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Prospective memory in patients with closed head injury: A review☆

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ABSTRACT

This paper aimed to review the limited, but growing literature on prospective memory (PM) following closed head injury (CHI). Search of two commonly used databases yielded studies that could be classified as: self- or other-report of PM deficits; behavioral PM measures in adults with CHI, behavioral PM measures in children and adolescents with CHI, and treatment of PM in adults with CHI. The methodology and findings of these studies were critically reviewed and discussed. Because of the small number of studies, meta-analysis was only conducted for studies that used behavioral PM measures in adults to integrate findings. PM deficits were found to be commonly reported by patients with CHI and their significant others and they could be identified using behavioral measures in adults, children and adolescents with CHI. However, more work is needed to clarify the nature and mechanisms of these deficits. Although some promising results have been reported by studies that evaluated PM treatment, most studies lack tight experimental control and used only a small number of participants. The paper concluded with some suggestions for future research.

1. Introduction

Traumatic brain injury (TBI) refers to an acquired brain injury resulting from closed head injury (CHI), penetrating missile wounds, exposure to blast, or some combination of these mechanisms. TBI is by far the most common cause of acquired brain injury in civilians with 1.7 million new cases annually in the U.S. (Faul, Xu, Wald, & Coronado, 2010). Cognitive and behavioral sequelae of TBI are the primary determinants of disability in about three quarters of adults who suffer long term limitations of activities and are unable to fully resume their roles in society (Jennett, Snoek, Bond, & Brooks, 1981; Langlois, Rutland-Brown, & Wald, 2006). The focus of this review is on CHI associated with sudden acceleration or deceleration of the freely moving head in civilians, because this type of injury accounts for more than 95% of occurrences of TBI in civilians (Faul et al., 2010).

Mechanisms of TBI due to CHI include motor vehicle crashes, falls, assaults, and sports-related injuries. These typically impart direct or indirect impact and rotational movement to the brain resulting in focal lesions such as contusions to brain regions such as orbital frontal cortex and the temporal pole that are proximal to bony protrusions of the inner table of the skull. Shear strain at the time of injury can stretch or tear axons, which may undergo progressive damage over time due to secondary insults such as release of excitotoxic neurotransmitters, inflammation, and free radicals, followed by Wallerian degeneration causing disconnections among brain regions (Povlishock & Katz, 2005). Small hemorrhagic lesions and demyelination also contribute to white matter injury following CHI. Gray matter injury results from contusions, hypoxic-ischemic insult and other secondary injury. Hippocampus is a gray matter structure that is especially vulnerable to CHI, often showing volume loss on magnetic resonance imaging (MRI), performed months or years post-injury (Wilde et al., 2007), and in neuropathology studies (Kotapka, Graham, Adams, & Gennarelli, 1994). The severity of these focal and diffuse pathological processes among patients with CHI is heterogeneous (Saatman et al., 2008), resulting in marked inter-individual variation in the effects of CHI on cognitive processes such as attention, memory, and executive function. (Dikmen et al., 2009; Levin, Benton, & Grossman, 1982).

Declarative memory (i.e., conscious recall of facts and events) deficit disproportionate to relatively recovered intellectual function is a frequent sequel of CHI, with memory impairments

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persisting in about one quarter of patients sustaining moderate to severe TBI (Goldstein & Levin, 1995; Levin & Hanten, 2002). These findings are based largely on a subtype of declarative memory called retrospective memory (RM; i.e., retention and recall of previously learned information) rather than another subtype termed prospective memory (PM). PM is defined as the encoding, storage, and delayed retrieval of intended actions and is a relatively new type of memory that has only gained attention and interest in the clinical and experimental literature in the last 20–30 years (Kliegel, McDaniel, & Einstein, 2008). It is considered to be instrumental for performing everyday activities such as remembering to take medications, keeping appointments, completing tasks at work, and assignments at school (Shum, Fleming, & Neulinger, 2002). Given its close relationship with everyday functioning, impaired PM after CHI is considered to contribute to disability and limits participation in self-care, community, and occupational activities, thus providing a rationale for assessment and rehabilitation efforts (Fleming, Shum, Strong, & Lightbody, 2005).

A plausible mechanism for PM deficit is disruption of white matter connections by axonal injury, given that PM-related activation involving the frontal pole (BA10) is consistent across PET studies (Burgess, Qualye, & Frith, 2001; Okuda et al., 1998) and emerging evidence from fMRI studies that also supports participation of the dorsolateral, ventrolateral, and orbital frontal regions in addition to parietal cortex (Reynolds, West, & Braver, 2009; Simons, Schölvinck, Gilbert, Frith, & Burgess, 2006). This postulated disconnection effect has also received support from McCauley, Wilde, et al. (2010) who reported a relation between compromised integrity of white matter connections on diffusion tensor imaging (DTI) and PM deficit in children following moderate to severe CHI. Taken together, the extant functional imaging and DTI literature is consistent with a frontal pole-guided neural network supporting PM (also see Okuda et al.'s paper in this special issue).

In contrast to an extensive literature on assessment and interventions for RM deficit in patients with CHI (see Goldstein & Levin, 1995; Levin & Hanten, 2002; Vakil, 2005; Wilson, 2002), comparatively few studies have investigated the effect of these injuries on PM. This is understandable given the short history of PM but surprising considering that PM difficulties are reported by patients with CHI and their significant others as a frequent and significant problem (Hannon, Adams, Harrington, Fries-Dias, & Gipson, 1995; Roche, Fleming, & Shum, 2002). Consequently, the primary aim of this paper is to report a review on the limited, but growing literature on PM following CHI. Specifically, it aims to identify studies that have been conducted in this area, group them according to types, and critically review their methodology and findings. Where a sufficient number of studies was available in a group, meta-analysis was used to integrate the findings. Finally, this review aims to identify gaps and suggest directions for future research in this emerging but important clinical research area.

2. Literature search

Identifying relevant articles to be included in the current review involved two steps. First, SCOPUS was searched for articles with the terms: "brain injury" AND "prospective memory"; "head injury" AND "prospective memory" in their titles, abstracts or keywords. The time period searched was from "All Years" to 10 July 2010. In addition, Web of Science® was searched for articles with the same terms in their topics. The time period searched was from 1900–1914 to 10 July 2010. We decided to use the terms "head injury" and "brain injury" rather than "traumatic brain injury" and "closed head injury" so as not to miss any relevant articles that might have used the more general terms in their articles. Second, the reference lists of the resulting articles from the SCOPUS and Web of Science® searches were perused for relevant additional articles to ensure none were missed in the database search.

Of the 100 articles found, 70 were deemed unsuitable for the current review because: (1) their samples consisted of patients with other types of brain injury or consisted of a mixture of patients with CHI and patients with other aetiologies without reporting results separately; (2) their samples consisted of only normal individuals without brain injury; (3) they were either review articles or conference abstracts that examined PM in patients with CHI; and (4) PM was only briefly mentioned and not directly measured or researched in their studies. The remaining 30 articles can be grouped into four types: studies that asked patients with CHI (adult, children and adolescents) to self-report or their relatives to report PM deficits (a total of 4); empirical studies that used behavioral measures to examine PM impairments in adults (14); empirical studies that used behavioral measures to examine PM impairments in children and adolescents (5); empirical case or group studies that evaluated the effects of intervention on PM impairments in patients with CHI (adult, children and adolescents) (7). As expected, the first step of this review indicated that only a relatively small number of studies have been conducted on PM and patients with CHI. In the next sections, these studies are reviewed according to the four groups. Given the relatively small numbers in three of the four groups, meta-analysis was undertaken only for the empirical studies that used behavioral measures to examine PM impairments in adults with CHI.

3. Studies using self- or other-report

Details of the five studies included in this group are summarised in Table 1. Of these, four were conducted on adults with CHI and one (viz., Ward, Shum, Dick, McKinlay, & Baker-Tweney, 2004) on children and adolescents. The four adult studies all used self- and/or other-report questionnaires to evaluate whether patients with CHI have significantly more PM problems than controls. Mateer, Sohlberg, and Crinean (1987) developed a 30-item everyday memory functioning questionnaire that covered six memory domains (viz., anterograde episodic, anterograde semantic, retrograde episodic, retrograde semantic, working memory, and PM). They found that individuals with and without CHI reported more PM failures than other types of memory. Hannon et al. (1995) used the Prospective Memory Questionnaire (PMQ) in their study. The PMQ is a 52-item questionnaire that has four PM subscales: long-term episodic, short-term habitual, internally cued, and techniques to remember. Hannon et al. found that the ratings of 15 patients with CHI were significantly different from those of 114 controls on one of the subscales (viz., short-term habitual) of the PMQ. Roche et al. (2002) used the Comprehensive Assessment of Prospective Memory (CAPM) in their study. The CAPM is a 39-item questionnaire that can be used by self and significant others to indicate the frequency of occurrence of various PM deficits during the previous month. The items include both basic and instrumental activities of daily living (ADL). Roche et al. (2002) did not find their patients with CHI and controls to be significantly different in the mean frequencies of self-report PM deficits on either the basic or instrumental ADL. However, the significant others in their study reported significantly more PM problems for both the basic and instrumental ADL scales than the significant others of the controls. According to Roche et al., these conflicting findings are likely to be due to the commonly found self-awareness difficulties in patients with CHI (Fleming, Strong, Ashton, 1996).

In a later study, Roche, Moody, Szabo, Fleming, and Shum (2007) explored the perceived reasons of PM forgetting by patients with CHI and their significant others by using Section C of the CAPM. This section has 15 items and covers five phases of PM (viz., formation