. BPPV was reported by many authors as the most common peripheral vestibular disorder causing post concussion Dizziness (PCD), [21] the prevalence was reported as between 10 57%. [22] The present study was aimed at studying the factors which predisposed, promoted and perpetuated vertigo in Head injury patients.

## Materials and Methods

**Design:** A prospective study of 83 patients with head injuries who attended the Emergency Department of a tertiary care Hospital and later treated by General Surgery, Neuro- surgery, General Medicine and ENT departments were included between February 2018 and January 2020.

**Ethics Clearance:** Inclusion of the patients to the study was purely on voluntary involvement through informed consent. The study synopsis was approved by the Institution Ethics Committee. (Reference number 21/2018),

**Inclusion Criteria:** Patients aged above 18 years and below 57 years were included. Patients of both genders were included. Patients with the Head Injury Severity Score (HISS) as mild, minimal and moderate grades were included; patients with Glasgow coma scale (GCS) 15 were included. Patients with no loss of consciousness or amnesia were included. Patients less than 5 minutes loss of consciousness or amnesia were included. Patients with moderate GCS 9 to 13 and/or loss of consciousness of more than 5 minutes or focal neurological deficits were also included. Patients enrolled up to 6 months after head injuries were included.

**Exclusion criteria:** Patients with severe head injury; GCS more than 8 were excluded. Patients with vertigo within 4 weeks prior to the head injury were excluded. Patients with known Oto-vestibular or neurological disorders causing vertigo or balance problems were excluded. Patients with neck injury were excluded. Patients with dementia, consent incompetency and substance abuse were excluded. Patients using tobacco were not included. Patients with metal objects implanted in their body not compatible with MRI were excluded. Patients on aminoglycosides were excluded. Patients with previous history of psychiatric conditions or on psychiatric drugs were excluded.

**Practical Inclusion:** All the patients admitted with head injuries were registered for the study irrespective of the presence of vertigo or not, but they were examined as per inclusion criteria after the head injury. The median time between trauma and the first examination was 07 days (range 03–20 days).

**Diagnostic Procedures:** All the 83 patients were elicited of thorough clinical history to identify pre-existing medical illnesses like hypertension, Diabetes Mellitus, migraine, hypercholesterolemia, thyroid function abnormalities, obesity, renal impairments, pulmonary diseases and constipation or recent history of undergoing surgery under general anesthesia, or spinal anesthesia, which could have perpetuated vertigo following head injury. A particular attention was paid to elicit the presence of vertigo**,** its onset, and typical features, duration of attacks, relation to head movements of different types. All the patients were advised to sit upright for half an hour before commencing the ENT examination. It consisted of examination of the ears, nose and Throat followed by looking for spontaneous nystagmus, head shaking test, Romberg's test, Unterberger's test, Dix-Hallpike positional test, positioning test.

**Dix-Hallpike maneuver:** Patient was made to lie in supine position with the head turned 45° to one side (right or left) and the neck extended approximately 20°. Then a supine roll over was done to turn the head to its extreme to one side followed by to its extreme to the other side. Then finally back to the first side. The neck to remain always flexed approximately at 10 to 20° throughout the procedure. The patients

remain for 20 to 30 seconds in each new position during the procedure. If nystagmus occurred the position was held for 1 minute otherwise for the standard 30 seconds. Peripheral vestibular disorders were diagnosed using Bárány Society diagnostic criteria for BPPV. Other types of vertigo classified were unspecific dizziness, exclusively orthostatic dizziness, and no dizziness. In confirmed cases the onset was confirmed by questioning the patients to determine the first experience of positional vertigo or dizziness. Further follow up was done at $6^{th}$ and $12^{th}$ week using **Dizziness Handicap Inventory:** The Dizziness Handicap Inventory (DHI) contained 25-questions in a self-answerable questionnaire given to the patients to evaluate impact of vertigo on the quality of their lives. It was also used to assess the severity of vertigo and the final outcome of vertigo rehabilitation exercises and anti vertiginous drugs [23]. It had three sub scales: 1. DHI- E: Anxiety or mental strain caused or influenced by vertigo related questions-09. 2. DHI- F: Physical handicap, affecting routine daily living caused by vertigo related questions- 09 and DHI- P: Motion provoked vertigo related questions-07. (Each question carrying 4 marks each) The response scale varied from 0 points (No) to 4 points (Yes). The total score was calculated for 100; higher the total score, graver was the degree of handicap. For total score of 100, the degree of incapacity was taken as slight, if the score was between 0 and 30 points, moderate between 30 and 60 points and severe, when above 60 points [23]. For DHI- F and DHI- E subscales, the degree of incapacity was nonexistent when the score was 0 and 14 points, moderate deficiency when the points were 15 to 24 and severe deficiency when the score was above 25 points. For DHI- P subscale, the grading of incapacity was nonexistent when the score was 0-9 points, moderate deficiency when the points were 10 to 16 and severe deficiency when the points were above 17. Answering the questionnaire took 10 to 15 minutes. Patients were advised to report if they experience fresh attack of vertigo, or change in its character. A revised vestibular assessment was undertaken in such patients. The treatment used was individualized to the established diagnosis which included for Brainstem concussion, Vestibular rehabilitation was adopted. For Labyrinthine concussion, Vestibular suppressants and vestibular rehabilitation were used and for benign paroxysmal positional vertigo, The Epley maneuver and vestibular rehabilitation was used in the study subjects.

## Statistical Methods

Logistic regression was used to analyze different predisposing, and perpetuating factors of vertigo. Variables included were age, gender, and trauma severity. Mean standard deviation and percentages were used to express the values of the variables. Statistical significance was calculated using Chi square test with p value less than 0.05 was taken as significant. The risk-time curve of Vertigo was visualized using Kaplan-Meier and smoothed hazard ratio graphs. Statistical analyses were done using Microsoft excel software.

## Results

Among the 83 patients there were 61 (73.49%) males and 22 (26.50%) females with a male to female ratio of 2.3:1. Patients aged 18 to 27 years were 12 (14.45%), Patients aged 28 to 37 years were 36 (43.37%), Patients aged 38 to 47 years were 21 (25.30%), and Patients aged 48 to 57 years were 14 (16.86%). The mean age was 38.75±3.15 years. The head injury severity as per Head Injury Severity Scale (HISS) was minimal in 24 (28.91%), 26 mild in (31.32%) and 33 moderate in 33 (39.75%) of patients (Table 1). There were 44 (53.01%) patients with ore-existing diseases and 39 (46.98%) patients without pre-existing diseases. The distribution of HISS grading and gender distribution was tabulated in Table 1. There was no statistical significant predilection of

any age group to gender or degree of head trauma (p>0.05)

**Table 1: Shows the variables: Age, Gender and Head Injury Severity Scale (HISS) in the study (n-83)**

| Variable | Patients with pre-existing diseases-44 (53.01%) | | Patients without pre-existing diseases-39 (46.98%) | | Percentage | P value |
|---|---|---|---|---|---|---|
| Age | Number | Percentage | Number | Percentage | | |
| 18 to 27 Yrs | 06 | 07.22 | 06 | 07.22 | 14.45 | |
| 28 to 37 Yrs | 18 | 21.68 | 18 | 21.68 | 43.37 | 0.144 |
| 38 to 47 Yrs | 13 | 15.66 | 08 | 09.63 | 25.30 | |
| 48 to 57 years | 07 | 08.43 | 07 | 08.43 | 16.86 | |
| Gender | | | | | | |
| Male- 61 | 32 | 38.55 | 29 | 34.93 | 73.49 | 0.967 |
| Female- 22 | 12 | 14.45 | 10 | 12.04 | 26.50 | |
| HISS | | | | | | |
| Minimal-24 | 12 | 14.45 | 12 | 14.45 | 28.91 | 0.812 |
| Mild- 26 | 15 | 18.07 | 11 | 13.25 | 31.32 | |
| Moderate-33 | 17 | 20.48 | 16 | 19.27 | 39.75 | |

The incidence of vertigo among the three groups of HISS grading were compared by logistic regression method with minimal trauma as reference and it was observed that increased risk of development of vertigo was with moderate HISS grading when compared to minimal of HISS grading (p value was 0.026; <0.05). The risk of developing vertigo was not associated with mild head trauma (Table 2).

**Table 2: Shows the incidence of vertigo among the HISS grades, male patients above 50 years using logistic regression method. (Moderate Vs minimal was significant; p value<0.05).**

| Variable | *P*-Value | Odds Ratio | Confidence Interval |
|---|---|---|---|
| Mild Vs minimal | 0.154 | 1.48 | 0.6 to 5.98 |
| Moderate Vs minimal | 0.026 | 5.25 | 1.1 to 16.74 |
| Age above 50 years | 0.829 | 3.26 | 0.4 to 2.1 |
| Gender (Male) | 0.713 | 1.81 | 0.5 to 2.7 |

Pre-existing conditions such as hypertension was observed in 11/83 (13.25%), Diabetes Mellitus in 05/83 (06.02%), Obesity in 07/83 (08.43%), hypercholesterolemia in 05 (06.02%), Migraine in 04 (04.81%), Renal diseases in 03 (03.61%), thyroid hormone dysfunction in 02 (02.40%), Obstructive pulmonary diseases in 03 (03.61%) and history of undergoing surgery under general anesthesia in 04 (04.81%) patients. Totally there were 44/83 patients with pre-existing diseases in the study of vertigo patients following head injuries and 39/83 patients without any pre-existing diseases prior to head injury (Table 3). There were 39 patients who did not reveal any pre-existing diseases in the study.

**Table 3: Shows the pre-existing medical conditions in the subjects (n-83).**

| Pre-existing conditions | Number | Percentage |
|---|---|---|
| Hypertension | 11 | 13.25 |
| Diabetes Mellitus | 05 | 06.02 |
| Obesity: BMI> 35 $Kg/M^2$ | 07 | 08.43 |
| Hypercholesterolemia | 05 | 06.02 |
| Migraine | 04 | 04.81 |
| Renal diseases | 03 | 03.61 |
| Thyroid hormone dysfunction | 02 | 02.40 |
| Obstructive Pulmonary diseases | 03 | 03.61 |
| H/O General anesthesia/spinal anesthesia | 04 | 04.81 |
| Total | 44 | 53.01 |

The distribution of vertigo patients following head injury with their pre-existing diseases and HISS grading were tabulated in Table 4. There were 39/83 (46.98%) patients, who did not reveal pre-existing diseases in the study. The distribution of degree of head trauma in patients with different pre-existing diseases was shown in the Table 4. There was no statistical significance in the degree of head trauma incidence and the pre-existing diseases in the study, as p value was 0.154 ($P < 0.05$ taken as significant).

**Table 4: Shows the distribution of vertigo patients with and without pre-existing diseases graded according to HISS (n-83: patients with pre-existing diseases- 44, without pre-existing diseases- 39).**

| Pre-existing conditions-44 | Number - % | Minimal-24 | Mild-26 | Moderate-33 |
|---|---|---|---|---|
| Hypertension | 12 (26.50%) | 05 | 03 | 04 |
| Diabetes Mellitus | 06 (14.45%) | 02 | 02 | 02 |
| Obesity: BMI> 35 | 07 (12.04%) | 02 | 02 | 03 |
| Hypercholesterolemia | 05 (07.22%) | 01 | 02 | 02 |
| Migraine | 04 (04.81%) | 01 | 01 | 02 |
| Renal diseases | 03 (03.61%) | 01 | 01 | 01 |
| Pulmonary diseases | 04 (04.81%) | 01 | 01 | 02 |
| H/O G.A/spinal-anesthesia | 03 (03.61%) | 01 | 01 | 01 |
| TOTAL | 44 (53.01%) | 14 | 13 | 17 |
| No pre-existing diseases-39 | 39 (46.98%) | 10 | 13 | 16 |

Among the 83 patients the peripheral and central causes of vertigo were analyzed from the vestibular function tests performed on them. There were 47/83 patients with peripheral vertigo; among them Paroxysmal Positional Vertigo (BPPV) was observed in 14 (16.86%), Labyrinthine concussion in 12 (14.45%), Post traumatic Ménière's disease in 08 (08.43%), and Perilymph fistulas in 07(09.63%) and cervical vertigo in patients. There were 36/83 (46.98%) patients with central vertigo; among them brainstem concussion was noted in 18 (21.68%), $VII^{th}$ nerve complex injury in 11 (13.25%), Otitic hydrocephalus in 07 (08.43%), was observed. (Table 4)

**Table 4: Shows the distribution of different causes of peripheral and central causes of vertigo following head trauma in the study (n-83).**

| Patho-physiology of Vertigo | Number | Percentage |
|---|---|---|
| Peripheral Vertigo- 47 | | |
| BPPV | 14 | 16.86 |
| Labyrinthine concussion | 12 | 14.45 |
| Post traumatic Ménière's disease | 08 | 09.63 |
| Perilymph fistula | 07 | 08.43 |
| cervical vertigo | 06 | 07.22 |
| Central Vertigo- 36 | | |
| Brainstem concussion | 18 | 21.68 |
| VII$^{th}$ nerve complex injury | 11 | 13.25 |
| Otitic hydrocephalus | 07 | 08.43 |

The distribution of incidence of Head trauma in patients with different causes of peripheral and central vertigo was tabulated in Table 5.

**Table 5: Shows the incidence of peripheral and central vertigo in the study (n-83).**

| Pre-existing conditions-44 | Number % | Peripheral vertigo 47- (56.62%) | Percentage | Central Vertigo 36- (43.37%) | Percentage |
|---|---|---|---|---|---|
| Hypertension | 12 (26.50%) | 08 | 09.63 | 04 | 04.81 |
| Diabetes Mellitus | 06 (14.45%) | 04 | 02.40 | 02 | 02.40 |
| Obesity: BMI> 35 | 07 (12.04%) | 05 | 06.02 | 02 | 02.40 |
| Hypercholesterolemia | 05 (07.22%) | 02 | 02.40 | 03 | 03.61 |
| Migraine | 04 (04.81%) | 02 | 02.40 | 02 | 02.40 |
| Renal diseases | 03 (03.61%) | 01 | 01.20 | 02 | 02.40 |
| Pulmonary diseases | 04 (04.81%) | 02 | 02.40 | 02 | 02.40 |
| H/OG.A/spinal-anesthesia | 03 (03.61%) | 02 | 0.40 | 01 | 01.20 |
| Total | 44 (53.01%) | 26 | 31.32 | 18 | 21.68 |
| Nopre-existing diseases-39 | 39 (46.98%) | 21 | 25.30 | 18 | 21.68 |

The mean total scores and subscales scores; DHI-P, DHI-F and DHI-E scores of patients belonging to both with and without pre-existing diseases at the time of examination, at 6$^{th}$ week and 12$^{th}$ wee were tabulated in Table 6 and 7. It was observed that the rehabilitation was comparatively rapid in patients without pre-existing disease. A T test calculator for dependent means was used to find the statistical significance of the mean values; it was found that the value of "t" was -2.477808 and the p value was 0.03 (p taken as significant at <0.05). (Tables 6 and 7)

**Table 6: Shows the DHI total and subscale scores; DHI-P, DHI-F and DHI-E scores in patients with pre-existing diseases (n-44).**

| | DHI Total and subscale Scores (Mean and SD values) | | | |
|---|---|---|---|---|
| Patients with pre-existing diseases | Total score | Physical DHI- P | Functional DHI-F | Emotional DHI-E |
| First examination | 66.42±09.35 | 26.43±6.24 | 35.83±4.39 | 36.81±6.80 |
| Examination at 6th Week | 60.80±08.31 | 22.75±3.65 | 31.31±4.10 | 31.50±7.01 |
| Examination at 12th Week | 54.20±5.67 | 20.60±4.55 | 29.72±3.62 | 30.95±5.50 |

**Table 7: Shows the DHI total and subscale scores; DHI-P, DHI-F and DHI-E scores in patients without pre-existing diseases (n-39).**

| | DHI Total and subscale Variable Scores (Mean and SD values) | | | |
|---|---|---|---|---|
| Patients with no pre-existing diseases | Total score | Physical DHI- P | Functional DHI-F | Emotional DHI-E |
| First examination | 67.92±08.35 | 27.14±7.04 | 36.31±07.89 | 37.01±7.35 |
| Examination at 6th Week | 53.54±04.11 | 20.55±03.65 | 30.87±05.80 | 30.90±05.64 |
| Examination at 12th Week | 50.20±05.67 | 17.24±04.55 | 24.13±03.62 | 25.75±08.62 |

## Discussion

This was a prospective observational study conducted on head injury patients complaining of vertigo. The degree of vertigo was assessed at the time of admission 6th week and 12th week intervals based on vestibular rehabilitation in addition to the regular treatment. A Dizziness Handicap Index (DHI) questionnaire was used to assess the quality of life during this period. The effect of the vestibular rehabilitation was maintained intervention was maintained. There were no differences between the patients with or without pre-existing diseases in relation to their age, gender, degree of concussion brain injury. The present study was supported by similar studies which indicated advantages of vestibular rehabilitation after traumatic brain injury [24,25]. The final outcome of vestibular rehabilitation in reducing the dizziness handicap index was rapid and favorable with patients without pre-existing diseases than patients with pre-existing diseases. The improved DFHI indices/scores (Total, DHI-P, DHI-F and DHI-E) reflected upon the physical, functional and emotional factors and improved the quality of life. Kurre, A *et al* [26] from their study of "exploratory factor analysis of the Dizziness Handicap Inventory (German version)", found similar improvement in motor performance, patient's self perception and quality of life of the patients following head injury. Gottshall [27] from his study pointed out that head injury patients recover from vertigo in a period of 8 weeks following vestibular rehabilitation and a few more require an additional 8 weeks to recover from imbalance. He further stated that the response to vestibular rehabilitation varies with the cause of the vertigo in these patients. Among them BPPV requires shorter time [27]. Combined central and peripheral causes resulting in vertigo require longer recovery periods [28]. Murray *et al* and Gurley, JM, Hujsak, BD *et al* [29,30] from their studies concluded that in addition vertigo, not only causes physical impediment but also produces emotional and functional symptoms, with an overall effect on the quality of life [29]. There was no other difference between the patients with and without pre-existing diseases in other outcomes. All patients in this study received assessment and information from a physiatrist

and were offered multidisciplinary rehabilitation.

## Conclusions

Vertigo after concussion brain injury was common. All the patients responded to vestibular rehabilitation from 3rd week onwards. By 12th week the patients without pre-existing diseases with central vestibular dysfunction and fixed peripheral vestibular dysfunction were either resolved or greatly improved. The patients with pre-existing diseases responded rather slowly and the DHI indices/scores were more compared to the patients without pre-existing diseases.

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