Critical Review:

Does having a traumatic brain injury during childhood affect literacy outcomes?

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This critical review examined the impact of traumatic brain injury on reading outcomes in children ages 3-15. Study designs included cohort studies, longitudinal cohort studies, mixed nonrandomized clinical trials, a longitudinal mixed nonrandomized clinical trial, a retrospective cross sectional study, and a case control study. Overall, the evidence suggested that traumatic brain injuries during childhood negatively affect literacy outcomes.

Introduction

Approximately one million injuries are reported to the central nervous system per year, with an overall prevalence of traumatic brain injury (TBI) ranging from 180-220 per 10 000 children (Blosser & DePompei, 2003). There is a prevailing view that childhood brain injury is not detrimental to later functioning and that early injury can be recovered from both rapidly and to near completion (Ewing-Cobbs & Barnes, 2002). This false belief may have negative effects upon the academic setting in which a child is placed, the treatment that a child receives, and the support that is available to a child with a brain injury. Literacy skills are imperative to academic success, especially as the student transitions from learning-to-read to reading-to-learn in the primary years of school. Difficulties in literacy can have lasting and profound effects upon the individual in the areas of academic, social, and vocational success (Ewing-Cobbs & Barnes, 2002). Since successful literacy skills can have such long-lasting and far reaching effects upon an individual's life, it is important to determine if and how TBI affects literacy outcomes in children. These findings could lead to raising awareness regarding the impact of TBI on child literacy and result in a greater focus on the support of functional literacy skills in treatment and educational goals.

Objectives

The primary objective of this paper is to critically evaluate the existing literature regarding the impact of childhood TBI on literacy outcomes. The secondary purpose is to discuss the clinical implications of these findings and propose suggestions for future research.

Methods

Search Strategy

Computerized databases, including CINAHL, Scopus, PubMed, and PsychINFO were searched using the following search parameters: ((brain injury) OR (traumatic brain injury)) AND ((reading outcomes) OR reading) OR (reading comprehension) OR (literacy)) AND (children).

Selection Criteria

Studies selected for inclusion in this critical review paper were required to investigate the reading outcomes of children with TBI on standardized tests of reading comprehension and/or reading fluency.

Data Collection

The results of the literature search yielded the following study designs: cohort study, longitudinal cohort study, mixed nonrandomized clinical trial, longitudinal mixed nonrandomized clinical trial, retrospective cross sectional study, and case control study

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Results

Cohort Study#1. Barnes, Dennis, and Wilkinson (1999) investigated the possible risk for reading decoding accuracy and reading comprehension difficulties in 55 children with closed head injuries, recruited from a head injury database at the Hospital for Sick Children. Children were categorized into three groups according to age at injury: before 6.5 years (before basic word decoding skills are acquired), from 6-9 years (while reading decoding and comprehension skills are being acquired), and after 9 years of age (after decoding and some reading comprehension skills are acquired). The Woodcock Reading Mastery Test-Revised was administered for reading decoding and comprehension.

Multiple regressions indicated that age-at-injury had a significant effect upon reading decoding and reading comprehension. ANOVA for group effects revealed that there was a significant effect of age-at-injury on reading decoding. Post hoc tests indicated that children injured before 6.5 years had lower word decoding scores than those injured after this age. A significant effect of age-at-head injury on passage comprehension was found, with children injured after age 9 identified

as having higher reading comprehension scores than children being injured before 9 years of age.

Laterality of contusional damage was investigated using CT reports, with groups divided into left, right, and bilateral contusions, or mild-moderate noncontusion. Laterality had a significant effect upon reading decoding, with left-sided having lower scores than right-sided lesions or mild-moderate injuries. Bilateral lesions had lower scores than right-sided lesions on reading decoding. For reading comprehension, a trend for laterality was observed, with left-sided and bilateral contusions having poorest outcomes.

Comparison across brain injury severity and age made the absence of a control group appropriate and participants were well selected and identified. Examinations were conducted using the Woodcock Reading Mastery Test Revised, a gold standard in the field for assessing reading comprehension and decoding. Statistical analyses were clearly described for the reader and appropriately compared groups for differences, with the use of post hoc tests to help to correct for multiple comparisons. This study Level II provided compelling evidence to suggest that childhood brain injury has negative effects on literacy outcomes, especially for those injured at a younger age and found to have a left-sided lesion.

Cohort Study #2. Barnes, Dennis, and Wilkinson (1999) studied 43 head injured children chosen from the previous study, and 43 normally developing non-head injured controls for reading decoding and fluency of decoding skills. Participants were pair-wise matched for age-at-test, grade, sex, word recognition accuracy, and phonological coding or spelling-sound translation. In order to match participants for word decoding accuracy only, groups were tested for oral vocabulary and reading comprehension. *t* tests confirmed that there were no differences. Decoding speed was tested for with real words and nonwords. ANOVAs compared the head injured and control groups and identified head injured children as slower at naming all types of words, despite showing no difference in error rates.

Barnes et al. (1999) indentified and selected participants in a rigorous manner to ensure that groups were initially well-matched. A control group compared children with TBI to the norm. A study limitation included the use of word tests taken from stimuli presented in other research works and not from standardized tests. The statistical methods implemented were appropriate. This level II study provided compelling evidence that reading decoding outcomes are reduced in childhood TBI.

Longitudinal Cohort Study#1. Ewing-Cobbs et al. (2006) conducted a study that reported on academic outcomes, including reading, on an average of 5 years post-injury, in 23 children who sustained a TBI before the age of 6. A control group of 21 children were selected for comparable socio-demographic background, age at assessment, sex, ethnicity, grade level, and access to financial and social resources. Intelligence was the only variable assessed multiple times longitudinally. Results of IQ testing indicated a persistent and significant deficit amongst the TBI group. Reading was assessed using the Woodcock Johnson III and Gray Oral Reading Tests, 4th edition. *T* tests revealed that children with TBI scored significantly lower than the control group on all reading measures, except for reading fluency. In connected written text, the TBI group scored significantly lower on decoding accuracy, reading speed, and comprehension. The TBI groups were significantly more likely to experience unfavourable academic outcomes, such as failing a grade or special education.

Multiple regressions indicated that word decoding scores were predicted by group membership and family resources. Pearson correlation coefficients revealed that age-at-injury was negatively correlated with letter-word identification and reading fluency; that Glascow Coma Scale scores were positively correlated to word attack, reading fluency, and oral comprehension, but that the duration of impaired consciousness was negatively correlated with reading, fluency, and oral comprehension. Academic achievement scores (word decoding, reading fluency and comprehension) were lower in the TBI group. Basic skills (word decoding) and academic reasoning tasks that required reading and language comprehension were difficult for the TBI group. Fluency was reduced in all areas, which indicated a slowed processing speed for decoding and producing written text.

This Level II study provided valid information in the gathering of participants. A larger sample size would have been preferred. The control group provided the opportunity to comment on childhood TBI impairments in comparison to the norm. Upon critical evaluation of this study, the tests used were both valid and appropriate for evaluating reading performance. Longitudinal assessment of just IQ is a limitation of the study. Statistical methods, while appropriate, were presented in a confusing manner. Overall, the material would be considered compelling in showing that children with TBI have significantly poorer literacy outcomes than the norm.

Longitudinal Cohort Study #2. Hanten, Li, Newsome, et al. (2009) compared 173 children with TBI (mild,

moderate, severe), aged 5-15, on five occasions over the course of two years post-injury in order to assess for reading and expressive language outcomes.

The Gray Oral Reading Test-3rd Edition was conducted for reading comprehension, while the Woodcock Johnson Tests of Achievement III was administered for word decoding and accuracy. The test of Rapid Automized Naming was used to name common objects, as it has been identified as a strong predictor of reading ability. Spoken Nonword Discrimination was conducted to assess for phonological discrimination of nonwords.

Analysis of variance for continuous variables indicated that reading comprehension was significantly lower in the more severe groups, in the cases of lower socioeconomic status, with earlier age-at-injury, although younger children showed better recovery. Rate and accuracy of reading did not differ significantly amongst injury severity groups, but SES was indicated as a significant factor. Age-at-injury affected recovery, with younger children initially more impaired at injury, but had a faster rate of recovery. It was concluded that higher-level literacy processes, present in older children, are more vulnerable to TBI.

Critical evaluation of this Level II study revealed that a sufficient sample size was used. However, the lack of a non-brain-injured control group presented as a limitation to this study. The procedures and tests conducted and the statistical calculations performed were valid and well documented. The longitudinal aspect of the study allowed for the analysis of the long-term effects of TBI upon children, a component missing in some studies in the field. Such information should be deemed compelling in considering the contribution of severity of childhood TBI upon reading comprehension and higher-level literacy processes across time, which has been indicated as being vulnerable to TBI.

Retrospective Cross Sectional Study #1. Hanten et al. (2009) compared age-at-injury to injury severity. From medical records or previous participation in TBI studies, 135 children were recruited. Participants, grouped by severity (mild, moderate, severe), sustained a TBI at least two years prior to the study. Groups did not differ in mean age at test or injury, or interval, but those with mild TBI tended to have higher SES.

Analysis of variance for continuous variables indicated that the mild group had the highest reading comprehension, rate, and accuracy scores. Those with the older age-at-injury and longer interval between injury and testing performed best within each injury severity group.

This study provided an adequate sample size, but lacked a non-brain injured control group to assess for developmental and practice effects. Despite this, the statistical methods and results provided compelling evidence on the effects of childhood TBI reading and support that TBI has negative effect upon reading for those who are young and have more severe injuries.

Mixed Nonrandomized Clinical Trial #1. Catroppa and Anderson (1999) studied 69 children with a closed head injury occurring between ages 8-12, grouped according to injury severity (mild, moderate, or severe). Severity was based on Glascow Coma Scale scores, post-traumatic amnesia time, and neurological and radiological findings. Children were studied at 0-3, 12, and 24 months post-injury. Parents and teachers filled out questionnaires, and children were tested for reading, in addition to spelling and arithmetic skills using the Wide Range Achievement Test – 3.General intelligence and listening comprehension were also tested for.

The Vineland Adaptive Behaviour Scale, the Rowe Behavioural Rating Inventory, and a medical questionnaire assessed pre-injury daily functioning, medical conditions, reading accuracy, reading comprehension, spelling, arithmetic, attention, and restlessness. ANOVA and Chi-square showed no significant pre-injury differences between groups. Repeated measures ANCOVA, co-varying for pre-injury reading levels, revealed a significant main effect for group, with post hoc analysis revealing a significant difference between mild and moderate TBI groups at 12 and 24 months post-injury on reading accuracy scores. The mild TBI group achieved the highest scores. A significant difference was found for the severe group in their ability to process verbal information, extract meaning, and answer comprehension questions. Stepwise multiple regressions showed that reading accuracy was predicted by pre-injury reading accuracy and verbal IQ, as measured by The Wechsler Intelligence Scale for Children – 3rd Edition. Reading comprehension was best predicted by verbal IQ alone. Findings suggested that a child's pre-injury skill level in reading affected these skills two years post-TBI, therefore indicating that reading skills are resilient following TBI. Since head injury is likely to affect the acquisition of skills not yet acquired, reading and spelling may be relatively resilient in the age group studied, since such skills had already been established.

Participants were well selected for this study. Testing, while sufficient for reading accuracy, was not acceptable for reading comprehension. Although reading comprehension was stated as a measured variable, the study only tested and reported on listening comprehension. As such, information reported on

reading comprehension should not be interpreted as valid. Statistical analyses were valid and compelling for reading accuracy in relation to educational difficulties experienced by children with TBI.

Mixed Nonrandomized Clinical Trial # 2. Catroppa et al. (2009) examined educational skills, including reading accuracy, spelling and arithmetic, in 84 children who had sustained mild, moderate or severe TBI at young (3-7 years) and old (8-12 years) ages. Different age groups were tested to determine if age-at-injury had an effect on educational outcomes. The Vineland Adaptive Behavior Scale assessed pre-injury functioning. Intelligence was assessed using The Wechsler Preschool and Primary Intelligence Scale – Revised or the Wechsler Intelligence Scale for Children – III, in addition to Full Scale IQ. The Wide Range Achievement Test – 3 assessed word reading, spelling and arithmetic skills as indicators of academic performance, at 2 and 7 years post-injury.

Appropriate statistical analysis included ANOVA, ANCOVA, chi-square, and multiple regressions. A significant difference was found between the young and old group for age-at-injury. The mild TBI groups had significantly higher IQ scores, while age did not affect IQ. The old TBI groups performed significantly better on reading performance and arithmetic, with no significant interactions between the two. Full Scale IQ was the only significant long-term predictor of reading accuracy, spelling, and arithmetic. Findings suggest that acute intellectual ability contributes to the long-term outcome of reading, and other educational outcomes, with the poorest performance likely to be observed in the case of children with severe TBI. Younger age-at-injury was associated with more compromised intellectual abilities, indicating more vulnerability to TBI. With word reading, the old TBI group performed significantly better the young group, suggesting that these skills may have been acquired prior to injury and were therefore less vulnerable to the effects of TBI.

Statistical methods were thorough and appropriately interpreted in this Level II study. A small sample size was indicated as a limitation to the interpretation of results presented. Despite this, the information provided was compelling in suggesting that both severe and early age brain injuries result in poor reading outcomes.

Longitudinal Mixed Nonrandomized Clinical Trial #1. Ewing-Cobbs, et al. (2004) conducted a study to evaluate the change in academic achievement scores over a 5-year follow-up in 77 children with TBI, ranging in age from 5-15 years at the time of injury. Participants were tested a minimum of three (up to six) occasions. Groupings were made according to severity of TBI (mild-moderate and severe) and age-at-injury (5-7, 8-12, and 12-15 years). The WRAT Reading Recognition subtest measured phonological processing and fluency of word retrieval. Reading comprehension was measured using the Reading Comprehension subtest from the Peabody Individual Achievement Test and the WRAT's Reading Recognition subtest. Comprehension was also based on measures of receptive vocabulary and auditory working memory.

Word-decoding scores were lowest for the severe group. Scores increased over the follow-up time for all groups, with greater increases for those injured at a later age, but then decelerated over time. At three years follow-up, scores for all severity groups were lowest in children aged 5-8 at injury. Reading comprehension scores were significantly lower for the severe TBI group, especially those injured at an older age. However, reading comprehension for the group as a whole did not differ from the norm. Hierarchical regression models revealed that coma duration and SES only predicted reading recognition. Word Fluency and Rapid Automatized Naming significantly enhanced prediction of word decoding, while reading comprehension was significantly related to the level of vocabulary development.

The lack of a control group to compare to children with TBI on longitudinal achievement scores was a study limitation. The authors stated that the reading comprehension measure was unable to assess reading speed, which has been identified as deficient and related to reading comprehension in children with TBI. As well, the reading comprehension measure failed to distinguish between literal and inferential comprehension or measure the ability to integrate information across text. Despite these limitations, this study provided longitudinal data, which is important when TBI consequences may not manifest themselves until several years following the injury. Statistical methods were thorough, and despite the limitations of the standardized tests, the information provided was compelling in supporting that children with early age injuries and severe TBI have poor literacy outcomes.

Case Control Study #1. Hawley, Ward, Magnay, & Mychalkiw (2004) assessed classroom performance in 67 children aged 5-15 years who had sustained a mild, moderate, or severe TBI. Children were matched for age, sex, and social background to an uninjured control group. Semi-structured questionnaires were filled out by parents and teachers. The Wechsler Objective Reading Dimensions was administered to compare reading age with chronological age (CA). At a mean of two years post-injury, over half of the TBI pupils were reading at least one year below their chronological age

and over one-third were at a level two or more years below their CA. There were no significant differences between the TBI severity groups. Hawley et al. (2004) reported that teachers were rarely aware of the presence of a brain injury and when they were, they were unaware of the possible long-term effects. As a result, it was reported that special educational assistance was provided in very few cases.

A strength of this study included its use of a control group, important for determining the severity of deficits in reading of children with TBI. This study, however, failed to provide information on the statistical methods conducted. It stated that SPSS was used to compute the numbers that were provided, but did not go any further into discussing the statistical analyses. The authors did not acknowledge or address any limitations of the study, thereby failing to provide implications for further, more informative research. Overall, due to statistical reporting, this study would be considered suggestive in supporting that children with TBI have deficits in reading.

Discussion

Overall, the critical appraisal of relevant research material suggests that reading outcomes in childhood TBI are negatively impacted following brain injury.

The research indicates that academic scores, including reading, are lower in children with TBI when compared to non-injured peers. The areas of word decoding, reading fluency, and reading comprehension have all been noted as particular areas of weakness in these children (Ewing-Cobbs et al., 2006). This is particularly so for those injured in the early childhood years, since early TBI results in significant and persistent consequences in the development of the skills required for reading (Ewing-Cobbs et al., 2004). As both general intelligence and literacy are developing in the rapid stages of child development, these children are more vulnerable to TBI since such skills are less likely to have been consolidated before the injury.

In addition to age-at-injury, severity of injury is also predictive of TBI outcome, with children with moderate or severe injuries being the most likely to experience ongoing academic, reading, and expressive language difficulties (Catroppa et al., 2009). Hanten et al. (2009), however, found that only higher-level literacy processes (i.e., reading comprehension) were more vulnerable to TBI severity and that lower-level skills (i.e., reading accuracy and rate) were not affected by severity. Lesion location is another predictive factor for basic reading and word decoding outcomes, with children with a bilateral or left-sided lesion being at greatest risk for poor development of these skills. Slower decoding skills, identified in these children, indicates slower processing and has been implicated in disrupted comprehension (Barnes et al., 2009). These deficits can carry over into any task requiring reading decoding and the comprehension of language, and as such, are likely to have negative far reaching effects upon academic performance and future life success.

Recommendations for Future Research

Research involving children injured at different points after birth, but before formal reading instruction may be helpful in identifying early developmental origins of later reading disabilities. In particular, longitudinal research would be helpful in determining what developmental precursors of reading (i.e., phonological awareness, retrieval of visual symbols, naming visual patterns, reliability of naming, and retrieval of naming for known objects), if any, are affected by early TBI and how this may lead to the failure or poor acquisition of later word recognition and reading skills. Long-term research may also be used to track later educational outcomes and the vocational success of adults who experienced a childhood TBI. Finally, the interaction between the deficits in reading, cognition, executive function, memory, and attention deficits should be addressed.

Clinical Implications

From the implications of the current findings, it is imperative that early intervention be implemented. This is especially so in preschool-aged children, in order to minimize the impact of deficits and to help implement strategies to decode and comprehend written materials that will be encountered throughout the child's academic career. Findings indicate that it is important to determine pre-injury status in reading skills since it influences post-injury outcome. If skills were not consolidated before the injury, outcomes are likely to be poorer.

It is important that the assessment of children with TBI target emerging age-specific reading skills. Assessment must include skills related to early reading decoding and comprehension in order to identify likely weaknesses in the lexical, phonological, and fluency skills that are necessary for appropriate reading development and success. Deficits at the discourse level (i.e., inferencing, understanding of nonliteral language, and social language) must also be evaluated and addressed since these difficulties can also negatively affect comprehension of text and spoken language. Cognition, memory, and attention should not be

ignored, as they are all likely to also contribute to language and reading comprehension problems in TBI.

Treatment and follow-up of children with TBI is important in ensuring that these children receive proper educational assistance in school. Difficulties with quickly recognizing words, decoding, and reading comprehension may have consequences in the classroom and in test situations, with longer text and time constraints being especially problematic. Since it appears that near-normal brain recovery in young children is no longer a plausible argument, it is imperative that those most at risk are properly identified before difficulties become exacerbated. Speech-Language Pathologists play an imperative role in identifying these students and their difficulties, and in raising awareness of these difficulties to educators. The Speech-Language Pathologist needs to provide appropriate and functional goals and treatment in the school system so as to support these children in becoming successful readers and students.

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