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Factors Predicting Functional and Cognitive Recovery Following Severe Traumatic, Anoxic, and Cerebrovascular Brain Damage

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Objectives: To compare demographic data, clinical data, and rate of functional and cognitive recovery in patients with severe traumatic, cerebrovascular, or anoxic acquired brain injury (ABI) and to identify factors predicting discharge home. **Participants:** Three hundred twenty-nine patients with severe ABI (192 with traumatic, 104 with cerebrovascular, and 33 with anoxic brain injury). **Design:** Longitudinal prospective study of inpatients attending the intensive Rehabilitation Department of the "Sacro Cuore" Don Calabria Hospital (Negrar, Verona, Italy). **Main measures:** Etiology, sex, age, rehabilitation admission interval, rehabilitation length of stay, discharge destination, Glasgow Coma Scale, Disability Rating Scale (DRS), Glasgow Outcome Scale, Levels of Cognitive Functioning, and Functional Independence Measure. **Results:** Predominant etiology was traumatic; male gender was prevalent in all the etiologic groups; patients with traumatic brain injury were younger than the patients in the other groups and had shorter rehabilitation admission interval, greater functional and cognitive outcomes on all considered scales, and a higher frequency of returning home. Patients with anoxic brain injury achieved the lowest grade of functional and cognitive recovery. Age, etiology, and admission DRS score predicted return home. **Conclusions:** Patients with traumatic brain injury achieved greater functional and cognitive improvements than patients with cerebrovascular and anoxic ABI. Age, etiology, and admission DRS score can assist in predicting discharge destination. **Keywords:** *Disability Rating Scale*, *discharge destination*, *outcome assessment*, *predictive factors*, *prognosis*, *rehabilitation*

ACQUIRED BRAIN INJURY (ABI) is an umbrella term encompassing both traumatic (ie, cerebral concussion, brain contusions, diffuse axonal injury, etc) and nontraumatic (intracerebral brain lesions, aneurysms, vascular malformations, anoxia, tumors, and infections) etiologies.[1] The various etiologies may have different mechanisms and vary in the potential for neural and functional recovery.[2]

A severe ABI may lead to significant impairment of an individual's cognitive, physical, and/or psychosocial functioning and thus is a leading cause of lifelong disability.[1,2] Studies have shown that traumatic brain injury (TBI) is a main cause of severe ABI.[1–3] Among nontraumatic etiologies, main causes are cerebrovascular[2,3] and hypoxic injuries (brain anoxia)[3,4] due to cardiac arrest.[5–9]

The main criteria for a severe ABI are a state of coma [Glasgow Coma Scale (GCS) score ≤8], at least 6 hours of loss of consciousness, and at least 1 day of amnesia.[1,5,10] This definition is typically applied to patients with TBI and cannot be easily applied to patients with cerebrovascular and anoxic brain injury, as the duration of loss of consciousness and posttraumatic

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amnesia is difficult to ascertain in patients with these etiologies.[2] Therefore, in this investigation, as in previous studies,[6,11–15] we used the initial postinjury level of the GCS (within the first 24 hours) alone to classify the severity of ABI of the different etiologies.

Predicting outcome of cognitive and sensory-motor impairment, disability, and discharge destination in patients with severe ABI is important to a rehabilitation team because it could improve decision making about the allocation of resources, provide a basis for realistic goal-setting and consequent evaluation of program effectiveness, as well as allow the family to adjust its' expectations and plan for the future.[2,16] Establishing likely functional and discharge outcome in severe ABI is a complex task that must take into account many clinical variables. Studies have assessed functional outcomes and endeavored to identify possible prognostic factors in subjects who have suffered an ABI.

About functional outcomes, some studies focus on only 1 etiology such as stroke,[17–19] TBI,[20–26] or anoxic brain injury[9] whereas others have compared traumatic and nontraumatic brain injuries[2,3,12,27–29] or 2 etiologies such as traumatic and anoxic brain injury.[5–7,30–32]

As a whole, these studies have shown that patients who survive a TBI achieve greater functional and cognitive recovery than those with non-TBI[2,3,9,27–29,33] and that patients with anoxic brain injury have a similar rate of recovery compared with patients with TBI but have a worse outcome, as they tend to reach the upper limit of their potential more quickly than the former.[5,6,8,30–32]

However, many studies have not focused on severe ABI but instead included patients with a range of injury severity from mild to severe.[2,6,30–32] Some studies investigating functional outcomes, prognostic factors, and discharge destination have compared persons with TBI versus non-TBI.[2,12,34] In our view, a main limitation of these studies is that the patients with non-TBI have a mix of etiologies such as cerebrovascular disorders,[2,12] aneurysms,[34] subarachnoid hemorrhage,[12,34] neoplasms,[34] metastases,[34] anoxia,[12,34] inflammation of the brain (encephalitis, meningitis),[2,34] vasculitis,[2] and hydrocephalus.[2] However, some of these etiologies have unique clinical courses. For example, patients with aneurysms and subarachnoid hemorrhage have potential for improvement whereas patients with neoplasms and metastases tend to progressively deteriorate. Therefore, comparing outcomes of patients with TBI with such a heterogeneous group of patients may lead to inaccurate conclusions. Moreover, studies involving adult patients with severe ABI cannot be compared with studies that include children and young adults.[27,29]

About the prognostic factors, the most commonly studied are age,[10,12,17,18,20,35,36] coma duration,[10,21] posttraumatic amnesia,[10,16] early rehabilitation,[22,36–38] and functional and cognitive levels at admission.[12,16–18,22,39–41] Unfortunately, the results are sometimes contradictory[42,43] and thus only partially clear and congruent conclusions can be drawn and applied to clinical practice in the management of patients with severe ABI of different etiologies.

The aim of this study was to compare patients with severe TBI with patients with severe cerebrovascular and anoxic brain injuries, based on the fact that these 3 etiology groups have a high incidence rate among patients with severe ABI and all have potential for functional recovery. In particular, we compared demographic and clinical data, functional and cognitive outcomes, and discharge destination in patients with severe traumatic, cerebrovascular, or anoxic ABI. In addition, we aimed to identify possible factors predicting discharge home.

METHODS

Participants

Between January 2004 and January 2008, a total of 404 patients consecutively admitted to the intensive Rehabilitation Unit of the "Sacro Cuore Don Calabria" Hospital (Negrar, Verona, Italy) were assessed for eligibility. Inclusion criteria were at least 18 years of age, severe ABI[1,5,10] following traumatic, cerebrovascular, or anoxic brain injury as determined by an initial postinjury GCS score (within the first 24 hours) of 8 or lower, and admission to the intensive inpatient Rehabilitation Unit. Excluded were patients with other neurologic (neoplastic, inflammatory) or psychiatric diseases. Nine patients were excluded because of neoplastic etiology, and 5 were excluded because of inflammatory brain damage, leaving 390 patients with moderate to severe ABI. Forty-two patients with TBI and 19 patients with cerebrovascular ABI were excluded because they had a moderate ABI (GCS score between 9 and 12).

Three hundred twenty-nine patients (233 men and 96 women) with severe ABI were recruited (Figure 1) and [AQ3] divided into 3 groups (traumatic, cerebrovascular, and anoxic) according to their etiology.

Severe TBIs (58.36%) were caused by motor vehicle accidents, falls, and sport injuries, whereas most severe cerebrovascular ABIs (31.61%) resulted from hemorrhagic stroke (intracerebral or subarachnoid). These patients were initially admitted to the neurosurgery unit or the intensive care unit (ICU) before being admitted to the intensive inpatient Rehabilitation Unit. Causes of severe anoxic ABI (10.03%) were cardiac arrest, monoxide poisoning, or respiratory complications during surgery. The group with TBI contained the greatest percentage of males. Mean age was significantly lower for the group with TBI ($P < .001$). For details, see Table 1. [T1]

During the rehabilitation stay, all patients received rehabilitation treatment by an interdisciplinary team involving an individualized cognitive and/or neuromotor program according to the patient's primary needs and rehabilitative goals.[2] Subjects received 3 hours of rehabilitation per day from Monday to Friday.[37,44] The study was approved by the Ethics Committee of the Department of Neurological, Neuropsychological, Morphological and Movement Sciences, University of Verona.

Test procedures

Demographic and clinical data

Upon admission to the intensive inpatient Rehabilitation Unit, age, sex, brain damage etiology, GCS score (recorded within 24 hours from the onset of injury), and the number of days since injury (rehabilitation admission interval, RAI) were recorded for all patients. At admission and discharge, the presence of tracheostomy and/or percutaneus endoscopic gastrostomy (PEG) intervention was recorded for all patients. Furthermore, all patients were assessed with the Disability Rating Scale (DRS),[40,45–47] Glasgow Outcome Scale (GOS),[45,48] Levels of Cognitive Functioning (LCF),[40,49] and the Functional Independence Measure (FIM).[47,50] Mortality, discharge destination, and rehabilitation length of stay (RLOS) in days were recorded at discharge.

Outcome measures

Disability Rating Scale

The DRS is a reliable and validated scale that provides quantitative information regarding disability in patients with ABI and allows monitoring of the patients' progress from coma to community living.[40,45–47] It consists of 8 items that assess 4 categories (arousal and awareness; cognitive ability for self-care activities; physical dependence on others; and psychosocial adaptability).[2] The DRS is scored such that higher scores represent a higher level of disability (range: 0, no disability; 30, death).

Glasgow Outcome Scale

The GOS is a global rating of functional recovery in patients with ABI.[45,48] It consists of 5 categories (1 = death; 5 = good recovery).

Levels of Cognitive Functioning

The LCF is a valid and reliable categorical scale with 8 levels that is widely used to evaluate recovery of consciousness and communication and for monitoring patients' cognitive and behavioral improvements after brain injury (score ranges from 1 to 8; higher score = better performance).[40,49]

Functional Independence Measure

The FIM is a valid and reliable[47,50] scale that rates the patients' ability to perform independently in self-care, sphincter control, transfers, locomotion, communication, and social cognition. It consists of 18 items, each rated on a 7-point scale (score ranges from 18 to 126; higher score = higher level of functioning/increased independence).[23,47,50]

Discharge destination

Discharge destination, home versus other, was recorded at time of discharge. "Home" was considered return home to the patient's previous living situation or

TABLE 1 *Demographic and clinical characteristics of patients*

Characteristics	Total	Traumatic	Cerebrovascular	Anoxic	*P*
Patients, mean (%)	329 (100)	192 (58.36)	104 (31.61)	33 (10.03)	
Age, mean (SD), y		39.36 (18.63)	55.93 (16.56)	50.55 (15.25)	<.001[a]
Sex, mean (%)					
Male		154 (80.21)	57 (54.81)	22 (66.67)	<.001[b]
Female		38 (19.79)	47 (45.19)	11 (33.33)	
Glasgow Coma Scale, mean (SD)		5.42 (1.82)	5.23 (1.91)	3.77 (1.39)	<.001[a]
RAI, mean (SD), d		40.57 (27.11)	50.71 (15.37)	58.21 (54.53)	<.001[a]
RLOS, mean (SD), d		68.08 (72.02)	83.14 (59.98)	78.00 (55.09)	.170[a]
Tracheostomy, mean (%)					
Admission		53 (27.60)	35 (33.65)	15 (45.45)	.102[b]
Discharge		7 (3.65)	12 (11.54)	13 (39.39)	<.001[b]
Percutaneus endoscopic gastrostomy, mean (%)					
Admission		16 (8.33)	16 (15.38)	13 (39.39)	<.001[b]
Discharge		27 (14.06)	31 (29.81)	17 (51.52)	<.001[b]

Abbreviations: RAI, rehabilitation admission interval; RLOS, rehabilitation length of stay.
[a]ANOVA.
[b]χ^2 test.

that of an extended family, whereas "other" referred to deceased patient, other hospital, or other rehabilitation structure.

Statistical analysis

The descriptive statistics included frequency tables with percentages and means and standard deviation calculations.

For categorical data (sex, presence of tracheostomy or PEG, and discharge status), the association between 2 variables was tested using a χ^2 test.

ANOVA was used to evaluate the differences among the clinical data and functional measures in the 3 different etiologic groups.

Gain was calculated as the difference between the score at discharge and the score at admission in each measure (eg, difference between the admission DRS and the discharge DRS score). Efficiency was calculated as the amount of improvement in the score of each scale divided by the duration of rehabilitation stay (ie, gain scores divided by RLOS). They were calculated to evaluate mean total and daily recovery during rehabilitation for each scale.

Post hoc comparisons with Bonferroni correction[51] were performed to compare TBI group versus cerebrovascular group, TBI group versus anoxic group, and cerebrovascular versus anoxic group.

Further analyses aimed at investigating the value of the DRS in predicting the probability of a patient returning home were performed. We chose the DRS as the main predictor variable on the basis of the fact that the DRS score showed the highest correlation with the scores of other scales used in this study as demonstrated by Spearman's rank correlation and its associated nonparametric test.

A logistic regression analysis with logit link was used to determine whether etiology can predict patients' return home: for this purpose, the discharge destination was recorded as 1 or 0 depending on whether the "patient returns home" or "patient does not return home," respectively. In the logistic model, etiology was considered as the determinant; age, sex, GCS, RAI, RLOS, admission DRS, and tracheostomy at admission were considered confounders.

A tree regression model was estimated to calculate admission DRS cutoff score needed to identify those individuals with a greater probability of returning home at discharge from inpatient rehabilitation. For each node selection of the tree model, the relative probability of the patient's returning home was calculated. Statistical significance of the tests and parameter coefficients was set at $P < .05$. Data were analyzed using the statistical package R 2.9.1 with Windows operating system and X86 machine.

RESULTS

Demographic and clinical characteristics

Initial severity of injury was significantly different across groups ($F = 9.25$, $P < .001$), with the patients with TBI having the highest GCS scores, followed by those with cerebrovascular and anoxic brain injury, respectively (see Tables 1 and 3). [T3]

RAI was significantly different among the groups ($F = 5.91$, $P < .001$). Post hoc comparisons showed that the patients with TBI had significantly shorter RAI than the cerebrovascular and anoxic groups whereas anoxic and cerebrovascular groups did not differ (see Table 3). The RLOS did not significantly differ among the groups. See Table 1 for details.

The frequency of tracheostomy at admission was not significantly different among the groups, but there was a significant difference at discharge, as well as a significantly different frequency of PEG at admission and discharge, with patients with anoxic brain damage showing the highest frequency in both cases.

Outcome scales

ANOVA revealed significant differences among the 3 groups on all outcome scales. Post hoc comparisons showed the patients in the TBI group to have a lower grade of disability as well as greater functional independence and cognitive status scores than the patients in the anoxic group at both admission and discharge. Compared with the cerebrovascular group, patients with TBI showed no significant differences with regard to admission DRS, GOS, and LCF scores, whereas at discharge, significant differences were recorded for DRS, GOS, and FIM scores. See Table 2 for the results of the ANOVA [T2] tests and see Table 3 for the results of the post hoc tests.

Gain and efficiency

Significantly different recovery was reflected in the gain and efficiency scores among the 3 groups for all scales. Post hoc comparisons identified significant differences in DRS, GOS, and FIM gain scores between the TBI and cerebrovascular groups and between the TBI and anoxic groups but no differences in gain between the cerebrovascular and anoxic groups. With regard to LCF gain, a significant difference was found only between those with TBI versus those with anoxic brain injury (Tables 2 and 3).

Discharge destination

Three patients with cerebrovascular injury died during inpatient rehabilitation. Within each etiology group, the main discharge destination was home; the comparison among groups revealed a significant difference

TABLE 2 *Comparison of severity of injury characteristics and functional outcomes*

Score	Traumatic	Cerebrovascular	Anoxic	*P*
Disability Rating Scale				
Admission	15.04 (6.58)	15.99 (5.49)	20.15 (5.18)	<.001[a]
Discharge	9.57 (6.70)	12.45 (6.85)	17.48 (7.05)	<.001[a]
Gain	– 5.47 (4.47)	– 3.54 (4.73)	– 2.67 (3.67)	<.001[b]
Efficiency	– 0.17 (0.22)	– 0.08 (0.17)	– 0.08 (0.15)	<.001[b]
Glasgow Outcome Scale				
Admission	2.96 (0.61)	2.93 (0.32)	2.64 (0.55)	.005[a]
Discharge	3.59 (0.84)	3.21 (0.73)	2.88 (0.86)	<.001[a]
Gain	0.63 (0.71)	0.30 (0.67)	0.24 (0.56)	<.001[b]
Efficiency	0.02 (0.06)	0.01 (0.03)	0.01 (0.04)	.013[b]
Levels of Cognitive Functioning				
Admission	4.89 (1.91)	5.04 (1.77)	3.39 (1.71)	<.001[a]
Discharge[c]	6.19 (1.84)	6.12 (1.70)	4.00 (2.02)	<.001[a]
Gain[c]	1.30 (1.22)	0.98 (1.39)	0.61 (0.86)	.005[b]
Efficiency[c]	0.04 (0.05)	0.02 (0.06)	0.02 (0.04)	.015[b]
Functional Independence Measure				
Admission	41.96 (31.81)	32.11 (18.43)	24.88 (17.72)	<.001[a]
Discharge[c]	74.64 (39.10)	56.98 (35.46)	37.36 (31.89)	<.001[a]
Gain[c]	32.29 (29.42)	24.04 (25.26)	12.48 (20.32)	<.001[b]
Efficiency[c]	1.22 (2.25)	0.65 (1.13)	0.51 (1.06)	.013[b]

[a]ANOVA.
[b]*P* value of ANOVA adjusted for age and sex.
[c]Statistics performed on 328 patients (1 patient dropped out).

($P < .001$). Patients with TBI had a higher frequency of returning home than the other groups, whereas the lowest percentage corresponded with patients with anoxic ABI. The subjects who did not return home were transferred to other hospitals or other rehabilitation structures (see Table 4). [T4]

TABLE 3 *Multiple pair-wise comparison among the 3 etiologies in each outcome measure*

	Traumatic vs cerebrovascular		Traumatic vs anoxic		Cerebrovascular vs anoxic	
	t	*P*	*t*	*P*	*t*	*P*
Glasgow Coma Scale	– 0.19	1.000	– 1.64	.000	1.46	.002
Rehabilitation admission interval	10.14	.036	17.64	.014	– 7.50	.766
Disability Rating Scale						
Admission	0.95	.606	5.11	.000	– 4.16	.002
Discharge	2.88	.002	7.92	.000	– 5.03	.001
Gain	1.93	.001	2.80	.003	– 0.87	.994
Glasgow Outcome Scale						
Admission	– 0.03	1.000	– 0.33	.003	0.29	.016
Discharge	– 0.38	.000	– 0.71	.000	0.33	.121
Gain	– 0.32	.000	– 0.38	.009	0.05	1.000
Levels of Cognitive Functioning						
Admission	0.15	1.000	– 1.50	.000	1.64	.000
Discharge	– 0.07	1.000	– 2.18	.000	2.12	.000
Gain	– 0.32	.109	– 0.69	.010	0.37	.407
Functional Independence Measure						
Admission	– 9.85	.009	– 17.08	.003	7.22	.546
Discharge	– 17.65	.000	– 37.27	.000	19.61	.028
Gain	– 8.25	.043	– 19.80	.000	11.55	.108

TABLE 4 *Patients' discharge destination*

Discharge destination	Traumatic	Cerebrovascular	Anoxic	*P*
Home	163 (84.90)	58 (55.77)	15 (45.45)	<.001[a]
Others				
Deceased	0 (0)	3 (2.88)	0 (0)	
Hospital	20 (10.42)	18 (17.31)	9 (27.27)	
Rehabilitation structure	9 (4.69)	25 (24.04)	9 (27.27)	

Values are expressed as number (percentage).
[a] χ^2 test; comparison performed between destination (home vs others) and type of injury.

Correlation among the clinical scales

Among the scales, the DRS was chosen for the regression analysis and tree regression because it showed the highest significant correlation with all the others (Spearman ρ DRS-GOS: -0.754; ρ DRS-LCF: -0.916; ρ DRS-FIM: -0.895; $P < .001$).

Logistic model for returning home prevision and tree regression

In the model, the referential participant taken into consideration is a patient who is younger than 45 years, female, and has a traumatic etiology of injury. Etiology had a clinical influence on patients' return home [cerebrovascular vs TBI: odds ratio (OR) = 0.259, 95% confidence interval (CI) = 0.115–0.580; anoxic vs TBI: OR = 0.316, 95% CI = 0.110–0.911]. Age and DRS score at admission significantly influenced the probability of returning home at discharge. Sex, GCS score, RAI, RLOS, and the presence of tracheostomy at admission did not significantly influence the probability of
[T5] discharge home (see Table 5).

The tree regression analysis identified the range of admission DRS scores correlating with the patient's probability of returning home. In particular, those with DRS scores lower than 19.5 were more likely to return home (86%) whereas those with DRS scores higher than 22.5 had a lower probability of home discharge (35%). For the patients with an admission DRS score between 19.5 and 22.5, the probability of returning home was 54%

DISCUSSION

In this study, we demonstrated significant group differences in demographic and clinical data, functional and cognitive outcomes, and discharge destination in patients with severe ABI due to TBI, cerebrovascular accident, or anoxia. In addition, we identified prognostic factors in discharge destination and, in particular, how scores on the DRS at admission can predict the probability of return home.

It is worth noting that despite the extensive literature devoted to the outcome of persons with TBI versus non-TBI, only tentative conclusions useful for clinical practice can be drawn because of differences in group composition or because of the small number of patients examined.

A main drawback in previous studies is that they have compared patients with TBI to "blended" groups of patients with non-TBI,[2,34] where the latter have various brain injury etiologies and thus could have very different outcome and potential of recovery.[2,34] Thus, compared with the large amount of data specific to the outcome of TBI, it is difficult to find homogeneous patterns of outcome among the multifaceted aspects of the non-TBI subcategories.

Therefore, in this study, we choose 3 major etiologic categories based on their high incidence and congruent tendency toward functional recovery (although at different rates). Thus, we excluded categories that have frequent spontaneous worsening (eg, neoplasms or vasculitis) or infrequent occurrence (eg, encephalitis, hydrocephalus).

One main issue for discussion arising from our study concerns the difference in the severity of the clinical picture among the 3 etiologic groups. Our results suggest that patients with TBI and cerebrovascular injury are typically less severely affected than those with anoxia as indexed by the level of GCS within 24 hours after the injury and the levels of DRS, GOS, and LCF at admission; patients with TBI and cerebrovascular damage display a similar severity on all outcome measures except for the FIM.

Here, it is important to underline that our patients with cerebrovascular damage were all admitted from the neurosurgery or the intensive care unit. Thus, most underwent surgical removal of intracerebral hemorrhage or [AQ4]
subarchnoid hemorrhage and consequently they represent a select sample of patients with severe cerebrovascular disease. This explains why these patients had such

TABLE 5 *Results of a logistic regression model reported with odds ratio and 95% confidence interval*[a]

	Odds ratio	P	95% Confidence interval
Cerebrovascular (vs traumatic injury)	0.259	.001[b]	0.115–0.580
Anoxic (vs traumatic injury)	0.316	.033[b]	0.110–0.911
Age (>45), y	0.430	.027[b]	0.203–0.910
Sex (male)	0.652	.263	0.308–1.379
Glasgow Coma Scale	1.041	.688	0.855–1.267
RAI, d	1.000	.956	0.990–1.010
RLOS, d	0.998	.362	0.992–1.003
Admission DRS	0.875	<.001[b]	0.811–0.943
Tracheostomy at admission	0.537	.112	0.249–1.156

Abbreviations: DRS, Disability Rating Scale; RAI, rehabilitation acute interval; RLOS, rehabilitation length of stay; Tracheostomy at admission, presence of tracheostomy at admission.
[a]Each odds ratio was adjusted for other variables in the final model that included the 9 variables listed in the table.
[b]$P < .05$.

low GCS scores when compared with the larger population of patients with stroke (ie, ischemic stroke).

With regard to disease severity, previous studies report conflicting results. The studies involving patients with TBI and anoxia report similar levels of GCS and FIM scores in these 2 groups.[6,30] This discrepancy with respect to our data may be explained by differences in selection criteria. Indeed, while our study included only patients with severe ABI, the other studies also included patients with a mild to moderate clinical condition.[6,30]

As to studies comparing patients with TBI versus patients with non-TBI, results across studies have been somewhat divergent. A recent study by Colantonio et al[34] on a very large sample of patients reported higher admission FIM scores in the TBI group, congruent with our findings. On the contrary, a study by Cullen et al[2] reported similar levels of FIM and DRS scores at admission in both (TBI and non-TBI) groups. In our view, this inconsistency may be mainly related to the multifarious composition of the non-TBI groups in the studies.

The length of the RAI in the different groups is an interesting subject of discussion. In our study, the TBI group had a shorter RAI than the other groups. On the other hand, the literature contains reports of similar RAI between patients with TBI and patients with anoxic brain injury[31,32] and between patients with TBI and non-TBI.[2] In our view, this discrepancy may be explained by differences in the organization of rehabilitation care in different countries. In a Canadian study, patients were admitted to the rehabilitation ward after a longer stay (RAI range, 72–84 days)[2] in the ICU than patients in an Italian study (RAI range, 50–62 days[3]; RAI range, 40–58 days in our study) or those in an Austrian study (RAI range, 27–55 days).[5] These different results could imply that patients in Canada are admitted to rehabilitation units when they are rather medically stable and thus in a more favorable stage of their recovery. Furthermore, this could imply that the rehabilitation wards in Italy and Austria not only offer rehabilitation but can also provide some intensive care procedures.

Another issue deserving discussion deals with the rate of recovery during the rehabilitation stay. This study shows that patients with TBI have an overall greater recovery rate (gain) than the other groups. Moreover, although patients with cerebrovascular damage display greater average gain scores than patients with anoxia, these differences are not statistically significant. Previous large-scale studies comparing patients with TBI versus patients with non-TBI reported data congruent with our own.[2,34] However, studies that compared patients with TBI with those with anoxia report conflicting data. Indeed, as in our study, 2 studies reported that patients with TBI achieve greater gains than patients with anoxia.[31,32] On the other hand, Shah et al[6,30] reported that these groups have a similar daily recovery rate and that patients with anoxia tend to have a greater gain than those with TBI. The discrepancy found in the latter studies might be attributed to the small patient samples or to the different levels of severity of the patients (mild, moderate, and severe) included.

The main discharge destination at the end of rehabilitation was home. This occurred most often with TBI patients and least often for those with anoxia. This is in accordance with some studies,[6,9,17,31] but others reported an almost similar rate of return home for patients with TBI and anoxic brain injury.[5,30] Those who did not return home were instead transferred to other hospitals or other rehabilitation or hospital wards.

The logistic regression demonstrated that age, etiology, and DRS admission score most significantly influenced return home. Many previous studies have confirmed that age can predict outcome or discharge home.[7,28,39] One study, however, did not show a significant difference in discharge destination in younger and older individuals with TBI.[20]

The highest probability of returning home, seen in persons with TBI compared with those with cerebrovascular damage and anoxia, could have been due to the lower grade of disability and better cognitive status in these subjects at discharge. This fact, confirmed by the assessment scores, may be associated with an easier management of these patients at home. The lower age of subjects with TBI may be associated with an increased probability to return home because, most likely, these patients have young parents who are able to assist them with their activities of daily living.[20] Subjects with cerebrovascular damage (who in our sample more frequently returned home than subjects with anoxia) demonstrated a lower probability of return home than those with TBI etiology, as shown by logistic regression. This can be explained by the older age of subjects with cerebrovascular damage and by the consequently higher incidence of comorbidity, which increases the likelihood of admission to other destinations because they may be more difficult to manage at home.[3]

Among the various scales, the DRS was selected for the logistic regression because it demonstrated the highest correlation with the other scales used in the study. In particular, the correlation between DRS and LCF was almost optimal (0.89). Studies have provided data regarding the increased specificity and usefulness of this scale compared with others as well as its reduced incidence of ceiling and floor effects.[40,45,47] The increased sensitivity of this scale remains even 2 years after the acute event, and the ceiling effect is minimal even at 5 years after the acute event in subjects with TBI.[23] Studies have confirmed the prognostic value of the DRS score.[16,40,41,46]

To our knowledge, no previous studies have calculated the probability of return home on the basis of specific scores on clinical scales and features in individuals with severe ABI of traumatic, cerebrovascular, or anoxic etiology. The data obtained by the tree regression demonstrated that even patients with severe disability (DRS score <19.5 at admission) have a high probability of returning home (86%). To the contrary, patients in a vegetative state at admission to rehabilitation (DRS score >22.5 at admission) have a far lower probability of returning home (35%) and therefore of a good outcome, independent of the evolution of their clinical picture.

Although discharge destination in patients with severe ABI depends on many variables, including socioeconomic and psychosocial factors, the identification of clinical factors capable of predicting the probability of returning home could be of relevance in the management of patients, as it could assist clinicians in creating appropriate goals, ensuring that both patients and families have realistic expectations about rehabilitation as they begin to plan for the future. In the first stages after admission, clinicians could plan the most suitable rehabilitative program for the patient and, if there is a high probability that the individual will return home, immediately start training the caregivers in necessary postdischarge skills and knowledge. On the contrary, if the probability of returning home is low, clinicians could immediately start considering alternate discharge destinations.

Limitations of the current study include that no follow-up was performed; thus, we do not know whether patients remained home once discharged, and data on comorbidities were not collected.

CONCLUSIONS

This study describes the different patterns of functional and cognitive recovery of patients with severe traumatic, cerebrovascular, or anoxic ABI during inpatient rehabilitation. Although all participants showed some degree of recovery between admission and discharge, those with TBI achieved a greater recovery and returned home more often than patients with cerebrovascular and anoxic brain injury.

Moreover, some demographic and clinical data, specifically age, etiology, and admission DRS score, may be considered as main factors predicting discharge destination. In particular, the admission DRS score was found to be a useful predictor of the probability of returning home in patients with all 3 etiologies of ABI.

Findings of this study could improve knowledge on recovery potential in patients suffering from the most frequent etiologies of severe ABI. Furthermore, they could help clinicians in the planning and organization of rehabilitative procedures from the very early phases of inpatient rehabilitation.

[AQ5]

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Queries to Author

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