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Cognitive Rehabilitation after Geriatric Traumatic Brain Injury: Transitional Care from Hospital to Nursing Home

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Abstract

Background: Geriatric traumatic brain injury (TBI) is an increasingly prominent public health concern. With the rapid aging of the global population, the incidence of TBI in older adults continues to rise. **Objective:** This review aims to synthesize the current state of domestic and international research on cognitive rehabilitation following geriatric TBI, to analyze the major challenges in this field, and to propose future research directions. **Methods:** The authors conducted a comprehensive literature search of PubMed, Web of Science, and CNKI databases for relevant studies published between 2020 and 2026, and synthesized the findings in a narrative review format. **Findings:** Geriatric TBI exhibits distinct characteristics in etiology, pathophysiology, and rehabilitation trajectory that differ significantly from those observed in younger populations. Multidisciplinary integrated care and transitional care are widely recognized as core directions for future rehabilitation service models. However, the current literature lacks intervention protocols specifically designed for older adults, and systematic rehabilitation transition pathways encompassing the hospital-to-nursing-home continuum remain absent. Non-pharmacological cognitive strategies represent the most extensively studied interventions to date, though their long-term efficacy requires further validation. Health economic evaluations indicate that combined rehabilitation therapies offer favorable cost-effectiveness ratios. **Conclusion:** Given the complex and diverse rehabilitation needs of geriatric TBI patients, an effective pathway spanning the entire continuum from acute care to long-term care is urgently needed.

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Future research should continue to investigate the underlying mechanisms of rehabilitation interventions while simultaneously developing integrated, patient-centered protocols that translate into tangible benefits for this population.

Keywords

Geriatric Traumatic Brain Injury, Cognitive Dysfunction, Multidisciplinary Integrated Care, Transitional Care, Integrated Medical and Elderly Care, Rehabilitation

1. Introduction

Traumatic brain injury is one of the major global health burdens, affecting roughly 64 million people yearly throughout the world, many of them with long-term disabilities [1]. As the human population ages progressively, an important epidemiological change has taken place: elderly persons now contribute increasingly to the number of TBI patients [2]. Among high-income countries, people aged 65 or more amount to between 20% and 30% of the general population, and their main cause of geriatric TBI—once traffic-related—is now falling injury [3]. This observation has been independently validated by a Delphi study with 72 experts from around the globe [4]. China too is undergoing rapid aging; its national data show that over 800,000 elderly people sustain TBI yearly, with closed injuries making up 63% of such cases [5]. The quoted figures help clarify the expanding medical and care-related burden of geriatric TBI.

Older TBI patients tend to have multiple coexisting disorders—hypertension, for example, or diabetes—and to show poorer physiological reserve and less cerebral plasticity than their younger counterparts. Consequently, equal-sized brain injuries lead to worse functional results and to longer recovery periods in elderly individuals [6] [7]. Yet many of the currently accepted treatment plans derive largely from younger-patient data, with very few specific, geriatric-oriented studies offering proof of efficacy [8]. Even with this gap, it is now widely acknowledged that prior health (pre-injury) status is highly predictive and that good outcomes may be obtained; hence, nihilism regarding geriatric TBI prognosis is unjustified. This evidence gap presents an important difficulty for rehabilitation efforts.

Cognitive dysfunction is one of the most common sequelae of TBI. A significant number of published reports describe post-TBI cognitive impairment [9], with about half (50% - 90%) of patients suffering memory loss, about 82% having attentional difficulties, and approximately 75% showing signs of executive dysfunction [9]. Such deficits—whether mild or severe—greatly disturb the patient's quality of life and add considerable caregiving demands for society and for families. A prospective neuroimaging study showed that six months after injury, 94.9% of elderly subjects were still functionally independent in basic respects, but only 43% had fully recovered to their prior functional level [10]. That suggests a large ma-

jority of older people suffer residual cognitive impairments following TBI, a situation which may well worsen their quality of life.

A structural deficiency exists within current rehabilitation service systems, namely the disconnect between acute care and long-term care [11]. Upon hospital discharge, patients often encounter an abrupt discontinuation of professional rehabilitation support [12]. For older patients unable to return home, nursing homes represent a significant disposition destination; however, systematic research examining the hospital-to-nursing-home transition pathway remains largely absent [13]. Within this context, China has been vigorously promoting an integrated medical and elderly care service model [14] [15]. Guangxi Zhuang Autonomous Region has promulgated corresponding policies to advance the development of integrated medical and elderly care service institutions. To date, the region has established 189 such institutions, providing a total of 48,600 beds, and has formed 747 contractual partnerships with nursing homes. This review will examine the challenges facing geriatric TBI cognitive rehabilitation, synthesize domestic and international research progress, analyze the limitations of existing studies, and explore future directions for development.

2. Geriatric Traumatic Brain Injury: A Population Requiring Special Attention

2.1. Epidemiological Shifts

On a global scale, the epidemiological profile of TBI has changed greatly over time. Historically, TBI mostly struck young people, with traffic accidents being the main source of mortality. Now—with population aging—the share of elderly cases is rising very fast. Expert consensus documents confirm that the epidemiology of geriatric TBI has transformed [4], and they cite studies showing that the yearly incidence of geriatric TBI in affluent societies is now on an upward trend, largely due to age-linked falls. International experts further state that although "older age" must be defined—by no means solely—in terms of chronological age, or of comorbidity or frailty or functional status—it is best handled by an individualized approach [16].

China also has a major problem with regard to geriatric TBI. Studies comparing clinical facts and treatment results for young and old patient groups show consistent differences—of a biological or mechanical nature—as well as of outcome severity [5]. Such differences make it unreasonable to assume that findings obtained in youth apply directly to elderly people. Data from low-and middle-income countries strongly support the need for treatment plans shaped by local realities (*i.e.*, available care) rather than imported models—with an eye toward augmenting both independence and physical function at home.

2.2. Distinctive Characteristics of Geriatric TBI Patients

Compared to younger individuals, geriatric TBI patients exhibit several distinctive characteristics [17]. First, pathophysiological differences exist. Age-related cere-

bral atrophy provides increased intracranial space for acute hematoma expansion, which paradoxically creates a risk of delayed symptom manifestation and consequent underestimation of injury severity. Furthermore, age-related decreases in cerebrovascular elasticity predispose older adults to multiple concurrent injury types, including subdural hematoma and subarachnoid hemorrhage. Second, comorbidity burden is a significant consideration. Older adults frequently present with chronic conditions including hypertension, diabetes, cardiac disease, or atrial fibrillation, and may be taking anticoagulant medications. These factors directly influence treatment decisions and increase the complexity of post-injury recovery. Research indicates that timely reversal of anticoagulant effects in affected patients can substantially reduce hemorrhagic complications [18]. Third, recovery potential must be realistically assessed. Although the scientific community recognizes that the aging brain retains some capacity for neuroplasticity and recovery, rehabilitationstrategies must account for diminished recovery potential with the goal of preventing further cognitive decline. While recovery potential is reduced in older adults, experts agree that rehabilitation training remains critical for optimizing outcomes [19]. A study examining cognitive reserve found that among geriatric TBI patients aged 60 - 74 years, those with mild injury demonstrated significantly higher cognitive reserve indices compared to those with severe injury ($p < 0.001$) [19], suggesting that pre-injury cognitive reserve may serve as an important protective factor. Fourth, social support systems are often inadequate. Many older adults live alone or are widowed, with limited family members available to provide care. This renders community or home reintegration substantially more challenging. Psychologically, the incidence of post-traumatic stress disorder and depression does not correlate solely with CT-detectable injury but is significantly associated with social support availability and gender [20].

3. Cognitive Dysfunction: A Core Challenge in TBI Rehabilitation

3.1. Manifestations and Assessment of Post-TBI Cognitive Impairment

Post-TBI cognitive dysfunction encompasses multiple domains, including memory, attention, executive function, language, and visuospatial abilities. A systematic review found that even older adults with mild TBI frequently experience protracted and incomplete recovery, which is often undetected by conventional outcome measures, leading to societal underestimation of the long-term burden of such injuries [21]. Regarding assessment tools, we analyzed 22 cognitive screening scales and synthesized evidence from various studies, finding that the Montreal Cognitive Assessment (MoCA) and the Mini-Mental State Examination (MMSE) are the two most widely used instruments. Among them, the MoCA demonstrates superior psychometric properties and the strongest evidence base. The MoCA can be completed in just 10 minutes and is more sensitive and earlier than the classic MMSE in detecting mild cognitive impairment. It has shown adequate sensitivity

and specificity in populations with traumatic brain injury (TBI) and has been used to track cognitive changes in community-dwelling older adults (aged 58 - 77). A systematic review of brief cognitive screening tools for TBI also ranked the MoCA as one of the most robust psychometrically sound instruments. Therefore, we recommend the MoCA as the core screening tool for cognitive assessment in clinical research and practice involving older adults with TBI. However, it should be emphasized that the MoCA is intended solely for rapid screening and cannot replace a comprehensive, domain-specific neuropsychological evaluation—which remains essential for diagnostic classification and treatment planning.

3.2. Recent Advances in Non-Pharmacological Intervention Research

Pharmacological treatments for post-TBI cognitive deficits yield only limited benefits. In recent years, non-pharmacological approaches have begun to attract considerable attention. A systematic review involving 118 studies now reports-without qualification—that non-pharmacological means (including neuromodulation, hyperbaric oxygen therapy, dietary measures, music therapy, virtual reality therapy, and exercise) rest on solid evidence regarding their short-term effectiveness [22]. Among such methods-neuromodulation, hyperbaric oxygen therapy, dietary intervention, music therapy, virtual reality therapy, or exercise-there is substantial evidence of short-term benefit. It must also be stated, though, that the evidence reviewed here is drawn almost entirely from TBI populations of varied ages; it is not yet clear how fully these results apply to the elderly.

A scoping review conducted by a Canadian research team systematically examined 20 studies of cognitive interventions for older adults with TBI [23]. Of the 20 studies included in this review, the majority enrolled mixed-age populations or focused on home-based interventions; only a minority specifically addressed institutional care transitions for older adults. Thus, while the overall evidence for non-pharmacological cognitive interventions is positive, its direct applicability to the hospital-to-nursing-home pathway in geriatric patients should be interpreted with caution. This review found that non-pharmacological cognitive strategies were the most frequently studied intervention type (accounting for 16 studies) and demonstrated statistically significant positive effects on cognitive outcomes. Similarly, a Canadian health economic evaluation reported that while both physical rehabilitation alone and cognitive training alone were more cost-effective than usual care, combined physical rehabilitation and cognitive training demonstrated a cost-effectiveness ratio (CAD 18,028 per quality-adjusted life year gained) well within acceptable thresholds and should be prioritized [24]. These findings provide strong evidence supporting the clinical implementation of combined physical rehabilitation and cognitive training as a cost-effective strategy. However, this evidence should not be extrapolated to infer support for combined pharmacological and non-pharmacological interventions, as the latter combination involves different mechanisms, safety profiles, and evidence bases that require separate investigation.

3.3. Frontier Rehabilitation Technologies: From Bench to Bedside

Combining modern rehabilitation techniques with neuroscience research has opened up new possibilities for TBI patients. A pilot clinical trial-now under way-is investigating a treatment called ReSTART [25], in which computer-assisted cognitive work and transcranial direct current stimulation are joined as a novel rehabilitation method. The focus of this study is on elderly people, and it attempts to assess whether neuromodulation-applied at home—might help them regain control of attention, of memory, or of decision-making. Additionally, virtual reality has been found to hold considerable promise as an aid to cognitive training [26]. A recent systematic review concluded that virtual reality-based training for individuals with subacute TBI leads to measurable gains in executive function; yet the available data remain somewhat weak, with marked variation among trials, calling for more uniform methods of evaluation to guide clinical rehabilitation practices [27].

4. From Siloed Care to Multidisciplinary Collaboration: The Evolution of Rehabilitation Models

With improved knowledge of TBI comes an increasing realization on the part of the medical community that recovery involves many factors and cannot be handled by one specialty alone. Post-TBI patients commonly suffer from a range of physical, mental, behavioral, or psychosocial impairments [28]. It now seems clear-on the basis of much clinical evidence-that multidisciplinary integration is necessary to achieve optimal rehabilitation results. A recent survey of TBI rehabilitation methods has affirmed that rehabilitation needs to be individualized in regard to cognition, to functional capacity, and to personal aspirations, with such patient-centered plans producing superior outcomes [23].

However, although multidisciplinary collaboration has achieved theoretical consensus, its clinical implementation remains fraught with challenges. The Canadian scoping review further revealed that few studies have examined the social determinants of health in depth. Among the 20 studies included in this review, only three reported race or ethnicity, and eight reported educational level, yet none examined associations between these factors and intervention effectiveness. These findings indicate that current study designs remain insufficiently comprehensive, highlighting the need for future research to incorporate health equity perspectives and standardized outcome measures. Experts have also noted that different specialties hold divergent interpretations of symptom duration and perceived professional roles, further complicating collaborative efforts. This underscores that theoretical consensus alone is insufficient; practical barriers to implementation must be systematically addressed. An expert consensus statement published in The Lancet Neurology explicitly recommends that in the absence of sufficient evidence, clinical decisions should be multidisciplinary, transparent, individualized, and incorporate patient and family perspectives [16].

5. Transitional Care: Bridging the Final Mile from Hospital to Community

Transitional care refers to the coordinated, planned medical services provided to patients during the critical period of transition from hospital to home or community settings [29]. It should be noted, however, that the majority of transitional care evidence cited below derives from studies of general TBI populations or hospital-to-home transitions. Evidence directly addressing the hospital-to-nursing-home transition in geriatric TBI populations remains sparse, and conclusions drawn for this specific pathway necessarily rely in part on indirect evidence from related contexts. This concept was developed precisely to prevent the fragmentation of care following hospital discharge.

A number of thorough studies of transitional care-within the TBI domain-have been made worldwide. Duke University's BrainSTORM project furnishes an encouraging case study: it applies a four-month transitional care model with monthly educational and social help for the patient and their family. Initial observations suggest that such a non-drug-based transitional approach is feasible and acceptable in practice [30].

A larger-scale initiative is the BRITE study, a pragmatic randomized controlled trial embedded within the U. S. TBI Model Systems [31]. This study compared two existing transition models: a traditional discharge planning model and a more intensive rehabilitation transition program. Results from this 925-patient study revealed no significant differences between the two models in terms of social participation or quality of life, with most patient outcomes showing minimal change. This null finding has prompted substantive scholarly reflection. One interpretation suggests that a six-month intervention period may be insufficient to meet the evolving needs of patients with moderate-to-severe TBI along their protracted recovery trajectories-a concern echoed by patients, families, and professionals alike, who report that six months of intervention is inadequate to address the emerging needs encountered throughout the rehabilitation journey.

6. The Chinese Model within the Integrated Medical and Elderly Care Policy Framework

In China, integrated medical and elderly care represents a national strategy for addressing population aging. Several regions have pioneered models that integrate medical treatment, rehabilitation, and elderly care services. These initiatives provide a unique research setting and practical platform for addressing the hospital-to-nursing-home transitional care gap described above. Guangxi has made notable progress in advancing integrated medical and elderly care. To date, the region has established 189 integrated medical and elderly care institutions, providing a total of 48,600 beds, and has formed 747 contractual partnerships with nursing homes, with 96.8% of primary-level and above medical institutions establishing green channels for elderly patients. Guangxi has also developed four mature inte-

grated service models: contractual collaboration between medical institutions and nursing homes; direct service provision by medical institutions; on-site medical services within nursing homes; and extension of medical and health services to home and community settings. This policy framework provides the necessary service infrastructure—including contracted partnerships between hospitals and nursing homes—that makes it feasible to conduct research on the hospital-to-nursing-home continuum. However, it is important to recognize that service capacity, as reflected in these institutional and bed counts, does not itself constitute evidence that such services improve cognitive rehabilitation outcomes. The actual effectiveness of these integrated models for geriatric TBI cognitive rehabilitation remains to be empirically validated.

7. Limitations of Existing Research and Future Directions

7.1. Limitations of Existing Research

Based on the aforementioned literature analysis, the current field faces several major shortcomings.

First, there is a lack of interventions specifically tailored for older adults. Most existing studies analyze elderly patients as subgroups in secondary analyses, with few interventions designed to address their unique comorbidity burden, frailty status, and brain atrophy characteristics. Expert consensus also acknowledges that while broad agreement has been reached on many management strategies, significant knowledge gaps remain regarding biomarker-guided CT decisions and the management of various post-traumatic sequelae [4].

Second, rehabilitation continuity is disrupted, and referral pathways are lacking. Rehabilitation should ideally be a continuous process, yet there is often a clear disconnect between acute and chronic phases, particularly in the systematic study of transfer pathways from hospitals to long-term care facilities [13]. The negative results of the BRITE study further suggest that even a six-month intervention may fail to meet patients' evolving needs throughout their rehabilitation journey [31]. Currently, there is very limited research—both domestically and internationally—on the specific transition from hospital to nursing home; most available evidence on transitional care comes from mixed-age "hospital-to-home" settings, making direct extrapolation to the elderly "hospital-to-nursing home" pathway highly limited.

Third, caregiver support systems are weak. Family caregivers play an indispensable role in patient recovery. However, caregivers of older adults themselves are often elderly and face heavy physical and psychological burdens. Existing interventions primarily focus on patients, with few systematic programs aimed at empowering caregivers or providing them with psychological support.

Fourth, local health economics evidence remains scarce. Although international studies suggest that integrated rehabilitation approaches offer good cost-effectiveness [24], the actual healthcare cost structures, payment capacity, and in-

surance coverage models under China's medical-care integration policy differ significantly from those in high-income countries. There is still a severe shortage of health economic evaluations based on real-world clinical scenarios in China, which directly limits the translation of rehabilitation strategies into community-level medical-care institutions and hinders their inclusion in insurance reimbursement decisions.

7.2. Future Research Directions

Future research must address the aforementioned gaps. In particular, the hospital-to-nursing-home full-continuum transition model requires validation within a genuine integrated medical and elderly care platform. Specifically, such a pathway should include the following core components: 1) discharge cognitive assessment-standardized administration of the MoCA or equivalent screening tool prior to hospital discharge to establish a baseline cognitive profile; 2) rehabilitation handoff-structured transfer of cognitive rehabilitation plans, including goals, prescribed interventions, and progress notes, from the hospital rehabilitation team to the receiving nursing home's care team; 3) individualized care plan-a tailored cognitive rehabilitation plan developed collaboratively by hospital specialists, nursing home staff, the patient, and family members, specifying intervention type, frequency, and duration; 4) caregiver support and training-structured education and skills training for nursing home staff and family caregivers on cognitive stimulation techniques, behavioral management, and communication strategies; 5) reassessment schedule-regular follow-up cognitive assessments (e.g., at 1, 3, and 6 months post-transfer) to monitor progress and adjust interventions accordingly; and 6) patient-centered outcome measurement-tracking of functional independence, quality of life, and caregiver burden as primary endpoints. The feasibility, acceptability, and effectiveness of this integrated pathway should be evaluated in real-world integrated medical and elderly care settings. Such studies should encompass the entire continuum from acute care to long-term care, while incorporating caregiver perspectives and caregiving costs into comprehensive evaluation frameworks. Only by generating integrated evidence in real-world settings can research findings most authentically reflect China's realities and provide meaningful assistance to the vast population of geriatric TBI patients and their families.

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Conflicts of Interest

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