Relationship between competency in activities, injury severity and post-concussion symptoms after traumatic brain injury

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Abstract

Objective: To determine to what extent injury severity and post-concussion symptoms after 3 months predict ability in activities 12 months after traumatic brain injury (TBI) and assess the frequency of problems in daily activities.

Methods: A one-year cohort of 63 persons with mild to severe TBI was assessed on admission, after 3 and 12 months. Injury severity was assessed using Glasgow Coma Scale, Abbreviated Injury Scale for the head and Injury Severity Score. Post-concussion symptoms were reported using Rivermead Post Concussion Symptoms Questionnaire after 3 months. Patient Competency Rating Scale (PCRS), a self-rating scale of ability in activities, was applied 12 months post injury. PCRS consists of the domains interpersonal/emotional and cognitive competency, and instrumental ADL. Multiple backward regression models were performed with the three subscales of PCRS as dependent variables.

Results: Activity-problems at 12 months were related to perceived cognitive and interpersonal/emotional competency. Post concussion symptoms reported at 3 months follow up were main predictors of cognitive and interpersonal/emotional competency at 12 months. Injury severity predicted only cognitive competency.

Conclusion: Symptoms evolving after the trauma seem to be the strongest predictor of perceived ability in activities in this population. This underlines the need for follow up after TBI to identify persons at risk of developing long-term activity limitations.

Introduction

Traumatic brain injury (TBI) is the leading cause of disability in people under the age of 40 (1). Blunt injury to the head may result in cognitive and behavioural deficit (2). The consequences of the damage vary according to location and severity, and time since injury (3) Hence, we wanted to study the burden of problems in daily living one year after TBI, and factors predicting these problems in a cohort of TBI survivors.

In the early phase after the TBI demographic and injury related factors affect the cause of recovery. Demographic factors including age are determinants for short term outcome (4). In addition, gender and alcohol addiction are of importance for the prognosis (5-7). Additional injuries to other parts of the body influence functioning in the early phase after TBI (8) . The causes of long-term impaired functioning and limitations in activities are multifactorial and often have a weak relationship to the severity of the head injury (9). Knowledge of factors that influence the course of recovery is valuable information when planning individual interventions and designing adequate rehabilitation programs. There is evidence that physical, cognitive and emotional symptoms may evolve after TBI and influence recovery (10). The most frequent symptoms are often termed post-concussion symptoms (PCS) and are among the major problems for people who have sustained mild TBI (11). One study found that symptoms gradually declined post-injury, but were correlated with self-rated disability in daily activities at 3 months after mild TBI (12). Stålnacke et al found a statistically significant association between dizziness and disability (13). Another frequent symptom reported after TBI is fatigue, which can be related to attention deficit and slower processing (14;15). However, there is lack of information regarding to what extent post-concussion symptoms predict long-term competency in daily activities.

Individuals that have sustained a severe TBI, have intracranial lesions that result in physical and mental impairment, causing problems with independent living skills (16). In the milder spectrum of TBI, problems with cognitive and emotional functioning dominate (17), causing limitations in complex daily activities, restrictions in social integration and participation. The non-physical symptoms of changes in cognition and emotions represent "invisible" problems, often underestimated by relatives and professionals (18). How these problems are experienced in daily life may preferably be captured by self-report. In TBI rehabilitation and research the use of subjective and activity-related ratings have been recommended (19). Limitations in activities may be captured by perceived changes in competency in essential areas of daily life. Competency is defined as the quality or extent of being competent (20) and is a standardized requirement for an individual to properly perform a specific task.

Thus, we hypothesised that post-concussion symptoms at 3 months, added to demographic factors and injury severity, predict the person's competency at one year post injury. We also aimed to assess the prevalence of perceived problems in competency in daily activities one year post injury.

Material and methods

Subjects

The target group comprised patients aged 16-60 years admitted to a metropolitan hospital, enrolled at the neurosurgical department with traumatic brain injury, and residing in the catchment area. Admission within 48 hours after the trauma was required. All included

patients had diagnoses in categories S06.0 to S06.9, according to the International Classification of Diseases version 10 (ICD-10). Over a 12 months period, from the middle of December 2000 to the middle of December 2001, 122 subjects (82 males and 40 females) were included. Four patients died in the acute phase, and 2 died within 6 months. The 116 surviving patients were invited to participate in the follow up at 3 and 12 months. Sixty-three of these signed the informed consent to participate and attended both. The study was approved by the Norwegian Regional Committee for Medical Research Ethics.

Procedures

Registrations were performed at admission and at 3 and 12 months after the injury. At admission, socio-demographic data, ethanol and drug influence were registered, along with the results of CT scan, clinical neurological deficits, Glasgow Coma Scale score (GCS), Injury Severity Score (ISS), Abbreviated Injury Scale (AIS) and post-traumatic amnesia (PTA).

At the follow-ups a standardized medical examination was performed by two senior physicians. The patients reported their symptoms according to the Rivermead Post Concussion Symptom Questionnaire (RPQ). A structured interview was conducted by 3 skilled occupational therapists in order to score the Patient Competency Rating Scale (PCRS).

Measurements

The Patient Competency Rating Scale (PCRS) (21) is a questionnaire assessing competency in daily life activities. It was originally designed to evaluate self-awareness of functioning in daily life after TBI. The validity and reliability of the scale for this purpose have been documented (22;23). The PCRS is a self-evaluation and may provide information on

perceived competency after TBI, like scheduling daily activities including work, participating in group activities and keeping appointments (23). The health professionals performed a structured interview where the patients were asked to score how easy or difficult it was to perform 30 specified daily tasks (24). Perceived competency was rated on a 5-point Lickert scale, 1=can´t do it, 2=very difficult to do it, 3=can do it with some difficulty, 4=fairly easy to do it, 5=can do it easily. According to a factor analysis (25), a sum score of 4 items was used for the domain of instrumental activities of daily living (IADL) (score range 4-20), 8 items for cognitive competency (score range 8-40) and 10 items for emotional and interpersonal competency (score range 10-50), see appendix for the included items.

The Rivermead Post Concussion Symptom Questionnaire (RPQ) is a reliable measure (26), which has been translated into Norwegian and consists of 16 items (Fig 1). The patients are asked to rate to which degree each item has been more of a problem than before the traumatic brain injury, rated on a 5 point Lickert scale: 0=not experienced at all, 1=no more a problem, 2=a mild problem, 3= a moderate problem, 4= a severe problem. No more of a problem "1" was recoded to "0" before summating the scores for all symptoms into a sumscore. A Rasch analysis has indicated that the RPQ comprises two underlying constructs (27). Thus the scores were calculated separately for the dimension of headache/dizziness/nausea, RPQhead (RPQh) and the 13 other, general symptoms, RPQ general (RPQgen) (also with score 1 recoded to 0).

The GCS score assesses the level of consciousness (28). The scale provides a score in the range from 3 to 15. The head injury was classified on admission as mild, moderate or severe, according to standard cut-offs for the GCS score (mild: 13 to 15, moderate: 9 to 12 and severe: 3 to 8). In 34 subjects, the GCS score was based on the score given on admission, or

pre-intubation values assigned at the site of injury. In 29 subjects, the GCS scores were assigned according to information in the medical record, describing the level of consciousness on admission.

The Abbreviated Injury Scale (AIS) version 98 was used (29). AIS classifies individual injuries by body region on a 6-point ordinal severity scale ranging from AIS 1 (minor) to AIS 6 (lethal). Subsequently, the total trauma profile was calculated by the Injury Severity Score (ISS). The ISS is the sum of the squares of the highest AIS code in each of the three most severely injured body regions (30), giving an ISS score from 0 to 75. In cases where at least one AIS severity code=6, an ISS of 75 is automatically assigned. In addition, AIS was calculated for the most severe head injury (AIShead) for all patients.

PTA was measured as time period for lost memory after the injury and based on information from the medical records and reported in the follow up consultation at 3 months post injury. The PTA time was categorized as none, less than 1 hour, from 1 to 24 hours, 1 day to 7 days and more than 7 days.

Data analysis and statistics

The study group was compared to the drop-outs regarding demographic factors and injury severity by independent sample t-tests and Mann –Whitney U analyses. Spearman correlation analyses between all the predictors; demographic factors (age, gender), alcohol/drug influence, injury severity (PTA, GCS, AIShead, ISS), RPQh and RPQgen were performed. RPQh and RPQgen correlated with rho>0.7 and were added separately in the analysis. The correlation for the other predictors was below 0.7. Backward regression analysis with probability <0.1 for removal was applied. Age, gender, alcohol/drug, PTA, GCS, AIShead and ISS were included in the preliminary models with PCRS emotional/interpersonal,

cognitive and IADL competency as dependent variables. All the analyses were performed by SPSS for Windows version 13.0.

Results

Patient characteristics, injury severity and symptoms at three months

Traffic accidents dominated among the injury causes (Table 1). More than 80 % of the patients had a mild TBI as evaluated by the GCS score. Sixteen per cent reported no PTA, 40 % below 1 hour, 22 % between one hour and 1 day, 13 % between 1 day and 1 week, and 9 % more than 1 week. The 53 drop-out subjects had a lower rate of employment (p=0.003) and fewer were married/cohabitant (p=0.018) compared to the 63 subjects attending follow up (Table 1). Injury causes and the impact of injury as evaluated by GCS on admission and ISS were similar in the study population and the drop-outs (Table 1). Persistence of post-concussion symptoms was reported in 47 of the 63 subjects at 3 months after the injury. Fatigue, forgetfulness and poor concentration were the most frequent symptoms reported to be more of a problem than before the injury (Fig. 1).

Insert Table 1 and then fig. 1 here

Competency in daily activities at 12 months follow-up

Forty-five of the 63 participants attending follow up reported problems in competency in at least one of the three dimensions of PCRS. Forty-three persons reported problems with emotional/interpersonal competency (median score= 4.8, range 2.8-5) and 37 subjects had problems with cognitive competency (median score 4.75, range 2.75-5). Only 21 persons reported problems with IADL competency. The results further showed that persons without problems in interpersonal/emotional competency, also had few problems with cognitive or IADL competency. Within emotional/interpersonal competency, problems with “staying

involved in work activities even when bored", and "keeping emotions from affecting my ability to go about the day's activities" were most frequently reported to be a problem. Within cognitive competency, "remembering important things to do" and "remembering last night's dinner" were frequently reported to be problems.

Relationship between the demographic factors, injury severity, post-concussion symptoms and competency in daily activities at 12 months follow up

None of the demographic or injury related factors came out statistically significant in the initial regression analyses. However, age, alcohol/drug, GCS, AIShead and ISS remained the best predictors in the different models and were kept for the final regression analyses, adding the two dimensions of the post-concussion symptoms (RPQh and RPQgen) separately for each of the 3 PCRS subscales.

RPQgen was a statistically significant predictor for all subscales of PCRS (Table 2). However, for PCRS cognitive competency, GCS and AIShead also remained in the final model explaining all together 42 % of the variance. RPQgen explained alone 43 % of the variance with respect to emotional/interpersonal competency, whereas only 14 % of the variance in IADL competency was explained.

Insert Table 2 here

RPQh was a statistically significant predictor of emotional/interpersonal competency explaining 31 % of the variance in the model. RPQh was also a significant predictor of cognitive competency, and explained 33 % of the variance in this model. RPQh was not a statistically significant predictor of IADL competency (Table 3). No other predictors increased the explained variance in the model with cognitive competency as the dependent variable when RPQh was included as a predictor.

Insert Table 3 here

Discussion

The present study supports the importance of post-concussion symptoms as determinants of functional outcome. Limitations in interpersonal/emotional competency, as well as cognitive competency, dominated the burden one year after injury in this representative cohort. The injury severity as evaluated by the GCS score and AIShead only influenced cognitive competency. GCS and AIShead lost the explanatory power when the headache/dizziness/nausea dimension was included in the analysis. Interpersonal and emotional problems as well as limitations in cognitive competency dominated these persons' daily life one year after trauma. Fewer problems were reported regarding IADL. If rehabilitation focuses mainly on physical functioning, there is a risk of overlooking these severe consequences of TBI (31).

Also in its milder spectrum, TBI is known to have a major impact on functioning over time (32). In a cohort of TBI patients with injuries ranging from mild to severe, a broad spectrum of outcome measures is needed to capture the problems of daily life. The UK national TBI study suggested using self-report measurements in order to detect these problems (33). Evaluation of emotional competency in activities, in particular, calls for a subjective approach. It has been detected that emotional problems have been underestimated by both professionals and the next-of-kin (18). Emotional and interpersonal competency is essential for people's ability to maintain family life and employment (34). These skills may also influence leisure activities, and in the long run influence the person's self esteem and quality of life (35). Problems in these domains should be focused in rehabilitation, and effective intervention strategies are needed.

Even though the present population represented a cohort admitted to a neurosurgical department, mild injuries as evaluated by GCS score dominated. The GCS score has been regarded as a reliable predictor of outcome in the more severely injured group (36;37), but may fail to predict outcome in the milder range of head injuries (38;39). PTA is also considered to be an important predictor of outcome after TBI (40) although valid measurement of PTA is a challenge and the role of PTA in the milder spectrum of TBI is less convincing (41). It is well recognised that a wide variety of post-concussion symptoms represent a main problem in the milder spectrum of TBI (42). In a previous study, the frequencies and patterns of post-concussion symptoms were independent of the injury severity (43). There is an ongoing discussion whether these symptoms represent organic signs of brain damage, or are more psychosocial in nature (44). RPQ has been developed in order to single out the symptoms that had been worse than before the injury, and thus only includes the scores from 2 to 4 (45). The ability of the participants to remember the symptom level before the injury could be questioned (46). Nevertheless, the symptom burden seems to be an important predictor of functional outcome. One could question if these different symptoms could add up to a measurement reflecting a valid underlying construct. By applying Rasch analysis, two underlying dimensions of RPQ were recently identified (47). Hence, we chose to divide the symptoms into these two dimensions. In the present study these dimensions correlated very closely and thus had to be added separately in the regression models. The dimension including headache/dizziness and nausea, RPQh, explained slightly less of the variance and was not predictive for IADL competency. This is not surprising, as the other dimension, RPQgen, contained 13 symptoms covering a broader spectrum of problems, like fatigue, noise sensitivity, forgetfulness and feeling depressed.

Interestingly, GCS and AIShead remained predictors of cognitive competency only together with the 13 symptoms, and not when the dimension of headache/dizziness/nausea was included. This result could indicate that the severity of the head injury is closely related to persistent headache, dizziness and nausea at 3 months, whereas the general symptoms to a greater extent reflect additional factors possibly of secondary nature. Novac et al. (48) showed that the number of symptoms together with injury severity, as evaluated by post-traumatic amnesia, predicted the functional outcome. However, relatively crude outcome measures were used, and the relationship between specific symptoms and outcome was not explored. It is tempting to speculate that the functional aspects of cognition are more directly related to the brain injury than the interpersonal and emotional problems that may develop over time. A possible interpretation is also that injury severity (as measured by GCS and AIShead) influence headache/dizziness/nausea which subsequently affects cognitive competency. The RPQgen contains symptoms that were frequently reported in the present study, like fatigue, forgetfulness, and feeling depressed. These symptoms have been significantly related to psychosocial and emotional outcome (49). Stulemeijer found that 1/3 of a cohort with mild TBI experienced severe fatigue and this was related to limitations in daily activities (50).

In our study the IADL dimension was best retained in the participants, in agreement with other studies of mild TBI (51). In mild TBI this dimension may be less at stake. Dikmen et al (52) included participants in a slightly more severe spectrum of TBI and studied outcome by neuropsychological functioning, emotional and functional status. In Dikmen's study, injury severity was related both to global functioning and to the cognitive domain, even 3 to 5 years after injury. In a Swedish study satisfaction with IADL was an important factor related to return to work after brain injury. The injury cause was mainly traumatic or vascular, and the study group may have had more severe injuries (53). Hence, the relationship between the

IADL dimension of PCRS and impact of the injury needs to be investigated in persons with different injury severities to establish their relationship.

The strength of the present study is its prospective design of a representative cohort of TBI patients. A disadvantage with this design is that it provides a limited number of patients with moderate and severe TBI. Another limiting factor was the high drop-out frequency, which is a common phenomenon in longitudinal studies of TBI (54). The drop out phenomenon is generally considered to cause an underestimation of problems after TBI (55). In the present study, the injury profile was similar in drop-outs and attendants, except that more of the drop-outs were single and unemployed. Hence, the persons not attending follow-up may be more vulnerable to the consequences of TBI. Competency in daily activities was assessed by self-rating. Due to impaired self-awareness in the TBI population the reliability of this rating may be questioned (56). However, the majority of the study population had suffered mild and moderate TBI. It has been shown that in such groups self-awareness tends to be less impaired than in those with severe TBI (57).

Post-concussion symptoms at 3 months are important indicators for possible limitations in everyday life one year after TBI. Injury severity on admission was only related to perceived cognitive competency. Hence, follow up in the earlier phases of TBI may add prognostic information about functional problems in daily life one year after TBI. In later phases of recovery some individuals experience activity limitation, which underlines the need for continued rehabilitation services. Post-concussion symptoms that persist at three months after injury indicate that the person may be at risk of experiencing limitations in daily life at one year. Follow-up assessment and intervention that target risk factors are needed in order to

prevent long-term adverse effects of the injury. Self-report assessments and client-centred interventions that include both the person and environmental factors are recommended.

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Appendix

Included Patient Competency Rating Scale (PCRS) items.

PCRS items *"How much of a problem do I have in…"*
Interpersonal / emotional competency
participating in group activities
starting conversation in a group
handling arguments with people I know well
staying involved in work activities even when bored
adjusting to unexpected changes
accepting criticism from other people
controlling crying
controlling my temper when something upsets me
keeping emotions from affecting my ability to go about the day's activities
recognizing when something I say/do has upset someone
Cognitive competency
remembering names of people seen often
remembering daily schedule
remembering things important to do
remembering last night's dinner
keeping appointments on time
scheduling daily activities
understanding new instructions
consistently meeting my daily responsibilities
IADL competency
preparing meals
washing up the dishes
doing the laundry
taking care of finances

Table 1. Demographic data and trauma scores for the TBI patients attending 3 and 12 months follow up, and for the drop-outs, excluding the 6 deceased. *p<0.05.

	Subjects attending follow up (n=63)	**Drop-out (n=53)**
Age in years (mean, SD)	38 (12)	34 (12)
Male	67%	66%
Married/cohabitant	57%*	36%
Employed	92%*	74%
Alcohol/drug influence	41%	49%
Injury causes		
-Fall	24%	21%
-Traffic	49%	40%
-Violence	13%	19%
-Other	14%	20%
GCS		
-severe	8%	4%
-moderate	10%	15%
-mild	82%	81%
ISS		
<8	40%	55%
8-18	50%	41%
>18	10%	4%

Table 2. Regression coefficient (B) with 95% CI, given for the final predictors in the backward multiple regression models including demographic factors, injury severity and 13 RPQ symptoms, RPQgeneral (RPQgen), with interpersonal and emotional (IP/E), cognitive (cog) and instrumental activities of daily living (IADL) at 12 months as dependent variables.

	B	**CI for B lower, upper**		**p-values**	**R squared**
IP/E					0.43
RPQgen	-4.21	-5.46	-2.96	<0.001	
Cog					0.42
GCS	0.36	-0.02	0.73	0.06	
AIShead	1.13	-0.16	2.41	0.09	
RPQgen	-3.35	-4.45	-2.26	<0.001	
IADL					0.14
RPQgen	-0.93	-1.50	-0.37	0.002	

Table 3. Regression coefficient (B) with 95% CI, given for the final predictors in the backward multiple regression models including demographic factors, injury severity and RPQ headache/dizziness/nausea, RPQhead (RPQh), with interpersonal and emotional (IP/E), cognitive (cog) competency and instrumental ADL (IADL) at 12 months as dependent variables.

	B	CI for B lower, upper		p-values	R squared
IP/E RPQh	-3.16	-4.30	-2.02	<0.001	0.33
Cog RPQh	-2.45	-3.38	-1.52	<0.001	0.31
IADL none					

Fig 1. The frequency of individual symptoms reported by 63 participants with traumatic brain injury, attending follow-up. Black bars represent the number of subjects reporting to have had the symptom after the injury (retrospectively reported in RPQ at 3 months follow up), grey bars represent the number of subjects reporting persistence of symptoms at 3 months.