Early Impaired Self-Awareness After Traumatic Brain Injury

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ABSTRACT. Sherer M, Hart T, Nick TG, Whyte J, Thompson RN, Yablon SA. Early impaired self-awareness after traumatic brain injury. Arch Phys Med Rehabil 2003;84: 168-76.

Objectives: To evaluate predictors of early impaired self-awareness after traumatic brain injury (TBI); to examine interrelationships of the perceptions of patient, clinician, family, and significant other of how patients are functioning after TBI; and to determine how early impaired self-awareness helps to predict employability at rehabilitation discharge.

Design: Inception cohort.

Setting: Two inpatient rehabilitation programs.

Participants: A total of 129 patients with TBI seen for inpatient rehabilitation at 1 of 2 rehabilitation centers. All subjects had emerged from posttraumatic amnesia before being assessed for this study.

Interventions: Not applicable.

Main Outcome Measures: Impaired self-awareness as measured by the Awareness Questionnaire (patient self-ratings, clinician ratings) and employability (rated on the Disability Rating Scale) at discharge from inpatient rehabilitation.

Results: Regression analysis revealed that early impaired self-awareness was predicted by age and functional status (FIM™ instrument total score) at admission to inpatient rehabilitation. Spearman correlation coefficients revealed that clinician, family, and significant other ratings of patient functioning were related (r_s=.42, P<.001), but were not related to patient self-ratings. Multiple logistic regression analysis revealed that early impaired self-awareness was predictive of employability at discharge from inpatient rehabilitation. Clinician ratings of patient functioning showed a positive relation to employability (P=.05), whereas patient self-ratings showed a trend toward a negative relation to employability (P=.09).

Conclusions: Our results support the importance of early impaired self-awareness assessment, its predictive value for complex functional activities, and the need for further research to determine if treatment programs for impaired self-awareness enhance functional outcomes.

Key Words: Awareness; Brain injuries; Rehabilitation.

TRAUMATIC BRAIN INJURY (TBI) can result in a variety of neurobehavioral impairments, including irritability, restlessness, depression, and impaired self-awareness.[1] Impaired self-awareness has received particular attention from rehabilitation workers because of its association with motivation for treatment[2,3] and long-term functional outcome.[4-6]

Although impaired self-awareness can be evident early after TBI, most published studies have investigated such impairment in postacute TBI patients, and have found that it has some general characteristics. Patients consistently show greater impaired self-awareness for cognitive and behavioral deficits than for physical impairments,[7,8] and in their responses to general questions about their functioning, rather than in responses to specific questions.[9] Patients with more acute self-awareness are more likely to complain of symptoms of depression.[10,11] Although there are some negative findings,[12-14] limited evidence exists that impaired self-awareness is related to severity of TBI, with more severely injured patients showing greater impaired self-awareness.[15,16] Finally, impaired self-awareness appears to be common after TBI. In a study of 66 postacute TBI patients, Sherer et al[5] found that, depending on the method of measurement, 76% to 97% of patients showed some degree of impaired self-awareness.

Although this impaired self-awareness is assumed to be a neurobehavioral deficit, the neural substrate is poorly understood. Inaccurate perception of one's abilities is not unique to TBI or other neurologic disorders. Allen and Ruff[12] found that unimpaired controls overestimated their abilities on some cognitive tasks and underestimated them on others; however, patients with TBI overestimated their cognitive abilities on virtually all tasks, and the magnitude of their overestimation was much greater than it was among the controls.

In contrast to the relatively large number of studies of impaired self-awareness in postacute TBI patients, our review found only 9 studies of early impaired self-awareness. We considered studies to be "early" if patients were studied within 6 months postinjury or during initial inpatient rehabilitation. McKinlay and Brooks,[17] in a sample of 55 patients with TBI, noted that at 3 months, 6 months, and 1 year postinjury, patients and family showed good agreement in reports of sensory impairments, but poorer agreement in reports of cognitive impairments and even poorer agreement for reports of emotional and behavioral changes. Patients consistently reported fewer emotional and behavioral problems than did their family members.

Anderson and Tranel[13] studied 100 neurologic patients, including 19 with TBI. Time from injury to evaluation was not reported, but the description suggests that the TBI patients were seen in their acute stage. Greater impaired self-awareness was associated with lower postinjury verbal intelligence and greater temporal disorientation. Severity of TBI as indicated by Glasgow Coma Scale (GCS) scores was not associated with degree of impaired self-awareness.

Ranseen et al[18] investigated impaired self-awareness in 32 patients with TBI who were undergoing inpatient rehabilitation. Patients consistently rated themselves as having higher levels of functioning than did rehabilitation staff members who were treating them. Patients with predominantly right hemi-

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sphere injuries showed greater impaired self-awareness than those with left hemisphere or diffuse injuries. The degree of impaired self-awareness was not significantly related to the degree of cognitive impairment. Patients with more accurate self-awareness reported higher levels of depression.

Godfrey et al,[19] by using a cross-sectional design, reported on the course of recovery of impaired self-awareness in 66 patients with TBI, 24 patients were 6 months postinjury, 19 were 1 year postinjury, and 23 were 2 to 3 years postinjury. The latter 2 groups were similar in injury severity, whereas the 1-year group had sustained less severe injuries, as indicated by GCS scores and duration of posttraumatic amnesia (PTA). These researchers found that patients who were 6 months postinjury rated themselves as less impaired than did their significant others, whereas patients who were 1 or more years postinjury rated themselves similarly to ratings by their significant others. Patients with more accurate self-awareness reported greater emotional distress.

In another longitudinal investigation with similar results, Fleming and Strong[20] studied 55 patients with severe TBI at 3 and 12 months postinjury. At 3 months, patients rated themselves as less impaired than did their therapists or significant others, especially in cognitive and emotional functions. Ratings among different informants were more similar at 12 months postinjury, although patients persisted in scoring themselves better than did their collateral raters on a few items.

Hart et al[21] investigated awareness of errors during performance of functional tasks in 18 patients with TBI who were undergoing inpatient rehabilitation and 18 control subjects who were matched for the total number of errors made. The patients showed poorer awareness of errors and less frequent self-correction of errors made while working on the tasks.

Sherer et al[16] studied 64 patients with TBI during their inpatient rehabilitation and found that they reported fewer impairments than did their family members. Patients complained more of physical symptoms while family members reported more cognitive and behavioral impairments. Both patients and family members showed greater agreement when asked specific questions about functioning, as opposed to general questions about overall functioning.

Newman et al[22] reported on impaired self-awareness in a mixed sample of 37 patients with TBI or anterior communicating artery aneurysm. The numbers of patients with each diagnosis were not given. For initial ratings, 36 of 37 patients (97%) described themselves as being less impaired than did the rehabilitation staff. A subset of 18 patients was rated a second time, and these ratings were more similar to staff ratings than were the initial ones, suggesting a decrease in the degree of impaired self-awareness. The possible significance of these findings for understanding impaired self-awareness after TBI is limited by the failure to report the number of patients with TBI (or a separate analysis for the TBI patients), or the time period between the 2 assessments. The reasons for not providing second ratings for 19 subjects (51%) were not reported.

Finally, Abreu et al[23] studied a group of persons with TBI of mixed acuity (9d to 119mo). The study also used a ratings-comparison approach, but unlike other studies in which subjects rate their overall abilities, Abreu asked subjects to judge their performances on functional tasks immediately after completing the tasks. Self-ratings were compared with ratings of a therapist who had observed the task. On most tasks, patients rated their performances as better than how they were rated by experienced clinicians. Interestingly, patients were also asked to rate the ability of other persons to perform the tasks; these ratings were more accurate, suggesting that generalized "judgment" difficulties did not account for the impaired self-assessment.

Interpretation of studies of impaired self-awareness is complicated by at least 2 important measurement issues. One is that different methods are used to measure impaired self-awareness in different studies, consequently, it is difficult to make comparisons across studies. All methods for estimating impaired self-awareness involve estimating the disparity between the patient's self-perception or self-report and some external criterion of his/her status. However, differences in the format of the self-report and/or the external criterion can affect the measurement of impaired self-awareness. For example, the assessment commonly involves comparison of patients' self-ratings of function to those of a collateral, usually a family member, a significant other, or a clinician who is treating the patient. In studies with postacute patients, the use of these different collaterals has produced dissimilar findings because of differences between family members or significant others and clinicians in their perceptions of the patients.[24,25]

Another important measurement issue is that the patient versus collateral rating is often expressed as a subtracted score (ie, a discrepancy score), with the implication being that the size of the score estimates the magnitude, or severity, of impaired self-awareness. But the magnitude of such a discrepancy score is actually constrained by the score used as the external criterion, which is typically selected for its presumed relation to the "true" level of function. Thus, assuming that a criterion such as a clinician rating is correlated with the actual ability level, then as that level increases (ie, toward the more competent end of the scale), the size of any possible discrepancy decreases. Comparing the discrepancy scores of more versus less competent subjects could thus make it appear as though the latter have worse impaired self-awareness (ie, larger discrepancy scores), whereas some of this effect could be because of their simply having "more room to disagree" on the rating scale (this issue is also discussed by Hart et al[26]). Similarly, in longitudinal studies, this constraint could make it appear that impaired self-awareness is decreasing over time, when the change could be a result of functional recovery, that is, improved scores on the external criterion.

As noted previously, several methods have been used in impaired self-awareness research, not all of which involve the calculation of patient versus collateral discrepancy scores. One method involves comparing patient self-ratings of cognitive abilities with performances on tests of those abilities. Such studies have found that patients with TBI overestimate their abilities,[13] and they overestimate their abilities to a greater extent than do persons without TBI.[12] Other investigators[27] have shown that persons with TBI often overestimate their abilities to perform simple functional tasks such as repeating words or solving arithmetic problems. As noted earlier, Hart[21] showed that patients with TBI made more errors than did controls on naturalistic tasks such as making toast, wrapping a gift, and packing a child's lunchbox. Patients were also less likely to correct their errors, which indicates a decreased awareness of the errors. Finally, in an investigation that compared self and other discrepancies between patients with TBI and unimpaired controls, Prigatano et al[15] found that patients were more likely than were controls to rate themselves as more competent than the informant. Taken together, these findings indicate that impaired self-awareness after TBI is not simply the result of a tendency of persons to view themselves more positively than they are viewed by others.

Based on our literature review, we sought to contribute to an improved understanding of early impaired self-awareness by studying a sample of patients with TBI during initial inpatient

rehabilitation. An improved understanding may have implications for rehabilitation interventions that address this impairment. We had 3 primary objectives: (1) to examine the interrelationships of patient, family, and/or significant other, and clinician ratings of patients' motor and sensory, cognitive, and behavioral and affective functioning; (2) to investigate predictors of degree of impaired self-awareness after TBI during inpatient rehabilitation; and (3) to study the relationship of degree of early impaired self-awareness to employability status at discharge from inpatient rehabilitation. Concerning objective 1, we hypothesized that ratings of family, significant others, and clinicians would be more strongly associated with each other than with the patients' self-ratings. We also hypothesized that patient self-ratings of motor and sensory functioning would be more strongly associated with corresponding family or significant others and clinicians' ratings than would their self-ratings of cognitive or behavioral affective functioning. With regard to objective 2, we hypothesized that degree of early impaired self-awareness would be predicted by indices of injury severity. With regard to objective 3, we hypothesized that impaired self-awareness would be predictive of employability at discharge from inpatient rehabilitation even after it was adjusted for demographic factors and measures of injury severity. We also examined the effects of clinicians' ratings and patients' self-ratings on rated employability at discharge from inpatient rehabilitation. In light of the preceding discussion on methodologic issues, we added a secondary objective: (4) to explore data analytic strategies that would help us to address some of the interpretive problems associated with the use of discrepancy scores in estimating the magnitude of impaired self-awareness.

METHODS

Study Population

The study population consisted of qualified subjects with TBI who were admitted to 1 of 2 inpatient brain injury rehabilitation programs (Methodist Rehabilitation Center in Jackson, MS; MossRehab in Philadelphia, PA). The majority of subjects were recruited as part of the National Institute on Disability and Rehabilitation Research Traumatic Brain Injury Model Systems (TBIMS) programs at the 2 sites. MossRehab also recruited persons with TBI who were not TBIMS subjects. Inclusion criteria for the TBIMS program[28] include medically documented TBI, treatment at an affiliated level I trauma center within 24 hours of injury, receipt of inpatient rehabilitation within the Model Systems, admission to inpatient rehabilitation within 72 hours of discharge from acute care, age of at least 16 years at the time of injury, and provision of informed consent by the person with injury or a legal proxy. TBIMS subjects were recruited for participation in that program at admission to inpatient rehabilitation, whereas nonsystem subjects were recruited when they met other qualifications that were required for participation in the study. Nonsystem subjects were similar with regard to demographic and injury characteristics to TBIMS subjects except that they received emergency and acute medical care at nonaffiliated level I trauma centers and, in a few cases, were sent home briefly or treated in subacute rehabilitation programs before admission to acute rehabilitation at the study center. To qualify for the study, subjects were also required to have emerged from PTA before discharge from inpatient rehabilitation; speak English; be free of premorbid conditions such as stroke, mental retardation, or severe psychiatric illness; and not have a severe language disorder that would compromise their ability to complete questionnaires.

Data Collection

Demographic information (age, gender, years of education), and injury severity data were collected through review of medical records and interviews with patients and family members. FIM™ instrument scores were rated at admission to inpatient rehabilitation and Disability Rating Scale (DRS) data were rated at discharge. Awareness Questionnaire data were collected either when PTA was resolved during inpatient rehabilitation or, if PTA resolved before admission, as soon as possible thereafter. Chronicity of injury was calculated as the interval in days from date of injury to date of assessment with the Awareness Questionnaire.

Injury severity was assessed in 2 ways. GCS[29] scores were obtained at admission to the emergency departments after TBI. Severity was classified in the usual way, with scores from 3 to 8 indicating severe TBI, scores from 9 to 12 indicating moderate TBI, and scores from 13 to 15 indicating mild TBI.[30] GCS scores have been shown to be predictive of later outcomes.[31,32] Time to follow commands (TFC) was used as a second index of injury severity. TFC was defined as the interval, in days, from injury until the patient was able to follow instructions at 2 consecutive assessments within a 24-hour period. TFC has also been shown to be a powerful predictor of functional recovery after TBI.[33-35]

Measures

FIM instrument. The FIM is an 18-item rating scale that assesses a patient's level of independence in self-care, mobility, bowel and bladder management, communication, cognition, and psychosocial adjustment. Each item is rated on a scale of 1 (total assistance) to 7 (complete independence). Rasch analysis has revealed 2 main factors or traits underlying FIM items: motor factor and a cognitive factor.[36,37] In our study, FIM ratings were completed by the treatment team.

Awareness Questionnaire. The Awareness Questionnaire[38] was used to assess impaired self-awareness. This questionnaire consists of 3 forms; these 3 forms are completed by the patient, a clinician who is familiar with the patient's functioning, and a family member or significant other. Each form consists of 17 items with which to assess motor and sensory, cognitive, and behavioral and affective functioning after TBI. Raters indicate how well the patient can perform in various areas at the time the questionnaire is completed, compared with how well the patient could perform before being injured. Items are rated on a 5-point scale (1=much worse; 5=much better). Scores can range from 17 to 85, with a score of 51 indicating that the patient is rated as functioning at a level "about the same" as his/her preinjury level. Factor analysis of the Awareness Questionnaire[38] has shown that there are 3 subscales—motor and sensory (4 items), cognition (7 items), and behavioral and affective (6 items). Total Awareness Questionnaire scores, plus the 3 subscale scores, are calculated by summing the appropriate items. Based on findings that persons with TBI rate themselves as being less impaired than do clinicians, the index of impaired self-awareness used in this study was calculated by subtracting clinician ratings from patient self-ratings. Because the patients were assessed before discharge from inpatient rehabilitation, we believed that clinicians would have more accurate perceptions of patients' current functioning than would family members or significant others. Patient and clinician discrepancy scores can range from −68 to 68. Negative scores indicate that the clinician rated the patient as more competent than the patient rated him-/herself, whereas positive scores indicate that the patient rated him-/herself as more competent than did the clinician (ie, impaired self-awareness).

In previous investigations, we found that negative discrepancies are relatively rare and usually small in magnitude, whereas positive discrepancies may approach the top score of 68. For this study, clinician Awareness Questionnaire ratings were completed by the treating neuropsychologist.

Disability Rating Scale. The DRS[39,40] was used to obtain the index of employability used as the outcome for analysis 3. The DRS is a 30-point scale that rates 8 areas of functioning: eye opening; verbalization; motor response; level of cognitive ability for daily activities of feeding, toileting, and grooming; overall level of dependence; and employability. Each area of functioning is rated on a scale of 0 to 3, 4, or 5, with higher scores representing lower levels of functioning. Scores on each item are summed to yield a total score between 0 and 30, with a higher score indicating greater disability. For our analysis, we used only the DRS employability rating. A rating of 3 on this item indicates that the patient is not employable under any circumstances, whereas lower ratings indicate some degree of employability, ranging from working in sheltered workshops to competitive employment. For analysis 3, subjects with DRS employability ratings of 3 were coded as not employable, whereas all others were coded as employable. DRS ratings were generally completed by the patient's physician with input from the treatment team.

Analyses

For the multivariable linear regression and logistic regression analyses, imputed values were used when data were missing on the predictor variables. For 2 of the patients with missing dates of testing with the Awareness Questionnaire, the dates of resolution of PTA were used as the imputed values. Two patients were missing 1 of the 17 items for the clinician ratings and 1 patient was missing 1 of the 17 items for the patient self-ratings. For those 3 missing values, the median of the completed items in the relevant subscales were used as the imputed values. For all other missing values, individual predictive models, by using the interrelationships among the other predictor variables and outcome, were used to impute the missing values for each predictor variable.

Analysis 1 (interrelationships of patient, family and significant other, and clinician ratings of patient functioning after TBI). The total scores and sensory and motor, cognitive, and behavioral and affective subscale scores for each of the ratings by patient, family or significant other, and clinician were calculated by summing the appropriate scores. Strengths of association among these scores were assessed by calculating Spearman correlation coefficients.

Analysis 2 (prediction of early impaired self-awareness after TBI). Potential predictors were selected based on our review of previous research and our hypotheses. Predictors investigated in this analysis were age (in years at time of injury), sex (male, female), education (years completed at time of injury), GCS (total score at emergency department admission), TFC (time in days from injury until the patient followed commands on 2 consecutive days), FIM (total score at rehabilitation admission), and chronicity (time in days from injury to assessment with the Awareness Questionnaire). Impaired self-awareness was measured as the difference between total Awareness Questionnaire patient self-ratings and total Awareness Questionnaire clinician ratings. The relationships of the predictors to impaired self-awareness were assessed by using multivariable linear regression. Associations of total Awareness Questionnaire patient self-ratings and total Awareness Questionnaire clinician ratings with impaired self-awareness discrepancy scores were examined by calculating Spearman correlation coefficients.

Analysis 3 (prediction of rated employability at rehabilitation discharge). Two models were examined to investigate prediction of employability at rehabilitation discharge. Predictors were again selected based on our review of previous studies, as well as the specific hypotheses for this study. The employability outcome (yes, no) was derived from the DRS. Predictors for the first model were age, education, TFC, FIM, and impaired self-awareness. Predictors for the second model were age, education, TFC, FIM, and patient and clinician Awareness Questionnaire totals. We selected these 2 models because we reasoned that the comparison between them would provide some indication of whether, and to what extent, the constraint on discrepancy scores (used in the first model) was affecting our results. If the discrepancy score (impaired self-awareness) proved to be a significant predictor in the first model, then we would expect clinician ratings to be a more powerful predictor of outcome than patient ratings in the second model, if the prediction of outcome from impaired self-awareness was largely an artifact of the patient's higher functional level and artificially lower impaired self-awareness score. In each case, the relationships of the predictors to the outcome were investigated by using multivariable logistic regression.

RESULTS

Study Population

During the study period, 144 TBIMS subjects were enrolled at the 2 study sites. Of these patients, 58 did not meet the additional criteria for inclusion in the study. Reasons for exclusion were failure to emerge from PTA rehabilitation discharge (n=33), discharged before data could be collected (n=11), non-English speaking (n=4), preexisting conditions (n=4), severe aphasia (n=3), and declined to participate (n=3). Of the 58 nonsystem subjects who met all inclusion criteria and were asked to participate in the study, 15 declined. As a result, the final study population included 129 subjects (86 TBIMS subjects, 43 nonsystem subjects), whose demographics and injury characteristics are presented in table 1. Most subjects were men (84%) who had sustained severe TBI (63%). Forty-six percent of the subjects were rated as having some degree of employability at rehabilitation discharge.

Analysis 1. Quartiles for the total Awareness Questionnaire scores and the Awareness Questionnaire subscale scores for patient, family or significant other, and clinician ratings are presented in table 2. These scores reveal that, as expected, patients generally rated themselves as more intact (higher Awareness Questionnaire scores) than did family or significant others or clinicians. Family or significant other ratings were intermediate between patient self-ratings and clinician ratings. Also as expected, patient self-ratings for motor and sensory functioning were more similar to family or significant other and clinician ratings than were patient self-ratings for cognitive and behavioral and affective functioning.

Associations among these scores (Spearman correlation coefficients) are presented in table 3. Except for the motor and sensory subscale scores, on which patient, family, and clinician ratings were all significantly intercorrelated (all $P<.001$), patient self-ratings were unrelated to the corresponding family or significant other or clinician ratings (all correlations close to 0.00). Correlations of corresponding family or significant other and clinician ratings were all significant (all $P<.001$) and ranged from .37 to .43. For family or significant other ratings and for clinician ratings, cognitive and behavioral and affective subscale scores were more strongly associated with each other than with motor and sensory subscale scores.

Table 1: Description of the Study Sample on Demographics and Predictors Other Than Awareness Scores (N=129)

Categorical Descriptors	Missing (%)	n (%)
Sex	0	
Male		108 (84)
Female		21 (16)
GCS total	6 (5)	
3–8		77 (63)
9–12		23 (18)
13–15		23 (18)
Employable	6 (5)	
Yes		56 (46)
No		67 (54)

Continuous Descriptors	Missing (%)	Median (25th, 75th percentile)
Age	0	33 (22, 45)
Education	1 (0.8)	12 (10, 13)
Duration of PTA	44 (34)	28 (16, 47)
TFC	4 (3)	3 (1, 14)
Chronicity	0	35 (23, 59)
FIM total at rehab admission	16 (12)	54 (38, 72)
Time from injury to rehab discharge	0	42 (32, 77)

Abbreviation: rehab, rehabilitation.

Analysis 2. Results of the multivariable linear regression analysis for prediction of impaired self-awareness are presented in table 4. The overall model accounted for 21% of the variability in impaired self-awareness. After adjustment for all other predictors, age and FIM made independent contributions to prediction of impaired self-awareness. Older age and more intact functioning as rated on the FIM at admission were associated with more accurate self-awareness. The failure of measures of injury severity (GCS, TFC) to predict impaired self-awareness may have been caused by their associations with the FIM (Spearman correlation coefficients=.19, $P=.04$

Table 2: Percentiles for Awareness Questionnaire Total and Subscale Scores for Patient Self-Ratings, Family and Significant Other Ratings, and Clinician Ratings

Awareness Questionnaire Scores	Missing	Percentiles		
		25th	50th	75th
Patient	1			
Total		43	48	53
Motor/sensory		8	10	12
Cognition		17	20	22
Behavioral/affective		16	18	20
Family/significant other	6			
Total		31	39	47
Motor/sensory		8	10	11
Cognition		11	14	19
Behavioral/affective		12	14	18
Clinician	2			
Total		27	32	37
Motor/sensory		8	9	10
Cognition		9	11	15
Behavioral/affective		9	12	14

NOTE. Higher Awareness Questionnaire scores indicate more intact functioning.

Table 3: Associations (Spearman correlation coefficients) Among Awareness Questionnaire Total and Subscale Scores for Patients, Family and Significant Others, and Clinicians

	Patient Motor/ Sensory	Patient Cognitive	Patient Behavioral/ Affective	Family Total	Family Motor/ Sensory	Family Cognitive	Family Behavioral/ Affective	Clinician Total	Clinician Motor/Sensory	Clinician Cognitive	Clinician Behavioral/Affective
Patient total	.81*	.91*	.91*	.08	.30*	.03	−.01	−.00	.33*	−.08	−.09
Patient motor/sensory	—	.65*	.64*	.01	.33*	−.05	−.09	−.07	.35*	−.13	−.16
Patient cognitive	—	—	.75*	.10	.23†	.08	.00	.04	.26†	−.03	−.04
Patient behavioral/affective	—	—	—	.06	.27†	.00	−.01	−.00	.31*	−.10	−.07
Family total	—	—	—	—	.70*	.95*	.92*	.42*	.24†	.33*	.34*
Family motor/sensory	—	—	—	—	—	.55*	.52*	.30*	.43*	.15	.20‡
Family cognitive	—	—	—	—	—	—	.82*	.40*	.15	.37*	.31*
Family behavioral/affective	—	—	—	—	—	—	—	.40*	.22‡	.30*	.37*
Clinician total	—	—	—	—	—	—	—	—	.44*	.88*	.87*
Clinician motor/sensory	—	—	—	—	—	—	—	—	—	.14	.20‡
Clinician cognitive	—	—	—	—	—	—	—	—	—	—	.68*

* $P\leq.001$; † $P\leq.01$; ‡ $P\leq.05$.

Table 4: Multivariable Linear Regression Analysis for Predicting Degree of Impaired Self-Awareness

Predictor	*df*	Comparison	Effect	95% CI	*P*
Age	2	22, 45	−2.2	−7.0 to 2.6	.04
Sex	1	Female, Male	4.0	−2.1 to 10.0	.20
Education	2	10, 13	2.2	−2.2 to 2.6	.28
Chronicity	2	23, 59	3.4	−2.7 to 9.6	.25
GCS	1	4, 12	−0.4	−5.7 to 4.9	.88
TFC	1	1, 12	0.2	−2.2 to 2.6	.85
FIM	2	38, 71	−5.9	−10.6 to −1.2	.04

NOTE. For the predictors with 2 *df,* linearity assumptions were relaxed by incorporating restricted cubic spline functions with 3 knots.
Abbreviation: CI, confidence interval.

Table 5: Multivariable Logistic Regression Analysis Predicting Employability Using Impaired Self-Awareness

Predictor	*df*	Comparison	Effect	95% CI	*P*
Age	1	22, 45	0.56	0.31–1.03	.06
Education	1	10, 13	1.55	1.00–2.40	.05
TFC	1	0.5, 12	0.86	0.57–1.28	.45
FIM	1	38, 71	1.02	0.51–2.03	.96
ISA	2	8, 23	0.48	0.26–0.91	.03

NOTE. For the predictor with 2 *df,* linearity assumptions were relaxed by incorporating restricted cubic spline functions with 3 knots.
Abbreviation: ISA, impaired self-awareness.

for GCS; −.46, $P=.001$ for TFC). Bivariate correlations for GCS and TFC with impaired self-awareness were −.22 ($P=.02$) and .33 ($P=.001$). If FIM was excluded from the multivariable linear regression model, TFC, but not GCS, made a significant contribution to prediction of impaired self-awareness, with patients with shorter TFC having more accurate self-awareness.

Bivariable correlations (Spearman correlation coefficients) of total Awareness Questionnaire patient self-ratings and total Awareness Questionnaire clinician ratings with impaired self-awareness discrepancy scores were .82 and .50, respectively (both $P<.001$). Scatterplots showing these associations are provided in figure 1.

Analysis 3. Results of the 2 multivariable logistic regression analyses are presented in tables 5 and 6. Both models were significant. The model with impaired self-awareness (table 5) accounted for 20% (R^2)[41] of the variability in employability, whereas the model with patient Awareness Questionnaire total and clinician Awareness Questionnaire total (table 6) accounted for 25% of the variability. For the impaired self-awareness model, years of education and impaired self-awareness made significant contributions to prediction of employability, after adjustment for all other predictors. Subjects at the 75th percentile of education (13y) were 1.55 times more likely to be rated as employable as were subjects at the 25th percentile (10y). Subjects at the 75th percentile of impaired self-awareness (23) were only .48 times as likely to be employable as those scoring at the 25th percentile (8). Note that higher impaired self-awareness scores are associated with poorer self-awareness. Stated another way, those with more accurate self-awareness were 2.08 times more likely to be employable than were those with less accurate self-awareness. Figure 2 shows the relationship of impaired self-awareness to probability of employability after adjustment for all other predictors. There was trend ($P=.06$) for an age effect on employability. Subjects at the 75th percentile of age (45y) were .56 times more likely to be employable as were those at the 25th percentile of age (22y).

For the patient Awareness Questionnaire total and clinician Awareness Questionnaire total model, education and clinician Awareness Questionnaire total made significant contributions to prediction of employability, after adjustment for all other predictors. The education effect for this model was essentially identical to the previous model. Subjects rated at the 75th percentile (37) on clinician Awareness Questionnaire total were 2.49 times more likely to be employable than were subjects rated at the 25th percentile (27). Higher total Awareness Questionnaire scores are associated with higher rated functioning. There was a trend ($P=.09$) for a patient Awareness Questionnaire total effect on employability. Subjects at the 75th percentile (53) on patient Awareness Questionnaire total were .70 times more likely to be employable than were those at the 25th percentile (43). Stated another way, patients who rated themselves as more impaired were 1.43 times more

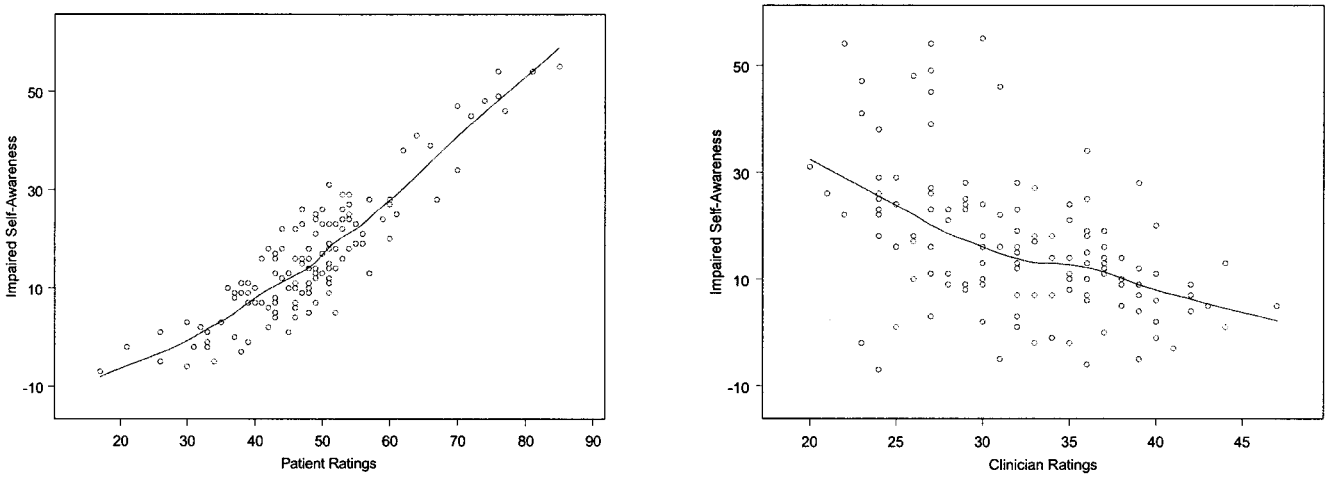

Fig 1. The relationships of patient total Awareness Questionnaire scores and clinician total Awareness Questionnaire scores to impaired self-awareness discrepancy scores.

Table 6: Multivariable Logistic Regression Analysis Predicting Employability Using Patient Awareness Questionnaire Total and Clinician Awareness Questionnaire Total

Predictor	*df*	Comparison	Effect	95% CI	*P*
Age	1	22, 45	0.59	0.32–1.11	.10
Education	1	10, 13	1.57	1.00–2.48	.05
TFC	1	0.5, 12	0.90	0.60–1.35	.61
FIM	1	38, 71	0.95	0.45–2.01	.89
Patient AQ total	2	43, 53	0.70	0.43–1.13	.09
Clinician AQ total	2	27, 37	2.49	1.08–5.73	.05

NOTE. For the predictors with 2 *df,* linearity assumptions were relaxed by incorporating restricted cubic spline functions with 3 knots.
Abbreviation: AQ, Awareness Questionnaire.

likely to be employable than were those who rated themselves as less impaired. Figure 3 shows the relationships of patient and clinician Awareness Questionnaire totals to probability of employability after adjustment for all other predictors.

DISCUSSION

Our hypotheses for analysis 1 were strongly supported. Consistent with previous studies, overall patients' self-ratings did not correlate with family or significant other ratings or clinician ratings. However, family and clinician ratings did significantly correlate with one another. Patients consistently rated themselves as less impaired than did family or significant others or clinicians. Also consistent with previous findings, patient self-ratings for physical (motor/sensory) functioning were more strongly associated with the corresponding family or significant other ratings and clinician ratings than were patient self-ratings for nonphysical functioning (cognition, behavioral/affective). Patients have more accurate self-awareness for physical functioning than for nonphysical functioning.

As reported by other investigators, family ratings of patient status agreed more with clinician ratings than with patient self-ratings, but generally noted less impairment in the patient than did the clinician ratings. There is evidence[42] that a positive working alliance between the family or significant others and clinicians facilitates more favorable patient outcome. Discrepant perceptions of patient functional abilities between family or significant others and clinicians may pose a barrier to such a working alliance. Our findings suggest that an important goal in early rehabilitation should be the education of, and rapport building with, family or significant others to facilitate greater agreement with clinicians in perceptions of patient functioning and a strong working alliance. Improved agreement should facilitate development of mutually acceptable therapeutic goals and improve patient participation in therapies. Development of a common perception of the patient may be more important to a successful working alliance than the degree to which the family or significant others or clinicians change their perceptions to achieve this common perception.

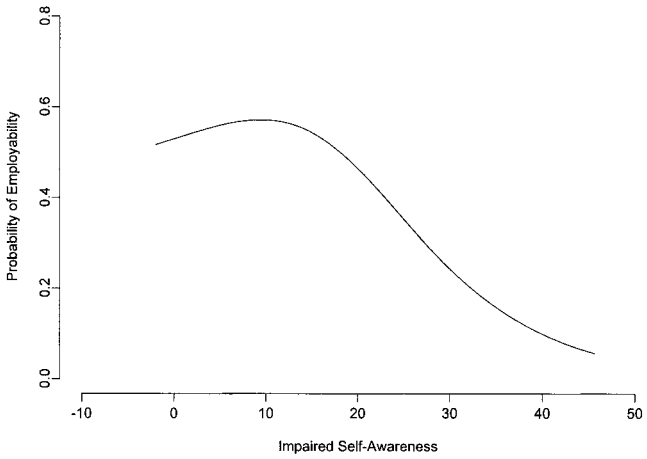

Fig 2. Relationship of impaired self-awareness to probability of employability after adjustment for other predictors.

Results provided only partial support for our hypothesis for analysis 2. The association of injury severity with impaired self-awareness, as measured by GCS and TFC, was quite modest. This association was not significant once adjusted for other predictors of impaired self-awareness such as age and FIM. As noted previously, the GCS scores were obtained when patients were admitted to the emergency departments. These scores are problematic because they may be affected by facial swelling, intubation, alcohol or other drug intoxication, or shock.[43] A stronger association between GCS and impaired self-awareness may have been found if best 24-hour GCS scores had been available for our patients. As noted, TFC has been predictive of other neurobehavioral outcomes in some other investigations.[33,34] However, variables recorded later in recovery are more likely to predict outcomes than variables recorded earlier.[44] In this study, after adjustment for other predictors, FIM at admission for inpatient rehabilitation showed a strong association with degree of impaired self-awareness. Patients with higher levels of functional independence had more accurate self-awareness.

The apparent relationship of impaired self-awareness to age was of interest and has not been reported previously. We have no conceptual model to explain why older patients had more accurate self-awareness than younger patients within these age ranges (25th percentile=22, 75th percentile=45). Age may be associated with other aspects of psychologic functioning that influence self-awareness. Recent research[45] has shown that self-awareness after TBI is associated with psychologic issues such as coping style. These findings support the need for additional research on the contribution of nonneurologic factors such as demographic factors and personality factors to impaired self-awareness.

Hypotheses for analysis 3 were also strongly supported. Accuracy of self-awareness as measured by discrepancy between patient self-rating and clinician rating was predictive of employability at rehabilitation discharge even after being adjusted for age, education, time to follow commands, and FIM at rehabilitation admission. Those who scored at the 25th percentile of impaired self-awareness, indicating more accurate self-awareness, were approximately twice as likely to be rated employable at discharge than those who scored at the 75th percentile. This is the first finding of its type with early im-

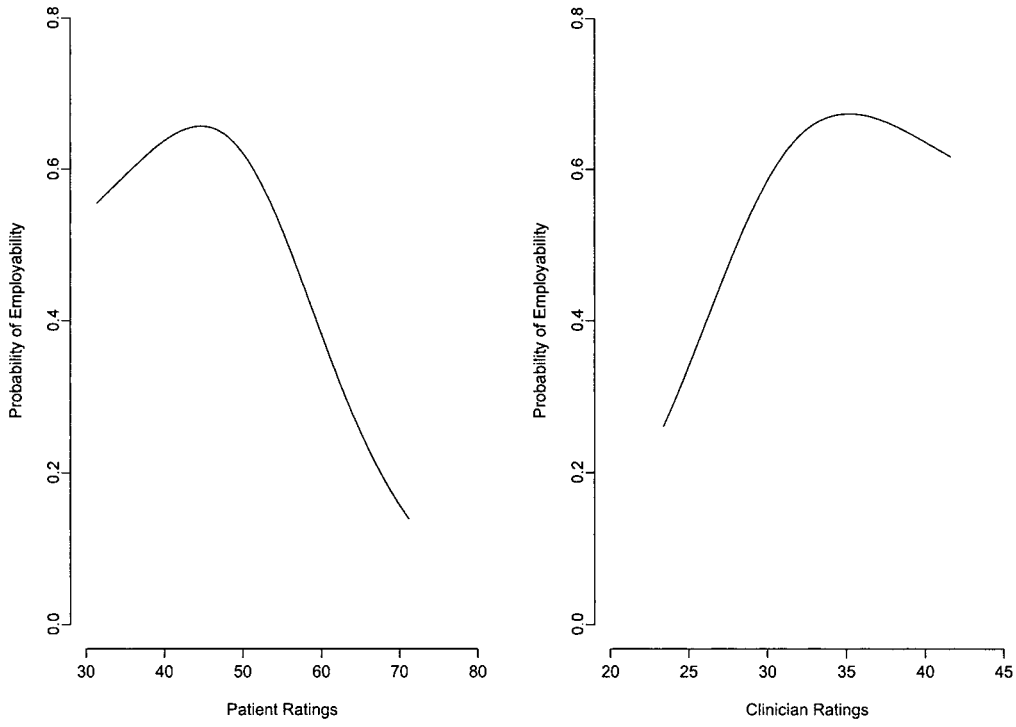

Fig 3. Relationships of patient Awareness Questionnaire total and clinician Awareness Questionnaire total to probability of employability after adjustment for other predictors

paired self-awareness and is consistent with studies of post-acute patients in indicating that impaired self-awareness is an important factor in predicting outcome after TBI.

Although we found that impaired self-awareness was more strongly associated with patient self-ratings than with clinician ratings (fig 1), it could be argued that the association of impaired self-awareness with predicted employability is primarily determined by the association of clinician Awareness Questionnaire ratings with predicted employability. Our analysis of the individual contributions of clinician ratings and patient self-ratings to predicting likelihood of employability addresses this issue. We found that the likelihood of employability increased with higher clinician rating of patient functioning, but decreased with higher patient self-rating of functioning (fig 3). This result shows that the relationship of impaired self-awareness to employability was not simply because of the positive association of clinician ratings with employability, but was also contributed to by the negative association of patient self-ratings with employability. Patients who rated themselves as being more competent after sustaining TBI than they were before their injuries had lower probabilities of being rated as employable.

CONCLUSION

Our demonstration that impaired self-awareness, as measured by patient and clinician discrepancies, is predictive of functional status at rehabilitation discharge provides support for the discrepancy method of measuring impaired self-awareness. Our data do not permit a direct test of the degree to which the previously discussed constraint on the magnitude of discrepancy scores may have affected our findings. However, the notion of the constraint suggests that impaired self-awareness scores will be primarily determined by clinician ratings, as opposed to patient self-rating. We found just the opposite; as shown in figure 1, impaired self-awareness scores were more strongly associated with patient self-ratings than with clinician ratings. Impaired self-awareness discrepancy scores for our subjects ranged from –7 to 54, with a median (25th, 75th percentiles) of 14 (8, 23). Thus, it does not appear that the mathematical constraint in the possible range of scores was a significant factor in these data. It appears most likely that the better impaired self-awareness scores in more competent patients reflect their more intact overall cognitive and behavioral functioning, resulting in more accurate self-awareness. Although the neural substrate of impaired self-awareness is poorly understood, it seems likely that it has some overlap with the neural underpinnings of cognitive, behavioral, and affective functioning. Thus, persons with more intact cognitive, behavioral, and affective functioning would be expected to have more accurate self-awareness. Although some impact of constraint in the possible range of impaired self-awareness scores for more intact patients on our findings cannot be ruled out, our results do not suggest that this was a major or significant factor.

Taken together, our findings support the notion that impaired self-awareness after TBI is an important phenomenon in the acute rehabilitation setting. A deficit in the ability to accurately assess one's current level of function is 1 determinant of "employability" as rated by treatment staff on rehabilitation discharge. This finding is in agreement with studies showing a later impact of impaired self-awareness on actual employment status in the postacute stages of recovery.[5] Our results support the need for further research to determine if treatment programs for impaired self-awareness enhance functional outcomes and the development of early interventions to promote greater agreement and better working alliances between families and treatment staff.

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