Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring 6 (2017) 196-200

Diagnostic Assessment & Prognosis

Age at injury is associated with the long-term cognitive outcome of traumatic brain injuries

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Abstract

Introduction: The association between age at injury (AAI) and long-term cognitive outcome of traumatic brain injuries (TBI) is debatable.
Methods: Eligible participants with a history of TBI from Alzheimer's Disease Neuroimaging Initiative were divided into a childhood TBI (cTBI) group (the AAI $\leq$ 21 years old) and an adult TBI (aTBI) group (the AAI $>$ 21 years old).
Results: The cTBI group has a higher Everyday Cognition total score than the aTBI group. All perceived cognitive functions are worse for the cTBI group than for the aTBI group except memory. By contrast, the cTBI group has higher assessment scores on either the Boston Naming Test or Rey Auditory Verbal Learning Test than the aTBI group.
Discussion: The AAI is associated with the long-term cognitive outcomes in older adults with a history of TBI.

Keywords: Alzheimer's disease; Executive function; Dementia; TBI

1. Introduction

Age at injury (AAI) has been shown to influence cognitive outcome in patients with traumatic brain injuries (TBI) [1]. However, the association between AAI and the long-term cognitive outcome of TBI is debatable. On one hand, the AAI was not associated with the cognitive outcome measured within the first year after TBI for children who sustained TBI before 6 years of age [2]. The AAI was also not an effective predictor for the long-term cognitive outcome in patients with a history of severe TBI when they were evaluated at an average of 14 years after TBI [3]. On the other hand, pediatric TBI patients with a younger AAI (<8 years old) were associated with a worse cognitive outcome when they were tested at least 6 years after TBI [4]. Moreover, a younger AAI was reported to be associated with a better long-term cognitive outcome of TBI in a study with a follow-up duration of 30 years [1]. Although the AAI has been studied with regard to its effects on cognitive performance in young patients with TBI [4–7], no study has been done to compare the long-term cognitive outcome between patients sustained with childhood TBI (cTBI) and adult TBI (aTBI). In this report, the AAI was investigated for its relationship with the long-term cognitive outcome of TBI by analyzing the cognitive performance of elderly participants enrolled in the Alzheimer's Disease Neuroimaging Initiative (ADNI). The findings have important

[1]Data used in preparation of this article were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database (adni.loni.usc.edu). As such, the investigators within the ADNI contributed to the design and implementation of ADNI and/or provided data but did not participate in analysis or writing of this report. A complete listing of ADNI investigators can be found at http://adni.loni.usc.edu/wp-content/uploads/how_to_apply/ADNI_Acknowledgement_List.pdf.

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http://dx.doi.org/10.1016/j.dadm.2017.01.008

implications for making prognosis and therapeutic plans for patients with a history of TBI.

2. Methods

2.1. ADNI

Data used in the preparation of this report were obtained from the ADNI database (adni.loni.usc.edu). ADNI is the result of efforts by many coinvestigators from a broad range of academic institutions and private corporations. Participants have been recruited from over 50 sites across the United States and Canada. To date, ADNI has recruited over 1800 adults, aged 55 to 90 years, to participate in the research, consisting of cognitively normal older individuals, people with early or late mild cognitive impairment, and people with early Alzheimer's disease (AD). Further information can be found at http://www.adni-info.org/ and in previous reports [8–13].

2.2. AAI

ADNI participants with a TBI history were selected by searching keywords from the medical history database as previously described [14]. For multiple traumatic brain injuries with the same severity (mild vs. moderate or severe), the date for the first injury was used to determine the AAI. When one TBI was more severe than the other ones, the date for the most severe TBI was used to derive the AAI. Based on the AAI, all participants with a history of TBI were divided into a cTBI group (the AAI $\leq$ 21 years old) and an aTBI group (the AAI $>$ 21 years old).

2.3. Cognitive assessments

All the participants had completed a battery of neuropsychological tests including Everyday Cognition (ECog) ratings, Boston Naming Test (BNT), and Rey Auditory Verbal Learning Test (RAVLT). The subjective ECog ratings are used to assess the participants' perceptions about their capability to perform normal everyday tasks, in comparison to activity levels 10 years prior, on a five-point scale (1 = no change or actually performs better than 10 years ago; 2 = occasionally performs the task worse but not all of the time; 3 = consistently performs the task a little worse than 10 years ago; 4 = performs the task much worse than 10 years ago; 5 = participant/caregiver does not know) [15]. The ECog ratings cover multiple cognitive domains, including language, memory, visual spatial ability, and executive function, including planning, organization, and divided attention. The BNT is a language function test sensitive to both aphasia and object recognition deficit with a maximum score of 30 points. The RAVLT is a test for episodic memory to recall a list of words immediately after presentation and recall and recognize the words after a 30-minute delay interval [16].

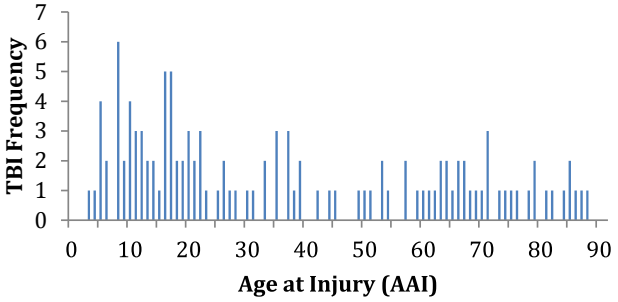

Fig. 1. The AAI showed a bimodal distribution. Abbreviations: AAI, age at injury; TBI, traumatic brain injuries.

2.4. Statistic analysis and figures

Two-way analysis of covariance was used to compare ECog ratings and cognitive performance on the BNT and RAVLT between the cTBI and aTBI groups, using AAI and baseline diagnosis as independent variables. Baseline age, gender, and education were controlled as potential confounding factors. A multivariate analysis of covariance (MANCOVA) model was used to compare ECog performance in different domains between the cTBI and aTBI groups. Results are shown in the form of mean $\pm$ standard error, and $P < .05$ is considered as significant for all statistical analyses with SPSS (version 23.0; IBM Corp., Armonk, NY, USA). Figures were created using Microsoft Excel or SigmaPlot (version 10.0).

3. Results

3.1. The AAI shows a bimodal distribution

In this study, the average lag time was 39.21 $\pm$ 23.07 years (n = 119), which refers to the delay between the sustaining time of TBI and the cognitive assessment time. The AAI of all participants with TBI showed a typical bimodal distribution. The first peak appeared in the

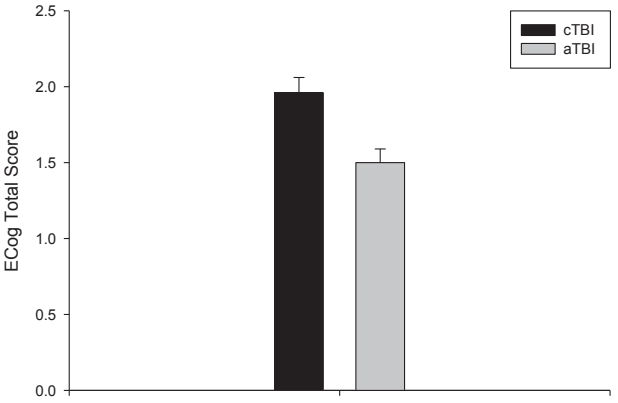

Fig. 2. The AAI affected the ECog total score. The cTBI group had a higher ECog total score than the aTBI group. Abbreviations: aTBI, adult TBI; AAI, age at injury; cTBI, childhood TBI; ECog, everyday cognition.