ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96:1411-8

ORIGINAL RESEARCH

Executive Functioning and Suicidal Behavior Among Veterans With and Without a History of Traumatic Brain Injury

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Abstract

Objective: To examine the relationship between executive dysfunction, as a multidimensional construct (ie, decision-making, impulsivity, aggression, concept formation), and suicide attempt (SA) history in a high-risk sample of veterans with moderate to severe traumatic brain injury (TBI).

Design: Observational, 2×2 factorial design. To estimate group differences, linear regression was used to model the primary and secondary outcomes of interest as a function of history of SA, TBI, and the interaction between the 2 variables. Additionally, to determine the pattern of performance over the course of the Iowa Gambling Test (IGT), scores were modeled across the 5 IGT blocks by using a varying-coefficient model.

Setting: Veterans Health Administration.

Participants: Veterans (N=133; no SA/no TBI, n=48; no SA/yes TBI, n=51; yes SA/no TBI, n=12; yes SA/yes TBI, n=22) completed the study measures.

Interventions: Not applicable.

Main Outcome Measures: IGT, Immediate and Delayed Memory Test, State-Trait Anger Expression Inventory-2, Wisconsin Card Sorting Test.

Results: All groups demonstrated learning over the course of the IGT, except for veterans with a history of both SA and TBI. No group differences were identified on other measures of executive functioning.

Conclusions: These findings highlight the potential, unique decision-making challenges faced by veterans with a history of TBI and SA. Specialized interventions focused on overall distress reduction and means restriction may be required to prevent future self-directed violence.

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Individuals with a history of traumatic brain injury (TBI) have higher rates of suicide attempts (SA) and death than members of the general population.[1,2] In a recent systematic review, Bahraini et al[3] identified 16 studies on the prevalence of suicidal ideation (SI), SA, and suicide death among those with TBI. Despite robust evidence supporting the link between TBI and suicide death,[3] findings highlighted the continued dearth of evidence regarding SI and SA. Less rigorous reviews suggest that existing evidence regarding risk factors is also sparse, particularly in regard to SA.[4] In a recent study[4] of adults admitted to the hospital after mild to severe TBI, 25% reported SI in the year postinjury. Predictors of SI included having Medicaid insurance, a higher self-reported postinjury depression,[5] a history of psychiatric disorders, and prior SA or

Presented to the World Congress on Brain Injury, March 24, 2012, Edinburgh, Scotland; the American Psychological Association, August 1-4, 2013, Honolulu, HI; and the World Congress on Brain Injury, March 20, 2014, San Francisco, CA.

Supported by the Veterans Health Administration Rehabilitation Research and Development Merit Review (grant no. D7210R) and the Rocky Mountain Mental Illness Research, Education, and Clinical Center. The views, opinions and/or findings contained in this article are those of the author(s) and should not be construed as an official Department of Defense or Veterans Affairs position, policy, or decision unless so designated by other documentation.

Investigator(s) adhered to the policies regarding the protection of human subjects as prescribed by Code of Federal Regulations.

This article conforms to applicable governmental regulations and discipline-appropriate ethical standards.

Disclosures: none.

0003-9993/15/$36 - see front matter © 2015 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2015.04.010

psychiatric hospitalization(s).[4] The severity of TBI and a history of substance abuse have also been noted as risk factors for suicide death.[2] Recently, Fazel et al[6] identified a 3-fold increase in the odds of suicide death among those with TBI. Psychiatric disorders and substance abuse were noted as risk factors.

In individuals with no neurologic history, executive dysfunction and SA have been linked.[7-9] Using the Iowa Gambling Test (IGT)[10] to measure decision-making, Jollant et al[8] noted differences in performance between individuals with histories of SA and healthy controls, and those with violent SA histories and affective controls; in both cases, adults with SA demonstrated more pronounced executive dysfunction. IGT performance[10] was also positively correlated with anger expression,[11] but was not correlated with self-reported impulsivity.[12] The authors suggested the link between decision-making and impulsivity required further clarification, and that using laboratory-based measures may be necessary. In line with this, Dougherty et al[7] used a laboratory-based measure of impulsivity, the Immediate and Delayed Memory Task (IMT/DMT),[13] to examine the relationship between impulsive responses and number of SA.

Taking an alternate approach, Keilp et al[9] employed neuropsychological measures used in clinical practice to examine performance among those with high-lethality SA, low-lethality SA, depressed controls, and comparison subjects. On the Wisconsin Card Sorting Test (WCST),[14] which measures concept formation, the inability to use previously successful strategies differentiated those with high-lethality SA from all other groups. In a follow-up study, those with high-lethality SA, most of whom used nonviolent methods, outperformed other depressed groups on an object alternation test. The authors proposed that this was linked to the function of the ventral prefrontal cortex (PFC), an area of the brain critical for decision-making.[15,16] This finding was unexpected in that nonpatients and those with a history of high-lethality SA showed the lowest error rates across test blocks. The authors concluded that ventral PFC dysfunction may not be characteristic of all individuals with SA, particularly those with more "carefully planned, nonviolent, though potentially lethal"[15(p129)] attempts.

To develop a neurocognitive model underlying suicidal processes, Jollant et al[17] conducted a review of studies focused on self-directed violence (SDV) and neuroanatomic and cognitive dysfunction. Areas identified included the ventrolateral PFC; the anterior cingulate gyrus; the dorsomedial PFC; the dorsolateral PFC; the amygdala and medial temporal cortex; high attention to specific emotional stimuli; impaired decision-making; lower problem-solving abilities; reduced verbal fluency; nonemotional attention; and reversal learning. The authors suggested that these areas of dysfunction can result in suicidal crises secondary to (1) value attribution (eg, increased sensitivity to others and the environment); (2) reduced regulation of emotional and cognitive responses (eg, poor problem-solving skills, lack of cognitive flexibility); and (3) facilitation of suicidal acts in emotional contexts (eg, impulsivity or challenges associated with disinhibiting behavior).[17]

Areas of cognitive dysfunction implicated in suicidal SDV among nonneurologic populations are characteristic of cognitive impairments after TBI. Frontal systems and corresponding executive functions, such as problem solving, emotional regulation, and inhibition, are particularly vulnerable to TBI. Deficits in these areas are associated with a host of functional problems including difficulties with decision-making, coping with stressors, relating to others, and adapting to life circumstances.

Preliminary studies in this area examined executive dysfunction (eg, self-reported impulsivity, aggression) as 1 risk factor for SDV in those with TBI.[18,19] Yurgelun-Todd et al[20] evaluated relationships between the integrity of frontal white matter systems and measures of impulsivity and SI among veterans with and without TBI. Significantly decreased fractional anisotropy values in the left cingulum and left and total genu were observed in the TBI group, as were higher levels of impulsivity. Additionally, total and right cingulum fractional anisotropy values were positively correlated with current SI and impulsivity. Finally, Homaifar et al[21] conducted a pilot study exploring the relationship between executive dysfunction and SA among 47 veterans with mild to severe TBI, with and without a prior SA. Between-group performance was evaluated on the IGT,[10] IMT/DMT,[13] WCST,[14] and Lifetime History of Aggression Scale.[22] Only WCST perseverative error T-scores significantly differentiated veterans with and without an SA history.

This study was designed to further this line of research by exploring the relationship between executive dysfunction—as a multidimensional construct comprising laboratory-based decision-making, laboratory-based impulsivity, anger expression, and concept formation—and SA among veterans. Based on expectations regarding performance variability within cohorts, a planned exploratory aim included modeling IGT scores for each of the 4 groups to assess patterns of decision-making. Primary and secondary hypotheses were that the effect of SA on decision-making (IGT) would depend on TBI history (none or moderate/severe TBI); and that the effect of SA on impulsivity (IMT/DMT), aggression (State-Trait Anger Expression Inventory-2), and concept formation (WCST) would depend on TBI history (none or moderate/severe TBI).

List of abbreviations:

DMT	**Delayed Memory Test**
IGT	**Iowa Gambling Test**
IMT	**Immediate Memory Test**
PFC	**prefrontal cortex**
SA	**suicide attempt**
SDV	**self-directed violence**
SI	**suicidal ideation**
TBI	**traumatic brain injury**
WCST	**Wisconsin Card Sorting Test**
VHA	**Veterans Health Administration**

Methods

Sample

The study protocol was approved by the local institutional review board. All participants provided informed consent. An observational 2×2 factorial design was used to investigate relationships between executive functioning, SA, and TBI. Groups included those with a history of moderate to severe TBI only, those with an SA history only, those without a history of moderate to severe TBI or SA, and those with both SA and TBI. Recruitment occurred between 2010 and 2014 within Veterans Health Administration (VHA) inpatient and outpatient settings and the larger community.

Measures

The IGT[10] is a computerized measure designed to assess aspects of executive functioning as they relate to real-world functioning.