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Analysis of Tilt Table and Coma Arousal Therapy Synergy Benefits in Severe TBI Cases – An Institutional Experience

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Abstract

Background: Severe traumatic brain injury (sTBI) is usually associated with Diffuse Axonal Injury (DAI) leading to significant prolonged neurological impairment, coma and long-term disability. Tilt table therapy (TTT) and Coma Arousal therapy (CAT) are used to re-stimulate the Reticular activating system (RAS). Mechanistically, TTT promotes cerebral perfusion, autonomic stability, and neuroplasticity through multisensory stimulation, complementing CAT's neural activation strategies. The combination accelerates recovery by enhancing both physiological and cognitive functions. This study aims to evaluate the effectiveness of combining TTT with CAT vs CAT alone to enhance recovery in patients with DAI.

Methods: A retrospective cohort study involving 30 sTBI patients compared outcomes between two groups: 15 patients received both TTT and CAT, while 15 received CAT alone. TTT involved daily sessions of verticalization to 60–80°, stimulating proprioceptive and vestibular pathways, while CAT focused on structured sensory stimulation to activate the reticular activating system (RAS). Outcomes were assessed using the Coma Recovery Scale-Revised (CRS-R), Glasgow Outcome Scale-Extended (GOS-E), Rancho Los Amigos Scale (RLA), Functional Independence Measure (FIM), and Disability Rating Scale (DRS).

Results: The TTT + CAT group showed significantly greater improvements across all metrics. Notably, CRS-R and FIM scores improved markedly ($p<0.01$), while GOS-E and RLA scores also reflected enhanced recovery ($p<0.05$). Although the study's limitations include a small sample size and short follow-up, the results underscore the potential of integrated therapy in severe TBI rehabilitation. The intervention was safe, with no adverse events reported.

Conclusion: Combining TTT with CAT rather than CAT alone, significantly improves consciousness and functional outcomes in sTBI patients, offering a cost-effective, promising strategy for early rehabilitation.

Keywords: Coma therapy; Tilt table therapy; Rehabilitation of diffuse axonal injury; Comparative analysis; Severe traumatic brain injury rehabilitation; Institutional experience.

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Introduction

Background and importance

Severe traumatic brain injury (sTBI) is a critical public health issue characterized by profound disruptions in cerebral function due to external mechanical force. It often results in altered consciousness, long-term disability, and high mortality rates.[1-3] The severity of TBI is typically assessed using the Glasgow Coma Scale (GCS), a standardized tool that evaluates eye, verbal, and motor responses.[4] A GCS score of ≤8 indicates a severe injury, often associated with coma or prolonged unconsciousness.[5] Coma is defined as a state of complete unresponsiveness to internal or external stimuli, with absence of wakefulness or awareness.[6] This state results from damage to the cerebral cortex, brainstem, or particularly the reticular activating system (RAS)—a network of neurons in the brainstem responsible for arousal and maintaining consciousness. Restoration of function in the RAS or its associated pathways is considered critical in facilitating emergence from coma. The RAS is a crucial neuronal network extending from the brainstem to the thalamus and cerebral cortex. It regulates alertness, sleep-wake transitions, and attention. Both TTT and CAT can indirectly stimulate the RAS through multisensory input and postural changes, thus facilitating arousal and responsiveness. Diffuse axonal injury (DAI) is a severe form of traumatic brain injury (TBI) characterized by widespread damage to the brain's white matter tracts. Managing DAI relies heavily on intensive

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care, neurological support, and rehabilitative therapies. Among these, coma therapy and tilt table therapy have emerged as critical interventions. Neuroplasticity, the brain's ability to reorganize and form new connections, is a central concept in recovery following brain injury. One of the mechanisms underlying neuroplasticity is collateral sprouting, wherein undamaged axons form new synaptic connections to reinnervate areas previously served by damaged neurons. TTT and CAT may create an enriched sensory-motor environment that fosters such collateral sprouting, especially in the early post-injury phase when plasticity potential is highest.

Understanding Coma arousal therapy (CAT) and its limitations

Coma arousal therapy (CAT; Fig. 1), also known as neurostimulatory therapy, aims to stimulate neural pathways and enhance recovery in patients with impaired consciousness.[7] The therapy involves sensory stimulation, structured routines, and pharmacological interventions to promote arousal and cognitive responsiveness. Sensory stimulation includes auditory (including familiar voices), tactile, olfactory cues, and sometimes visual and vestibular inputs, while pharmacological agents such as amantadine are used to support neural activity.[8, 9] Cognitive engagement activities are structured to maximize patient responsiveness. These stimuli are thought to increase activation of the RAS and associated cortical areas, thereby promoting transitions from coma to higher states of consciousness.[10, 11]

Major contraindications for CAT relate to the patient's medical instability, as introducing stimulation can trigger dangerous physiological responses. The therapy should only proceed once a patient is medically stable. CAT is contraindicated in patients with increased intracranial pressure, autonomic dysfunction, or unstable vital signs. Also, patients with a history of seizures or active seizure activity are not suitable for CAT due to the risk of seizure induction. Individuals with high-risk factors for seizures, such as a ventriculoperitoneal shunt, require careful assessment and potential pharmacological precautions. Patients with recent neurological or vascular surgery, unstable fractures, or open chest/abdomen are unsuitable for CAT. Patients with active bleeding, in a medically induced coma, or exhibiting agitation/combativeness are unsuitable for CAT. And finally, lack of family consent and a compromised airway are also contraindications for CAT.[12]

Understanding Tilt table therapy (TTT) and its limitations

Tilt Table Therapy (TTT) (Fig. 2) is a verticalization intervention that gradually elevates the patient to an upright position, thereby stimulating the cardiovascular and neurological systems.[13] This approach enhances orthostatic tolerance, improves cardiovascular stability, and promotes neuroplasticity through multisensory stimulation. This therapy has multiple physiological benefits: it improves autonomic regulation, increases cerebral perfusion, and prevents complications associated with prolonged bed rest (e.g., orthostatic hypotension, deconditioning, and venous thromboembolism). TTT mimics gravitational forces and facilitates sensory input from weight-bearing joints, potentially stimulating proprioceptive pathways and the vestibular system. Tilt table therapy facilitates early mobilization and helps manage autonomic dysfunctions commonly seen in DAI patients. Tilt table therapy leverages several mechanisms to enhance neuroplasticity. Verticalization through tilt table therapy introduces a rich array of sensory inputs, including proprioceptive, vestibular, and tactile stimuli.[14] This constant sensory feedback activates cortical and subcortical pathways, fostering synaptic remodeling and enhancing neural connectivity. Upright positioning improves cerebral blood flow, ensuring better oxygenation and nutrient delivery to damaged brain regions. This enhanced perfusion promotes the survival and growth of neurons, supporting neurogenesis and synaptogenesis. Even passive standing encourages isometric muscle contractions, stimulating motor neurons and reinforcing motor learning pathways. This activation helps maintain muscle tone and prevent disuse atrophy, indirectly supporting neural recovery. Tilt table therapy helps normalize autonomic functions, which are often

Figure 1. Clinical picture of Coma Arousal Therapy (CAT); Left picture - Auditory stimulation, Right picture - Visual and Vestibular stimulation

disrupted in DAI. Improved autonomic stability supports consistent neural signaling, reducing fluctuations that can hinder neuroplastic changes. The gradual shift to an upright position increases cortical arousal levels, enhancing responsiveness to environmental stimuli. This heightened arousal facilitates cognitive engagement, critical for higher-order neuroplastic adaptations.

Figure 2. Clinical picture showing Tilt Table Therapy.

While tilt table therapy requires specialized equipment and trained personnel, it offers significant cost-effectiveness when integrated with coma therapy. Early mobilization facilitated by tilt table therapy can reduce the duration of intensive care unit (ICU) stays and decrease the need for prolonged mechanical ventilation, both of which contribute to high healthcare costs. Moreover, faster recovery rates and improved functional independence reduce long-term rehabilitation expenses and caregiver needs, leading to overall cost savings. Preventing complications such as deep vein thrombosis and pressure ulcers through early mobilization also minimizes additional treatment costs. An advancement in this field is the Tilt Table with Integrated Stepping Device (TTISD), which combines verticalization with passive stepping movements of the lower limbs[15]. The rhythmic stepping action promotes circulation, engages spinal locomotor circuits, and may enhance afferent input to supraspinal structures, further stimulating cortical and subcortical areas involved in consciousness and motor control.[16]

A tilt table, though beneficial, has several contraindications that must be considered, categorized into cardiac, neurological, orthopedic, and other systemic conditions. Cardiovascular contraindications include severe heart conditions that may worsen with changes in blood pressure and heart rate, such as hypertrophic cardiomyopathy, severe aortic or mitral stenosis, left ventricular outflow tract obstruction, severe coronary artery disease, unstable vital signs, heart arrhythmias, acute deep vein thrombosis, and severe heart failure. Neurological contraindications encompass recent strokes, severe proximal cerebral arterial disease, coma, severe vascular insufficiency, recent transient ischemic attacks, and recent strokes. Orthopedic and musculoskeletal contraindications involve unstable fractures, unstable joints, fresh implants, acute inflammation, and the inability to stand. Other systemic contraindications include pregnancy, neoplastic disease, severe anemia, hypotensive shock, severe electrolyte or metabolic imbalance, end-stage renal failure, and intolerable symptoms. These contraindications highlight the importance of careful evaluation before proceeding with tilt table therapy to ensure patient safety and minimize risks.

Benefits of the combination of TTT and CAT

Comparing coma therapy alone with its integration alongside tilt table therapy reveals that the combination offers enhanced recovery benefits for DAI patients[17]. While coma therapy effectively stimulates cognitive recovery, adding tilt table therapy promotes autonomic stability, orthostatic tolerance, and neuroplasticity, and enhances cost-effectiveness. The reduction in long-term rehabilitation costs and the prevention of secondary complications highlight the economic advantages of this combined approach. Future research should focus on standardized protocols, long-term outcomes, and comprehensive cost analyses to optimize patient care strategies.

Evaluation

For quantifying progress, the Coma Recovery Scale-Revised (CRS-R) is an essential tool. It is more sensitive than the GCS in distinguishing between states like vegetative state/unresponsive wakefulness syndrome (VS/UWS) and minimally conscious state (MCS).[18] The CRS-R assesses six subscales: auditory, visual, motor, oromotor/verbal, communication, and arousal. It captures subtle signs of emerging consciousness, making it ideal for tracking the effects of interventions like TTT and CAT.

Aim of the study

This paper compares the standalone effectiveness of coma therapy with its combination alongside tilt table therapy in managing DAI, considering clinical outcomes, rehabilitation progress, patient recovery trajectories, and cost-effectiveness. The hypothesis is that early, structured interventions that engage both the autonomic and sensory systems can accelerate recovery from disorders of consciousness.

Materials and Methods

Study Design and Participants

This is a retrospective cohort study. 30 patients admitted to our institution who had RTA with severe head injury (GCS score less than 8), needing prolonged rehabilitation, were included. Those who were managed in multiple hospitals, went to AMA, and those with debilitating comorbid illnesses were excluded. There were 24 males and 6 females with severe head injuries needing prolonged rehabilitation. 15 patients underwent tilt table therapy in addition to coma therapy, and the remaining 15 cases received only coma therapy. The age group was 19 to 74 years, with a mean age of 40 years. The patients were randomized into two groups. The interventional group was

Table 1. Distribution of GCS scores in the combination of Tilt table therapy and Coma Arousal therapy.

Case	Age	SEX	GCS AD	GCS DC	GCS 1m	GCS 3m	GOS-E AD	GOS-E DC	GOS-E 1m	GOS-E 3m	RLA AD	RLA DC	RLA 1m	RLA 3m	CRS-R AD	CRS-R DC	CRS-R 1m	CRS-R 3m	FIM AD	FIM DC	FIM 1m	FIM 3m	DRS AD	DRS DC	DRS 1m	DRS 3m
1	29	Male	2t	11	14	14	2	5	5	5	1	7	9	10	1	14	17	21	18	95	114	118	29	22	17	15
2	43	Male	7t	10	12	13	3	3	6	7	2	9	10	10	3	17	19	22	18	56	74	98	24	20	19	18
3	25	Female	2t	5t	7t	12	3	3	3	4	1	4	5	8	1	17	20	23	18	36	54	95	29	18	15	14
4	43	Female	4t	7t	9t	11	2	2	5	6	1	2	7	9	1	10	15	20	18	115	120	121	29	26	25	20
5	74	Male	8t	15	15	15	3	5	6	6	1	3	3	7	1	10	14	19	18	115	117	126	24	15	8	8
6	37	Male	6t	12	12	14	2	4	4	5	1	4	6	8	5	15	17	21	18	98	101	115	24	11	4	4
7	24	Male	7t	15	15	15	3	6	6	6	2	9	10	10	3	21	23	23	18	115	120	121	24	9	2	2
8	49	Male	5t	9t	9t	14	2	4	5	6	1	7	7	8	4	19	20	21	18	72	84	110	24	24	21	18
9	37	Male	2t	8t	10	12	2	5	6	6	3	8	9	9	2	21	23	23	18	95	120	121	29	8	4	4
10	56	Male	2t	15	15	15	2	5	5	5	1	5	5	7	1	18	21	22	18	72	94	109	29	10	6	6
11	27	Male	2t	10	10	13	2	3	4	6	1	6	6	8	1	19	19	20	18	75	78	110	29	20	18	11
12	44	Female	7t	10	10	12	3	3	5	5	2	7	8	9	1	20	21	22	18	90	106	118	24	9	5	4
13	42	Male	3t	9t	12	13	2	4	5	6	1	7	8	8	3	18	21	21	18	91	107	117	29	8	7	6
14	43	Male	7t	15	15	15	3	5	6	7	2	7	8	10	1	18	21	23	18	98	113	123	24	11	6	6
15	26	Male	2t	11	11	12	2	5	6	7	1	7	8	9	4	17	19	21	18	40	45	99	29	24	19	10

AD – Admission
DC – Discharge
m – months
t – ET tube - tracheostomy

GCS - Glasgow Coma Scale
GOS-E - Extended Glasgow Outcome Scale
RLA - Modified Ranchos Los Amigos scale
CRS-R - Coma Recovery Scale - Revised
FIM - Functional Independence Measure
DRS - Disability Rating Scale

TTT and CAT combined, and the control group was CAT alone.

CAT protocols followed in our institution

The patient who had prolonged low GCS of less than 8 for more than 7 days is usually started on CAT. The stimuli given for CAT are visual (familiar faces and pictures of home and workplaces), olfactory (essential oils), auditory (familiar voices, songs, and sounds recorded are played back repeatedly at least 5 hours a day), tactile (brushing, limb mobilization), and vestibular (head up and frequent position change). The patients who are on sedation, have paroxysmal sympathetic hyperactivity, unstable vitals, and features of raised ICP are deferred from CAT.

TTT protocols are followed in our institution

Tilt table therapy is given on an electric tilt table. After all vitals are assessed, the patient is made to lie down and securely strapped. After ensuring secure strapping, the table is slowly elevated in 5-minute intervals while continuously monitoring pulse BO and SpO2, at angles averaging 60 to 80 degrees, as tolerated, until the final 90-degree angle is achieved. The position is maintained at 90 degrees for at least 20 minutes to an average of about 30 minutes daily, with continuous vitals monitoring in study participants. If the blood pressure drops or if the patient becomes symptomatic, the procedure is abandoned immediately. The patients who usually receive TTT are those with diffuse axonal injury and a high risk of DVT, warranting early mobilization. Those with hypotension, limb fractures, heart failure, and severe anemia are deferred from TTT.

Selecting the study groups

After excluding the failed or contraindicated groups, 30 patients were further divided into two groups. 15 patients had additional contraindications to TTT; hence, they were included in the control group, which received CAT alone. The other 15 were given both TTT and CAT and hence were the intervention group. Both groups received 30 minutes of CAT daily, and the intervention group received an additional 30 minutes of TTT.

Outcome Measures

Recovery evaluations were conducted at the time of admission, in the interval of admission, 1- and 3-months post injury using the Coma Recovery Scale-Revised (CRS-R) (assessing auditory, visual, motor, and communication functions), Glasgow Outcome Scale-Extended (GOS-E), Rancho Los Amigos (RLA) Scale Functional Independence Measure Scale (FIMS), and Disability Rating Scale (DRS) were used to compare the outcomes. The test for statistical significance for the group was an independent t-test. The results were analyzed and tabulated (Table 1) and (Fig. 3).

Results

Demographics and Clinical Characteristics

The intervention group had a total of 30 cases (n=15). The control group had 15 cases (n=15). The participants' ages ranged from 19 to 74 years, with a mean age of 40 years. The male-to-female ratio was 6:1. At the time of admission, the initial Glasgow Coma Scale (GCS) scores ranged from

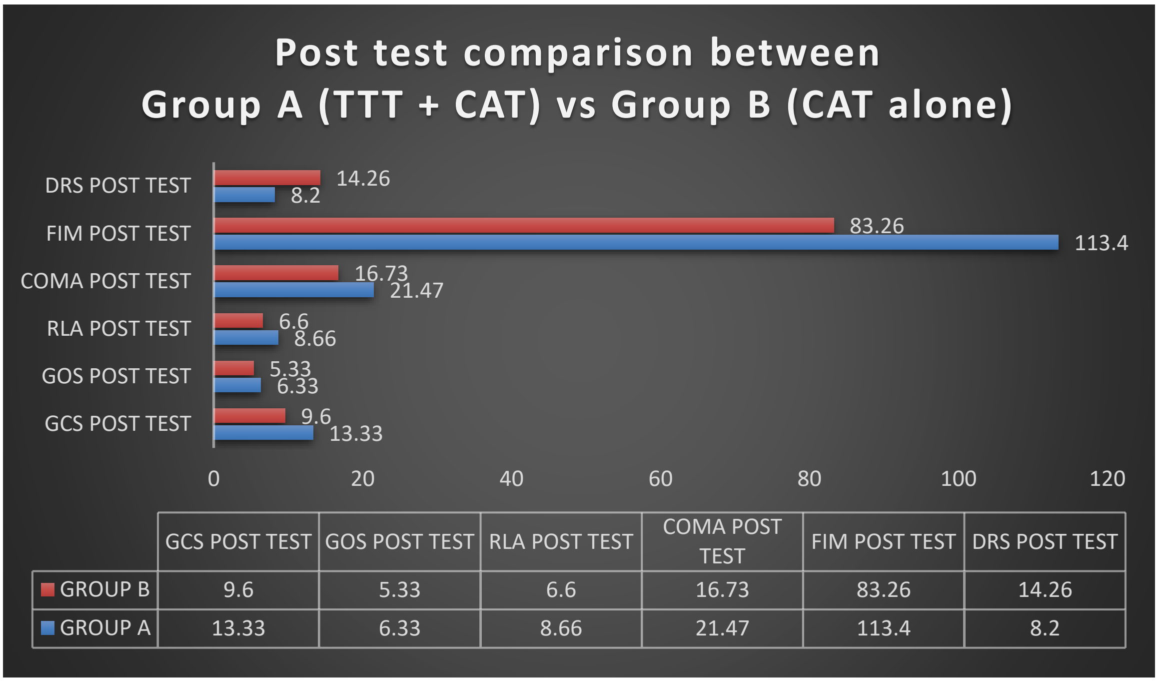

Figure 3. Comparison of Post test values between Group A (TTT + CAT) vs Group B (CAT alone). TTT – Tilt Table Therapy; CAT – Coma Arousal therapy

2T to 10T, with a mean score of 5T. The mean and standard deviation for the experimental group were 13.33 ± 1.34, and for the control group, 9.6 ± 4.38. The cause of injury was a road traffic accident (RTA). Both groups were comparable in terms of age, gender, cause of injury, and initial GCS scores.

Primary Outcomes

The statistical significance test used was the independent t-test. The outcomes compared were the Glasgow Coma Scale (GCS), Extended Glasgow Outcome Scale (GOS-E), Modified Rancho Los Amigos Scale (RLA), Coma Recovery Scale-Revised (CRS-R), Functional Independence Measure (FIM), and Disability Rating Scale (DRS).

The mean and standard deviation of GCS scores for the experimental and control groups were 13.33 ± 1.34 and 9.6 ± 4.38, respectively. The independent t-test yielded $t = 3.15$, $p < 0.004$. For the GOS-E scores, the mean and standard deviation for the experimental and control groups were 6.33 ± 1.17 and 5.33 ± 1.17, respectively. The independent t-test yielded $t = 2.33$, $p < 0.027$. For the RLA scores, the mean and standard deviation for the experimental and control groups were 8.66 ± 1.04 and 6.60 ± 2.06, respectively. The independent t-test yielded $t = 3.46$, $p < 0.002$. For the CRS-R scores,

The mean and standard deviation for the experimental and control groups were 21.47 ± 1.24 and 16.73 ± 6.41, respectively. The independent t-test yielded $t = 2.803$, $p < 0.009$. For the FIM scores, the mean and standard deviation for the experimental and control groups were 113.40 ± 9.66 and 83.26 ± 26.44, respectively. The independent t-test yielded $t = 4.145$, $p < 0.001$. For the DRS scores, the mean and standard deviation for the experimental and control groups were 8.20 ± 4.55 and 14.26 ± 8.42, respectively. The independent t-test yielded $t = 2.33$ and $p < 0.27$.

Overall, there was a statistically significant difference in recovery between the CAT-with-TTT group and the CAT-only group. The combination therapy was undoubtedly much more efficient. (Table 3 and Fig. 3).

Discussion

Severe traumatic brain injury (sTBI) poses a significant public health concern, resulting in prolonged morbidity and escalating financial and emotional strain for affected families. The primary contributor to this morbidity is diffuse axonal injury. Throughout the 19th century, various therapies were developed, and the concept of neuroplasticity has been incorporated into various rehabilitation approaches. CAT and TTT are rehabilitation procedures based on the principle of re-stimulating nerve regeneration through repetitive external stimuli.

Although there are limited studies comparing CAT and TTT combination, several studies have demonstrated the significant role of physiotherapy in the treatment of DAI patients. Lalwani et al. highlighted the advantages of the TBI rehabilitation service, citing the proportionally substantial progress in exercise tolerance and overall health. Furthermore, an extensive rehabilitation program for patients undergoing conservative treatment after a diffuse axonal injury is exemplified in the above case study.[19] Thomas et al. reported a case of DAI where, despite 8 months of medical management, there was no favorable outcome. However, in the same case, after 6 months of focused, intensive rehabilitation, the patient experienced significant improvements in head control, cognitive function, and voluntary attempts at functional activities. Our study demonstrated favorable outcomes with the combination of TTT and CAT, resulting in improved GCS and functional outcomes.[20] Aurore et al. suggested that rehabilitative interventions may benefit patients even years after the brain injury. CAT alone has demonstrated a favorable response in various aspects, surpassing medical management in many cases. Kumar et al.'s meta-analysis indicated that sensory stimulation, transcranial magnetic stimulation, and transcranial direct stimulation can improve behavioral outcomes of patients with DOC, with sensory stimulation being particularly effective.[21, 22] Niraj et al. corroborated this by emphasizing the superiority of sensory stimulation over no sensory stimulation in reviving comatose patients.[23] Trushitaa Chakraborty et al. 24 underscored the necessity of months of therapy after emerging from coma to reintegrate patients into society. Consequently, there is a pressing need for innovative coma arousal techniques that can provide better prognoses and demonstrate improvements within the anticipated time frame. Given the current research trends, there is substantial potential for further research in this area. Geeta Kushwaha et al. concluded that applying coma arousal techniques is an effective therapy for enhancing sensory functions in unconscious patients.[25] Although our study does not compare the benefits of CAT versus medical management, the effects of CAT have demonstrated significant improvement in overall GCS and functional outcomes. TTT is also an emerging treatment for comatose patient rehabilitation. Several studies have compared TTT to conventional therapy and have documented positive outcomes thus far. Harriet NG et al. concluded that there is some evidence that repeated passive standing on a tilt-table can improve consciousness, but the relevant studies raise further questions.[26] Riberholt et al.'s study focused on assessing the feasibility of an intensive physical rehabilitation intervention focusing on mobilization to the upright position, commencing as early as clinically possible versus standard care in the intensive care unit, with the intention of informing a subsequent randomized clinical trial that will investigate the benefits and harms of the intervention.[27] Riberholt CG et al. concluded that early head-up mobilization is feasible in patients with severe traumatic brain injury, although larger randomized clinical trials are necessary to explore the potential benefits and harms of such an intervention.[28] TTT has undergone several recent developments, including the integration of step-up therapy and robotics. The tilt table used at our institution is a motorized tilt table without step-up or robotic features; however, studies have demonstrated that such upgrades are highly beneficial. Czell et al. showed that passive leg movement during a tilt table test can stabilize blood circulation and prevent benign syncope in healthy adults.[29] Rosenfelder et al. concluded that robotic tilt table (RTT) treatment is not more effective in promoting recovery of consciousness than conventional physiotherapy in patients with subacute disorders of consciousness.[30] Despite the absence of an upgraded TTT at our institution, our study revealed that patients receiving combined TTT and CAT interventions exhibited significantly enhanced improvements in CRS-R, FIM, and GOS-E scores compared to those receiving standard care. These findings support the hypothesis that early, structured interventions engaging both the autonomic and sensory systems can expedite recovery from disorders of consciousness. This integrated approach likely utilizes multiple mechanisms: augmentation of cerebral perfusion through TTT, activation of the RAS and cortical areas via CAT, and promotion of neuroplastic changes such as collateral sprouting. Notably, no adverse events such as hemodynamic instability were reported, indicating the safety of this combined protocol.

However, our study has limitations, including a relatively small sample size, a short follow-up period, and the absence of neuroimaging or electrophysiological data to directly observe neural changes. Consequently, further research with larger cohorts, longer-term outcomes, and functional imaging is warranted.

Conclusion

The combination of TTT and CAT presents a promising, safe, and effective strategy for augmenting consciousness and functional outcomes in severely injured patients with sTBI. This integrated intervention should be incorporated into early rehabilitation protocols to optimize recovery prospects. Early rehabilitation of sTBI patients integrating these combination therapies into standard care protocols may enhance long-term outcomes.

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Ethical consideration

Compliance with ethical guidelines: Approved for study from Institutional Human Ethics Committee, PSG Institute of Medical Sciences and Research, Coimbatore. Approval number: Project No. 25/288. Date: 16 July 2025.

Competing Interests

The authors declare no conflict of interest.

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References

1. Puvanachandra P, Hyder AA. The burden of traumatic brain injury in Asia: A call for research. Pak J Neurol Sci. 2009;4(1):27-32. doi: 10.1186/1752-153X-3-27
2. Gururaj G. Epidemiology of traumatic brain injuries: Indian scenario. Neurol Res. 2002;24(1):24-28. doi: 10.1179/016164102101199503
3. Yattoo GH, Tabish A. The profile of head injuries and traumatic brain injury deaths in Kashmir. J Trauma Manag Outcomes. 2008;2:5. doi: 10.1186/1752-2897-2-5
4. Enberg, Ponsford J. Factors contributing to outcome following traumatic brain injury. NeuroRehabilitation. 2013;32(4):803-815. doi: 10.3233/NRE-130904
5. Greenberg DA, Aminoff MJ, Simon RP. Clinical Neurology. 5th ed. New York: Lange Medical Books/McGraw-Hill; 2002. Chapter 10, Coma; p. 199-236
6. Giacino JT, Ashwal S, Childs N, Cranford R, Jennett B, Katz DI, et al. The minimally conscious state: definition and diagnostic criteria. Neurology. 2002;58(3):349–353. doi: 10.1212/WNL.58.3.349
7. Mitchell S, Bradley VA, Welch JL, Britton PG. Coma arousal

procedure: A therapeutic intervention in the treatment of head injury. Brain Inj. 1990;4(3):273-79. doi: 10.3109/02699059009026177
8. Mandeep, Pravin Kumar. Effectiveness of Early Intervention of Coma Arousal Therapy in Traumatic Head Injury Patients. Int J Head Neck Surg. 2012;3(3):137-142. doi: 10.5005/jp-journals-10001-1114
9. Giacino JT, Whyte J, Bagiella E, Kalmar F, Childs N, Giacino JT, et al. Placebo-controlled trial of amantadine for severe traumatic brain injury. N Engl J Med. 2012;366(9):819-26. doi: 10.1056/NEJMoa1112950
10. Kumar S, Agarwal N, Sanal TS. Effectiveness of coma arousal therapy on patients with disorders of consciousness - A systematic review and meta-analysis. Brain Circ. 2024;10(2):119-133. doi: 10.4103/bc.bc_112_23
11. Bontke CF, Baize CM, Boake C. Coma Management and Sensory Stimulation. Phys Med Rehabil Clin North Am. 1992;3(2):259-272. doi: 10.1016/S1047-9651(18)30645-4
12. Baughman DJ, Watson CM, Beich JW, Herboso MNJ, Cuttie LK, Marlyne AC. Recommendation for Long-term Management of Adult Attention-Deficit/Hyperactivity Disorder in Military Populations, Veterans, and Dependents: A Narrative Review. Mil Med. 2024;189(5-6):e1343–e1352. doi: c10.55487/ijcih.v2i2.30
13. Bohannon RW, Green MD. Neurologic and musculoskeletal effects of tilt-table standing on adults: a systematic review. J Phys Ther Sci. 2021;33(9):700-706. doi: 10.1589/jpts.33.700
14. Urbenjaphol P, Jitpanya C, Khaoropthum S. Effects of the sensory stimulation program on recovery in unconscious patients with traumatic brain injury. J Neurosci Nurs. 2009;41(3):10-16. doi: 10.1097/JNN.0b013e3181a13189
15. Luther M, Krewer C, Müller F, Koenig E. Comparison of orthostatic reactions of patients still unconscious within the first three months of brain injury on a tilt table with and without integrated stepping. A prospective, randomised crossover pilot trial. Clin Rehabil. 2008;22(10):1034-41. doi: 10.1177/0269215508092821
16. Giacino JT, Katz DI, Whyte J. Neurorehabilitation in disorders of consciousness. Semin Neurol. 2013;33(2):142–156. doi: 10.1055/s-0033-1348960
17. Norwood MF, Lakhani A, Watling DP, Marsh CH, Zeeman H. Efficacy of Multimodal Sensory Therapy in Adult Acquired Brain Injury: A Systematic Review. Neuropsychol Rev. 2022;32:1-21. doi: 10.1007/s11064-022-09804-w
18. Giacino JT, Kalmar K, Whyte J. The JFK coma recovery scale- revised: Measurement characteristics and diagnostic utility. Arch Phys Med Rehabil. 2004;85(12):2020-29. doi: 10.1053/j.archpc.2004.07.011
19. Lalwani S, Dadgal R, Harjpal P, Saifee S, Lakkadsha T. Perks of Early Physical Therapy Rehabilitation for a Patient With Diffuse Axonal Injury. Cureus. 2022;14(10):e30886. doi: 10.7759/cureus.30886
20. Thomas A, Narayanasetti N, Vasan TS, et al. Effect of six months intensive multidisciplinary approach for fifteen months post-traumatic brain injury patient - a case report. Int J Health Sci Res. 2017;7(5):418-21.
21. Thibaut A, Schiff N, Giacino J, Laureys S, Gosseries O. Therapeutic interventions in patients with prolonged disorders of consciousness. Lancet Neurol. 2019;18(6):600-614. doi: 10.1016/S1474-4422(19)30115-4
22. Kumar S, Agarwal N, Sanal TS. Effectiveness of coma arousal therapy on patients with disorders of consciousness – A systematic review and meta-analysis. Brain Circ. 2024;10(2):119-133. doi: 10.4103/bc.bc_112_23
23. Kumar N, Sharma N, Chauhan A, Praveen S, Singh R. Effectiveness of Multi-Sensory Stimulation Program with Median Nerve Stimulation in Post-Head Injury Subjects with Decreased Level of Consciousness. Physiother Occup Ther J. 2019;12(1). doi: 10.21088/ptoj.0974.5084.12119.2 [1.1]
24. Chakraborty T, et al. A Review of Current Trends in Coma Arousal Techniques Used in Physiotherapy for Disorders of Consciousness (DOC). Int J Converg Healthc. 2022;2(2). doi: 10.55487/ijcih.v2i2.30
25. Kushwaha G, Subin S, Agrawal A, Siddiqui SS. Effectiveness of Coma Arousal Techniques to Improve the Sensory Stimulation in Unconscious Patients. Ann RSCB. 2022;26(1):3594-3613.
26. Ng H, King A. A systematic review of head-up tilt to improve consciousness in people with a prolonged disorder of consciousness. Clin Rehabil. 2020;35(1):13-25. doi: 10.1177/0269215919872500
27. Riberholt CG, Lindschou J, Gluud C, et al. Early mobilisation by head-up tilt with stepping versus standard care after severe traumatic brain injury – Protocol for a randomised clinical feasibility trial. Trials. 2018;19:612. doi: 10.1186/s13063-018-1832-0
28. Riberholt CG, Olsen MH, Søndergaard CB, Gluud C, Ovesen C, Jakobsen JC, et al. Early Orthostatic Exercise by Head-Up Tilt with Stepping vs. Standard Care After Severe Traumatic Brain Injury Is Feasible. Front Neurol. 2021;12:641357. doi: c10.1177/0269215508092821
29. Czell D, Schreier R, Rupp R, Eberhard S, Colombo G, Dietz V. Influence of passive leg movements on blood circulation on the tilt table in healthy adults. J Neuroeng Rehabil. 2004;1(4). doi: 10.1186/1743-0003-1-4
30. Rosenfelder MJ, Helmschrott VC, Willacker L, et al. Effect of robotic tilt table verticalization on recovery in patients with disorders of consciousness: a randomized controlled trial. J Neurol. 2023;270:1721–1734. doi: 10.1007/s00415-022-11435-x