Effect of Age on Longitudinal Changes in Symptoms, Function, and Outcome in the First Year After Mild-Moderate Traumatic Brain Injury

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ABSTRACT

OBJECTIVE: The aim of this study was to describe and compare the recovery and disability trajectory at 1 year post injury for younger and older adults with traumatic brain injury (TBI). **METHODS:** This was a prospective longitudinal cohort study. Individuals 21 years and older with mild to moderate TBI were recruited from the emergency department (n = 33). We measured symptoms, function (Glasgow Outcome Scale-Extended, Functional Status Examination), and health-related quality of life (HRQOL) at 1 week and 1, 3, 6, and 12 months post injury. **RESULTS:** Whereas the total number of symptoms does not differ between younger and older adults after TBI, the specific constellation of symptoms experienced does. Older adults are more likely to experience physical symptoms such as fatigue, balance, and coordination problems as well as complain of being bothered by noise. Younger adults, in contrast, endorse more psychological symptoms such as anxiety. Functioning as measured by the Glasgow Outcome Scale-Extended and Functional Status Examination was lower in older adults at 1 year post injury. Physical HRQOL was consistently poorer in the year post injury among older adults compared with younger adults after TBI. Mental HRQOL, in contrast, was higher in older adults post TBI at 1 year. **CONCLUSIONS:** During the first year post TBI, older adults report different symptom clusters than do younger adults post TBI. To foster improved recovery and HRQOL in the older adult post TBI, nursing management strategies should focus on balance, coordination, and energy conservation.

Keywords: aged, brain injuries, nursing, outcomes assessment

Traumatic brain injury (TBI) continues to be a leading cause of death and disability worldwide. Recently, the TRACK-TBI investigators found that less than half of adults with mild TBI who present to a level I trauma center returned to preinjury levels of daily functioning at 1 year.[1] In 2014, US adults experienced more than 2 million incident TBIs that required treatment,[2] representing a 53% increase over 2006. The highest rates of TBI-related emergency department visits, hospitalization, and death are seen in adults 75 years and older.[2] In the United States in 2014, more than 653 400 TBIs occurred among adults 65 years and older; the primary cause was fall.[2] The incidence of geriatric TBI continues to increase, despite a focus on injury and fall prevention.

In studies that have examined disability after TBI in older adults, there has been evidence to suggest that survivors have increased functional dependence.[3–5] Although this information is important, it offers little aid to clinicians who aim to diminish the problem of TBI-related disability in older adults. Although extensive research has been conducted examining recovery trajectories in younger populations, relatively few studies have been conducted in older adults with TBI.

As we age, our ability to regenerate nerve tissue and recover from a brain injury diminishes, which negatively affects outcomes in these individuals compared with younger adults. This raises the question of whether

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expected recovery patterns are valid in an older population. Because we do not currently have a good understanding of the natural history of recovery after TBI in older adults, predicting outcomes and providing care in the older adult TBI population remains difficult. The purpose of this study is to provide an initial exploration of the natural history of symptom experience and functional recovery after a mild-moderate TBI in older and younger adults in the first year post injury. This information may improve recovery and maximize quality of life in this cohort. This study sought to answer the following research questions: (1) "What symptoms, functional impairments, and health-related quality of life (HRQOL) issues are experienced by older adults in the first year post TBI?" and (2) "How are these similar or different than those experienced by younger adults post TBI?"

Methods

Settings and Participants

Participants with mild to moderate TBI were recruited from eligible patients seeking medical treatment at Harborview Medical Center, a regional level I trauma center. Participants met the following inclusion criteria: (1) arrival in the emergency department within 24 hours of injury, (2) primary diagnosis of TBI, and (3) initial Glasgow Coma Scale score of 9 to 15. In addition, participants were excluded if they had any of the following: (1) cervical spinal cord injury; (2) lower extremity fracture; (3) history of TBI, stroke, or dementia; (4) hospitalization within the past 6 months; (5) non–English speaking. We classified TBI subjects into 2 categories based on age at injury: younger adult with TBI (21-64 years) and older adults (65 years and older). Institutional review board approval was obtained for this study.

Procedures

A member of the research team approached participants or their legally authorized representative to obtain written informed consent within 24 hours of injury. Once consent was obtained, a member of the research team extracted information from the electronic medical record on demographics (age, sex, race, ethnicity), mechanism of injury, type and location of brain and other injuries, and comorbid health conditions. For persons who had initial consent provided by the legally authorized representative, continuing consent to participate was sought as soon as possible. Beginning at 1 week post injury and then again at 1, 3, 6, and 12 months post injury, researchers conducted face-to-face interviews with subjects to obtain answers to questionnaires regarding recovery after TBI. Injury data extracted from the electronic medical record were later verified with the hospital trauma registry.

One year after TBI, balance, fatigue, and being bothered by noise, were the top 3 symptoms reported by older adults.

Measures

Symptoms

The TBI Symptom Checklist is a 17-item questionnaire assessing status of physical and emotional symptoms. If symptom was present before injury, the instrument asks "What is the status now (same, worse, or better)?". This questionnaire also elicits severity rating of endorsed symptoms from 1 (not at all a problem for me) to 4 (severe problem for me).[6] Only symptoms that are new or worse since the injury are counted as being endorsed.

Function

Function was measured using the Functional Status Examination (FSE) and the Glasgow Outcome Scale-Extended (GOS-E) beginning at 3 months post injury. The FSE evaluates change in activities of everyday life as a function of an event or illness, including TBI, and covers 10 activity areas, namely, personal care, ambulation, travel, major activity involving work or school, home management, leisure/recreation, social integration, executive functioning, financial independence, and standard of living.[7,8] The tool is administered via structured interview. As many participants were retired, for the purposes of this study, we scored only 9 domains. Scores on each element range from 0 (no change) to 3 (almost all activities in this domain are no longer performed because of injury). The possible total modified FSE score then ranges from 0 to 27, with higher scores indicating lower function after injury.

The GOS-E is a brief descriptive scale that assesses functional outcome and is administered via interview, asking participants to report any new or worsening difficulties resulting from injury. It yields an overall score ranging from 1 (dead) to 8 (upper good recovery).[9] Scores less than 8 are indicative of some functional limitation.

Health-Related Quality of Life

The Short Form-12 version 2 (SF-12v2) is a 12-item questionnaire that measures HRQOL and has been validated for use in TBI patients.[10] Scores range from 0 to 100, with higher score indicating better health status. Subscales for physical component summary

(PCS) and mental component summary (MCS) are produced.[11]

Data Analysis

Descriptive statistics, *t* test, and χ^2 analyses were used to compare demographic and injury-related characteristics as appropriate between younger and older groups. Differences in symptom experiences between groups were examined using Fisher exact tests, whereas differences in function and HRQOL at each time point were compared using *t* tests. An α of .05 was used.

Results

A total of 33 subjects were recruited for a period of 16 months to participate in the study and were retained to 1 year post injury (see Supplemental Digital Content, Table 1, for sample characteristics, available at http://links.lww.com/JNN/A217). The mean age of the younger TBI cohort (n = 18) was 38.9 years (range, 23–63 years), whereas that of the older TBI cohort was 77.5 years (range, 65–91 years). There was a difference in sex representation across the 2 cohorts, with the younger cohort having a significantly higher percentage of men than the older TBI cohort (83.3% vs 40%, respectively). Other demographic and injury characteristics did not significantly differ across groups. Falls were the predominant cause of injury in the older TBI cohort (53.3%), whereas motor vehicle crash was the most common factor in younger adults.

Symptoms

At 1 week post injury, the average total number of symptoms endorsed on the TBI symptom checklist by younger and older adults after TBI was similar (6.7 and 6.4, respectively; see Table 1). Although the trend was toward a more rapid improvement in the average number of symptoms endorsed over time in the younger TBI cohort compared with the older cohort (eg, 4.7 vs 5.7 symptoms endorsed at 1 month post injury, 3.3 vs 6.0 at 6 months), this difference was not statistically significant. By 1 year post injury, both groups continued to report ongoing concerns, with younger adults endorsing 3.6 symptoms on average and older adults reporting an average of 3.9 symptoms (see Table 1).

In examining specific symptoms endorsed by the groups across the recovery trajectory, there were differences in the most common symptoms by younger and older TBI cohorts (see Table 1). For example, at 1 week post injury, the top 3 most common symptoms in younger adults were balance issues (61.1%), headache (61.1%), and irritability or lack of patience (55.6%), whereas older adults reported balance issues (73.3%), fatigue (66.7%), and dizziness (60%). At 1 year post injury, balance and fatigue (40% each) remain tied as the most reported symptom in the older adult TBI cohort, with being bothered by noise (33.3%) as the third most common. In contrast, younger adults report memory difficulty (38.9%) as the most prevalent symptom after TBI, with headache and anxiety tied for second most endorsed (33% each).

Furthermore, there were differences in prevalence of individual symptom experienced between groups across time (Table 1). Specifically, older adults were significantly more likely to endorse balance (1, 3, and 6 months) and coordination (1 and 6 months) issues, being bothered by noise (3 and 6 months), and experiencing fatigue (6 months) than the younger TBI cohort. In contrast, younger adults with TBI were significantly more likely to report anxiety at 1 month post injury (Table 1). In examining severity of symptom endorsement, older adults had significantly higher symptom severity scores across several issues and time points. Specifically, on average, older adults reported significantly higher symptom severity scores related to fatigue (1 and 6 months), balance (1, 3, and 6 months), coordination (1 month), and taste (6 months) compared with younger adults after TBI (see Supplemental Digital Content, Table 2, available at http://links.lww.com/JNN/A218).

Functional Status and HRQOL

Functional health status of older adults after mild-moderate TBI is significantly worse compared with that of younger adults across all time points as assessed by both the GOS-E and the FSE (Table 2). On the GOS-E, the average score on GOS-E is 6.9 (SD, 1.4) indicating lower good recovery at 3 months post injury. In contrast, older adults after TBI have an average of 5.1 (SD, 2.3) indicating lower moderate disability. This trend is consistent across the 6- and 12-month assessments. Similarly, on the FSE, the older adult TBI cohort has significantly higher scores on the FSE at the 3-, 6-, and 12-month assessments compared with the younger cohort, indicating higher disability after injury (Table 2).

There were significant differences between the 2 groups on physical HRQOL. Older adults with TBI reported consistently poorer overall physical HRQOL from 1 week to 1 year post injury compared with the younger TBI cohort (Table 2). No significant differences in the mental HRQOL (MCS) scores between the younger and older TBI cohorts were found from 1 week to 6 months post injury (Table 2). However, at 1 year post injury, the older adult TBI cohort reported significantly higher average mental HRQOL (56.0) compared with the younger adult TBI cohort (49.1).

Discussion

In this study, we sought to explore the symptom experience as well as function and HRQOL in persons

TABLE 1. Total Number and Frequency of Endorsement of Symptoms up to 1 Year After TBI by Age Group

Time Since Injury	1 wk		1 mo		3 mo		6 mo		1 y	
Symptom	**Younger TBI, n = 18**	**Older TBI, n = 15**	**Younger TBI**	**Older TBI**	**Younger TBI**	**Older TBI**	**Younger TBI**	**Older TBI**	**Younger TBI**	**Older TBI**
Headaches	11 (61.1)	5 (33.3)	7 (38.9)	4 (26.7)	4 (22.2)	4 (26.7)	3 (16.7)	3 (20.0)	6 (33.3)	3 (20.0)
Fatigue	9 (50.0)	10 (66.7)	8 (44.4)	10 (66.7)	9 (50.0)	9 (60.0)	4 (22.2)	10 (66.7)[a]	5 (27.8)	6 (40.0)
Dizziness	9 (50.0)	9 (60.0)	9 (50.0)	8 (53.3)	4 (22.2)	4 (26.7)	3 (16.7)	6 (40.0)	5 (27.8)	3 (20.0)
Blurred vision	8 (44.4)	6 (40.0)	5 (27.8)	5 (33.3)	4 (22.2)	3 (20.0)	4 (22.2)	3 (20.0)	5 (27.8)	4 (26.7)
Trouble concentrating	8 (44.4)	6 (40.0)	7 (38.9)	6 (40.0)	4 (22.2)	4 (26.7)	3 (16.7)	4 (26.7)	3 (16.7)	3 (20.0)
Bothered by noise	5 (27.8)	4 (26.7)	5 (27.8)	6 (40.0)	1 (5.6)	7 (46.7)[a]	1 (5.6)	6 (40.0)[a]	2 (11.1)	5 (33.3)
Bothered by light	7 (38.9)	5 (33.3)	3 (16.7)	3 (20.0)	4 (22.2)	3 (20.0)	3 (16.7)	4 (26.7)	4 (22.2)	3 (20.0)
Irritability, lack of patience	10 (55.6)	7 (46.7)	5 (27.8)	5 (33.3)	10 (55.6)	6 (40.0)	8 (44.4)	6 (40.0)	4 (22.2)	3 (20.0)
Lose temper easily	6 (33.3)	1 (6.7)	6 (33.3)	1 (6.7)	6 (33.3)	2 (13.3)	6 (33.3)	3 (20.0)	3 (16.7)	2 (13.3)
Memory difficulty	7 (38.9)	7 (46.7)	6 (33.3)	7 (46.7)	7 (38.9)	7 (46.7)	6 (33.3)	7 (46.7)	7 (38.9)	4 (26.7)
Anxiety	8 (44.4)	2 (13.3)	7 (38.9)	1 (6.7)[a]	5 (27.8)	4 (26.7)	5 (27.8)	5 (33.3)	6 (33.3)	2 (13.3)
Trouble with sleep	8 (44.4)	8 (53.3)	4 (22.2)	5 (33.3)	2 (11.1)	6 (40.0)	5 (27.8)	4 (26.7)	4 (22.2)	3 (20.0)
Balance	11 (61.1)	11 (73.3)	5 (27.8)	10 (66.7)[a]	3 (16.7)	8 (53.3)[a]	3 (16.7)	10 (66.7)[b]	4 (22.2)	6 (40.0)
Sexual difficulties	1 (5.6)	2 (13.3)	2 (11.1)	1 (6.7)	0 (0.0)	2 (13.3)	0 (0.0)	2 (13.3)	0 (0.0)	1 (6.7)
Coordination	1 (5.6)	4 (26.7)	1 (5.6)	6 (40.0)[a]	3 (16.7)	6 (40.0)	0 (0.0)	7 (46.7)[b]	2 (11.1)	2 (14.3)
Taste	8 (44.4)	5 (33.3)	3 (16.7)	4 (26.7)	2 (11.1)	5 (33.3)	2 (11.1)	6 (40.0)	2 (11.1)	4 (26.7)
Smell	4 (22.2)	4 (26.7)	2 (11.1)	4 (26.7)	2 (11.1)	4 (26.7)	3 (16.7)	4 (26.7)	3 (16.7)	4 (26.7)
Total no. symptoms endorsed, mean (SD)	6.7 (4.8)	6.4 (5.1)	4.7 (4.4)	5.7 (4.8)	3.9 (4.1)	5.6 (4.4)	3.3 (4.0)	6.0 (4.7)	3.6 (4.7)	3.9 (5.3)

Note. All data are reported as number (%), unless indicated otherwise.

Abbreviation: TBI, traumatic brain injury.

[a] $P < .05$.

[b] $P < .01$.

TABLE 2. Functional Status Ratings and Health-Related Quality of Life up to 1 Year After TBI by Age Group (Younger TBI, n = 18; Older TBI, n = 15)

	1 wk		1 mo		3 mo		6 mo		1 y	
	Younger TBI	Older TBI	Younger TBI	Older TBI	Younger TBI	Older TBI	Younger TBI	Older TBI	Younger TBI	Older TBI
Functional status										
GOS-E					6.9 (1.4)	5.1 (2.3)[a]	7.3 (1.4)	5.2 (2.4)[a]	7.2 (1.5)	4.6 (2.1)[b]
FSE					4.4 (6.0)	11.0 (8.7)[a]	3.4 (5.6)	10.3 (8.6)[a]	3.5 (5.8)	11.8 (7.0)[b]
Health-related quality of life										
SF-12v2 PCS	43.6 (12.2)	34.0 (15.2)[b]	41.7 (10.1)	32.8 (9.3)[b]	50.0 (14.2)	40.5 (10.6)[a]	51.1 (9.2)	36.3 (10.9)[b]	50.5 (11.7)	33.3 (9.3)[b]
SF-12v2 MCS	47.6 (10.1)	47.1 (15.1)	52.6 (7.6)	46.6 (12.3)	48.8 (6.5)	51.8 (9.7)	49.9 (6.5)	55.0 (7.2)	49.1 (7.0)	56.0 (9.3)[a]

Note. All data are reported as mean (SD).

Abbreviations: FSE, Functional Status Examination; GOS-E, Glasgow Outcome Scale-Extended; MCS, mental component summary; PCS, physical component summary; SF-12v2, Short Form-12 version 2; TBI, traumatic brain injury.

[a] $P < .05$.

[b] $P < .01$.

65 years and older in the first year post mild-moderate TBI to assess whether the recovery pattern is similar or different to those experienced by younger adults who presented to the same facility for treatment. We note that, whereas the total number of symptoms experienced by the 2 groups did not differ across time, the specific constellation of symptoms experienced was different across the year post injury. Similar to previous studies, fatigue was commonly experienced across TBI groups.[1,12,13] Older adults after TBI were less likely to report headache pain and more likely to have balance and coordination issues in the year post injury. This is an important consideration for both rehabilitation as well as prevention of future injury. Requesting or providing the older individual with referrals to evidence-based programs to address balance and coordination is important because the primary cause of injury in older adults is falls. Furthermore, a history of previous fall, the cause of injury in most of this sample, as well as balance and coordination issues place an older adult at an increased risk of repeat fall and fall-related injury. Such programs include Enhance Fitness, Tai Ji Quan: Moving for Better Balance, and the Otago Exercise Program.[14,15] The National Council on Aging provides a website that can assist individuals in finding a program in their area.[16] Furthermore, as balance and coordination are important for many activities of daily living/instrumental activities of daily living such as walking, transfers, and housekeeping, having ongoing mobility disability could be responsible for differences seen in functional measures across groups.

Our findings related to overall outcome as measured by GOSE are in line with the majority of other studies that have found that older adults have poorer overall outcome compared with younger adults after TBI.[17,18] However, a recent study involving older patients from level 1 trauma centers in the Netherlands reported that most individuals had GOSE scores of upper good recovery at 1 year after mild TBI.[19] These differences in outcome may be related to overall severity of injury in the 2 samples, as the mean injury severity score in our sample was twice as high (17.3 vs 8.2).[19]

Older adults after mild-moderate TBI had poorer physical HRQOL across all time points measured to 1 year post injury compared with younger adults. This is in contrast to previous work in severe TBI patients that found similar scores in SF-12 PCS at 3 months but noted a trajectory of improvement over time to 12 months post injury.[18] In the current study, PCS scores were relatively stable without overall improvement. It is unclear at this time what factors other than higher overall severity of injuries may have contributed to this finding. Our findings related to overall scores of the mental component of HRQOL to 6 months post injury was similar to that reported by Haller and

colleagues[18] after severe TBI. In contrast to that study that found that the mental component remained stable at 1 year in both younger and older groups,[18] we found that, in our sample of individuals with mild TBI, the MCS of the SF-12v2 was significantly better than that of the younger cohort. This was despite higher disability and lower physical HRQOL scores in this study and may reflect resilience,[20,21] differing expectations regarding recovery in the context of aging,[22] ability to integrate the sequelae of injury given stage of life course,[23,24] and, potentially, exacerbation of preexisting anxiety or depression, which are more common in younger than older adults.[25]

Study Limitations

There are several limitations to this study. The sample was small and did not enable us to control for covariates such as sex in the analysis. Although we were not surprised at the larger percentage of women in the older adult sample given aging demographics, we were not able to address whether differences seen in symptoms and function were related to age-related differences alone or a combination of age and sex. Further exploration is warranted in a larger sample that can adequately adjust for demographic covariates. Another limitation is that the results presented do not include information on treatment/management and response to inform future intervention design and nursing care. Further work, particularly integrating mixed-methods analysis to understand the symptom experience, management choices, and response, would be useful to aid future precision health management. Finally, this study recruited from a single facility and may not reflect the broader older adult population. However, the trauma center serves a wide catchment area, including multiple states, and is the county hospital, increasing confidence in sample diversity and representation.

Conclusion

During the first year post TBI, older adults report different symptom clusters than do younger adults post TBI. To foster improved recovery and HRQOL in the older adult post TBI, nursing management should focus on balance, coordination, and energy conservation. Findings from this study extend our knowledge of the natural history of recovery of older adults with a mild-moderate TBI.

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