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Exploring variables associated with rehabilitation length of stay in brain injuries patients

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***Background*. The impact of outcome measure as early variables on rehabilitation length of stay (LOS) in traumatic brain injury (TBI) patients remains poorly investigated.**
***Aim*. To investigate: 1) the association between LOS and motor and functional outcomes; 2) the predictive factors of LOS in TBI patients admitted to a rehabilitation center.**
***Design*. Retrospective study.**
***Setting*. Inpatient TBI Rehabilitation Centre.**
***Populations*. 241 TBI patients (190 males and 51 females, mean age 43.61±19.4 years, initial Glasgow Coma Scale of 6.96±3.39).**
***Methods*. We recorded demographic characteristics (age, sex, setting and LOS in the acute phase, rehabilitation LOS) and outcome measures (Glasgow Outcome Scale, Disability Rating Scale, Levels of Cognitive Functioning, Functional Independence Measure).**
***Results*. Average rehabilitation LOS was 58.82±58 days; 191 (79%) subjects were discharged from the rehabilitation center within 90 days. Rehabilitation LOS was significantly correlated with acute-care LOS (P=0.001) and Glasgow Coma Scale, but not with patients' age (P=0.250) or sex (P= 0.348). Rehabilitation LOS was significantly correlated with functional and cognitive admission outcome scores but not with gains during rehabilitation. Rehabilitation LOS was significantly less in the group of patients that returned back home respect to others. Regression analysis also illustrated that longer acute-care LOS was independently associated with significantly increased rehabilitation LOS (P<0.001).**
***Conclusion*. Our retrospective study suggests that rehabilitation LOS in TBI patients is correlated with timing of and score at admission to the rehabilitation setting rather than with gains in functional outcome.**
***Clinical Rehabilitation Impact*. This result may help to optimize inpatient service utilization, especially in term of LOS.**

KEY WORDS: Brain injuries - Length of stay - Treatment Outcome - Rehabilitation.

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Each year, about 1.5 million people affected by traumatic brain injury (TBI) die and several million receive subsequent emergency treatment.[1, 2] TBI is the leading cause of disability under the age of 40, with a deep impact on social and work reintegration and quality of life.[3, 4] Despite a growing emphasis on standardization in TBI care, rehabilitation is often lengthy and costly, and typically requires special facilities, equipment, and staff specialized in acute trauma.[5-7] In TBI patients, early admission to the rehabilitation setting is correlated with improved neurological outcomes, and significant associations have also been observed between length of stay (LOS) in the acute-care setting and higher rehabilitation charges.[8, 9] The influence of early (acute) and sociodemographic variables on rehabilitation LOS and inpatient rehabilitation costs has been studied. Several factors have been identified as significant predictors of rehabilitation LOS,[10] including rehabilitation intensity,[11] abnormal findings from

computed tomography, FIM score at admission,[10, 12] medical complications,[12-15] age,[10, 14, 16, 17] presence of intracranial bleeds, skull fractures, length of acute hospitalization,[10] and severity of injury.[10, 14] Specifically, longer rehabilitation LOS were seen in patients with lower functional independence at admission,[10, 12] medical complications such as extremity fractures and/or respiratory problems,[12-15] older age,[10, 14, 17] and more severe TBIs.[10, 11] The Italian Health Care System requires rehabilitation treatments for patients with severe acquired brain injury and particularly for patients with severe TBI (first 24-hours worst score at Glasgow Coma Scale ≤8) to be undertaken with special hospital wards called Units for Severe Acquired Brain Injury. Also subjects with milder levels of disability can be admitted to intensive rehabilitation on condition that they present important motor, cognitive and behavioral rehabilitation needs. Our Health Care System provides complete coverage for the whole in-hospital stay and no restriction on the LOS. A well-structured rehabilitation project should help an early estimation of LOS over the final outcome. This would permit better admission planning, optimize resources employment and define inpatient rehabilitation timing.

To our knowledge the studies on post-TBI patients that have attempted to identify factors influencing rehabilitation LOS in relation to early variables have yielded contrasting, mixed results.[18, 19] The working hypothesis is that longer rehabilitation LOS in TBI patients leads to better motor and functional outcome with less disability at discharge. The goal of our study on a population of TBI subjects admitted to a rehabilitation center was therefore: 1) to investigate the association between rehabilitation LOS and motor-functional outcomes; and 2) to determine the variables that influence rehabilitation LOS.

Materials and methods

Participants and procedure

A retrospective study was conducted in all patients consecutively admitted to the TBI centre of the "Sacro Cuore Don Calabria" Rehabilitation Department of Negrar (Verona, Italy), between January 2004 and November 2009. This Center's rehabilitation team is specifically skilled in the rehabilitation of TBI patients. Inclusion criteria were: 1) patients at their first TBI; 2) age ≥ 12 and < 85 years, 3) complete medical record; 4) outcome assessment carried out within 48 hours of admission and discharge from the rehabilitation center. Exclusion criteria were: 1) rehabilitation LOS ≤6 days and >300 days; 2) death occurring during hospitalization; 3) difficulty discharging the patients due to failure to find a suitable placement at the end of the rehabilitation program; 4) patients in a vegetative state. Initial Glasgow Coma Scale (GCS) scores were obtained from the initial emergency room reports and/or neurosurgical intensive care unit records within the first 24 hours after injury. The GCS between 3 and 8 correspond to severe injury.[20]

Demographic characteristics were recorded from medical records of patients, including: 1) age; 2) sex; 3) acute phase setting (neurosurgery or other ICUs); 4) time between TBI injury and rehabilitation admission; and 5) rehabilitation LOS. Discharge disposition was investigated and categorized as home with or without support and institution that include skilled nursing facilities, chronic hospital, long-term residences and special units for vegetative state.

The study was notified to our Institutional Review Board as requested by Hospital norms about retrospective study.

Outcome indicators

All TBI patients included in the study were evaluated at admission and discharge from the TBI rehabilitation center, by:

1) Glasgow Outcome Scale (GOS), used to investigate early acute medical predictors of gross outcome according to five categories: dead, vegetative, severely disabled, moderately disabled, and good recovery;[21, 22]

2) Disability Rating Scale (DRS) was originally developed to follow rehabilitative progress from come through different levels of functioning to return to community and it can help identifying patients most likely to benefit from in-hospital rehabilitation.[23] DRS measures functional ability by 8 items (maximum score=29 -extreme vegetative state; minimum score =0 - person without disability). The lower the score, the greater the level of independence, with researchers reporting good inter-rater reliability.[23, 24] Ratings between 0 and 5 are given for each, with total score indicating level of cognitive disability.

Overall score is used to determine whether disability is mild, moderate or severe;[23, 24]

3) Levels of Cognitive Functioning (LCF) scale, which is one of the earliest instruments developed to classify cognitive functioning according to eight levels (maximum score =8; minimum score =1 no response);[25]

4) Functional Independence Measure (FIM), which is a functional assessment measure in the rehabilitation community; it is an 18-item, 7-point ordinal scale, with increasing values indicating greater levels of independence. The 18 items describe levels of self-care, continence, mobility, communication and cognition; the sum of all 18 items gives the patient's total score, which ranges from 18-126.[26, 27]

Assessments were completed within 72 hours of admission to and discharge from inpatient rehabilitation.

Rehabilitation program

The "Sacro Cuore Don Calabria" TBI center of Negrar (Verona, Italy) is staffed by an interdisciplinary team, including physiatrists, neurologists, physical therapists, occupational therapists, speech-language pathologists, nurses, neuropsychologists, and social workers. Admission criteria to the inpatient rehabilitation program included the ability to participate in therapy, stable medical course, and the admitting physiatrist's clinical judgment of the potential benefits of the program to the patient. Therapies focused on individualized functional goals identified on admission to rehabilitation by the interdisciplinary team. Patients received three or four hours of physical and occupational therapy each day as well as psychology services. Where indicated, speech therapy was utilized for communication and swallowing problems. The treatment planning derives from a medical evaluation and rehabilitation project, which is based both on functional overall assessment (DRS, FIM, GOS and LCF score) and other specific problems (*e.g.*, speech, dysphagia, behavioral assessment). Time of discharge was decided by the rehabilitation team and determined when patients reached their functional goals.

Statistical analysis

Experimental data were organized in a spreadsheet and then imported in the R statistical environment (R version 2.10.1) to perform the statistical analysis.[28] For all variables basic statistics were calculated according to their measurement scale: mean, standard deviation, variance, variation coefficient, range for numerical variables; minimum and maximum frequency classes (mode) for nominal or ordinal factors. An error alpha value was set at 0.05 for all significance tests.

The difference between admission and outcome score (Delta) was calculated for FIM, GOS, LCF, DRS. Spearman's rank correlation coefficient was used to evaluate the association between ordinal factors or numerical discrete variables (*i.e.*, number of days). Cramer's V and the χ^2 test were used to test the association between nominal and ordinal factors. Pearson's correlation coefficient was calculated between numerical variables; when a correlation was significant, a simple linear regression analysis was performed to improve data description. Linear regression analysis was also performed between acute-care LOS and rehabilitation LOS. The significance of coefficients was tested using the ANOVA test.[29]

Results

Description of the subjects

We recruited 250 subjects post-TBI (196 males and 54 females, mean age 42.16 ± 19.00 years). Nine patients were excluded from the study because 5 of them (3 females and 2 males) had an LOS of less than 5 days, while 3 (all male) died during hospitalization. One patient was excluded due to his very long rehabilitation LOS (540 days). Hence, the study included 241 subjects (mean age 43.61±19.45 years): 190 males (mean age 42.33±18.59) and 51 females (mean age 48.35±21.93) with a 4:1 ratio (78.83% males *vs.* 21.16% females). Subjects were admitted to rehabilitation for an average of 37.76±25.13 days after TBI (males: 38.36±26.31 days; females: 35.48±20.09 days). Most patients (193 of all; 159 males and 34 females) were referred from the Neurosurgery Department.

The mean GCS score, recorded in the acute phase, was 6.96±3.39. The outcome variables measured at rehabilitation admission and discharge, are presented in Table I. There is a statistically significant improvement over the course of admission for all assessment tools (P<0.001).

Rehabilitation length of stay and outcome indicators

Rehabilitation LOS ranged between 7 and 260 days (mean 58.82±58.01; males: 58.45±59.10; females: 60.22±54.27). Of the 241 patients, 98 (40%) were discharged from our Rehabilitation Department within 30 days of hospitalization, 163 (67%) within 60 days, 191 (79%) within 90 days and 220 (91%) within less than 150 days. No significant correlation was found between rehabilitation LOS and age (P=0.250; r=-0.08), sex (P=0.348; r=0.01) or GCS (P=0.0980; r=0.080) of patients with TBI, but statistical significance was found between LOS in the acute-care setting (*i.e.*, from the day after trauma to rehabilitation admission) and rehabilitation LOS (P<0.001; r=0.41).

To more clearly explain the relationship between rehabilitation LOS and disability we divided our population into nine groups according to rehabilitation LOS, based on increasing intervals of 30 days: the patients with greater levels of disability had a longer rehabilitation LOS (Table II). Rehabilitation LOS was statistically correlated with rating scale scores at admission but not with gains as measured by FIM, GOS, DRS and LCF (Table III) and with GCS (P=0.000; r=-0.41). With regard to severity of injury the patients with a GCS score between 3 and 8 showed (N.=145; 60.1%) a statistically correlation (P=0.000; r=-0.45), but the others patients with a GCS >8 showed not a significant correlation (P=0.150; r=-0.133).

Figure 1 shows the linear regression analysis be-

TABLE I.—*Outcome variables measured in post-TBI patients at admission and discharge from Rehabilitation Center (The value are expressed with mean and standard deviation).*

Outcome variables	Rehabilitation admission	Rehabilitation discharge
Disability Rating Scale (score=0-29)	14.10 (6.68)	8.88 (6.39)
Glasgow Outcome Scale (score=0-5)	3.11 (0.61)	3.61 (0.82)
Levels of Cognitive Functioning (score=1-8)	5.19 (1.94)	6.47 (1.67)
Functional Independence Measure (score=18-126)	45.98 (32.02)	77.93 (38.12)

TABLE II.—*Outcome variables (mean value and standard deviation) at time of admission to Rehabilitation Department according to length of stay in rehabilitation setting (in days). GCS: Glasgow Coma Scale; DRS: Disability Rating Scale; GOS: Glasgow Outcome Scale; LCF: Levels of Cognitive Functioning; FIM: Functional Independence Measure.*

Rehabilitation LOS (days)	Number subjects	GCS	DRS	GOS	LCF	FIM
7-30	98	8.15 (3.46)	9.23 (4.90)	3.45 (0.61)	6.37 (1.36)	70.28 (32.56)
31-60	65	7.50 (3.27)	14.92 (5.45)	3.06 (0.43)	5.25 (1.68)	36.89 (22.03)
61-90	28	6.92 (3.34)	16.96 (4.92)	2.89 (0.42)	4.54 (1.86)	28.29 (14.63)
91-120	17	4.78 (1.99)	20.12 (3.28)	2.82 (0.39)	3.59 (1.23)	20.71 (3.79)
121-150	12	4.00 (1.53)	19.75 (6.44)	2.50 (0.52)	3.50 (2.15)	22.00 (6.48)
151-180	4	4.50 (2.12)	22.50 (1.73)	2.50 (0.58)	2.25 (0.50)	19.50 (3.00)
181-210	10	4.88 (2.10)	21.00 (3.33)	2.70 (0.48)	3.10 (0.99)	18.30 (0.67)
211-240	2	4.00 (1.41)	23.00 (2.83)	2.50 (0.71)	2.50 (0.71)	18.00 (0.00)
241-270	5	3.33 (0.58)	24.60 (0.58)	2.20 (0.84)	2.20 (0.45)	18.00 (0.00)

TAB. III.—*Results of correlation between rehabilitation LOS and outcome variables measured at rehabilitation admission and discharge expressed as differences between admission and discharge ([a]). DRS= Disability Rating Scale; GOS= Glasgow Outcome Scale; LCF= Levels of Cognitive Functioning; FIM= Functional Independence Measure.*

Outcome indicators	Time to evaluation	P	r
DRS (score=0-29)	Admission	<0.001	-0.22
	A-D[a]	0.470	0.01
GOS (score=0-5)	Admission	<0.001	-0.41
	A-D[a]	0.400	-0.02
LCF (score=1-8)	Admission	<0.001	-0.36
	A-D[a]	0.200	0.06
FIM (score=18-126)	Admission	0.010	-0.17
	A-D[a]	0.190	0.06

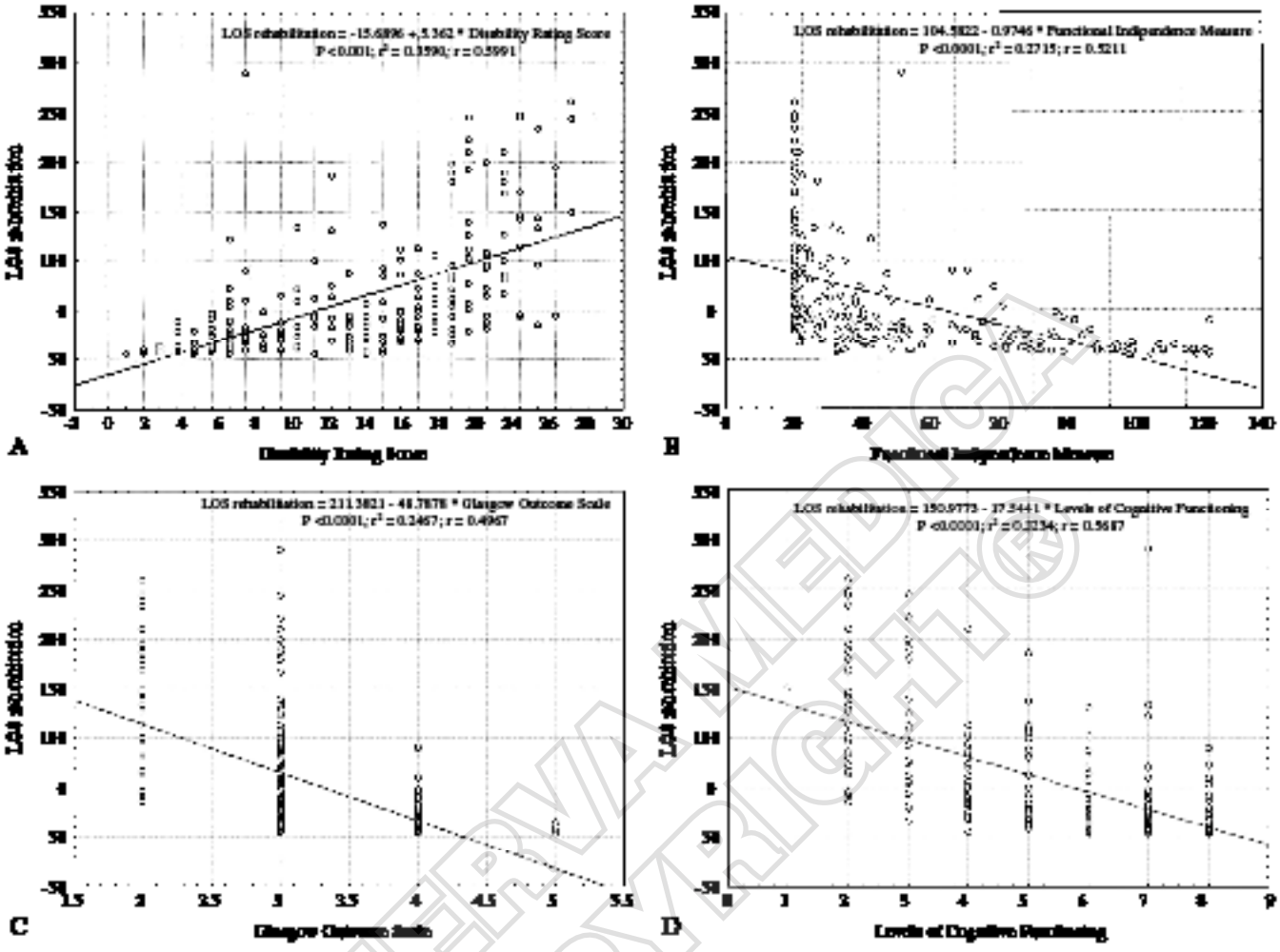

Figure 1.—Linear regression analysis between length of stay in rehabilitation setting (LOS rehabilitation) and Disability Rating Scale (A), Functional Independence Measure (B), Glasgow Outcome Scale (C) and Levels of Cognitive Functioning (D) at the admission in Rehabilitation setting.

tween rehabilitation LOS and DRS, GOS, LCF and FIM at the admission in Rehabilitation setting. Linear regression analysis performed to describe the relationship between LOS in the acute-care and LOS rehabilitation settings also revealed that longer acute-care LOS was independently associated with a significantly higher increase in rehabilitation LOS (P<0.001; r=0.405) (Figure 2). Linear regression analysis performed on the whole dataset identified this function as [Length of stay] =23.22+0.97 x [Time between trauma and rehabilitation admission time]. While omitting residues (too high or too low values, at the extremes of the distribution) with an asymmetric distribution, the following appears to be valid: [Length of stay] =0.97 x [Time between trauma and rehabilitation admission time].

With regard to disposition after hospital discharge, 177 (73.2%) of patients returned back home directly or continued with a rehabilitation program as an outpatient while the remaining 64 patients (26.8%) were recovered in various institution. The patients that returned back home showed a LOS significantly less to others (mean 54.09±60.7 *vs.* 77.98±56.3; P=0.007), no differences in age (average 42.33±19.6 *vs.* 45.46±18.4), but a significant differences at GCS (mean 7.44±3.5 *vs.* 5.76±2.5, P=0.003)

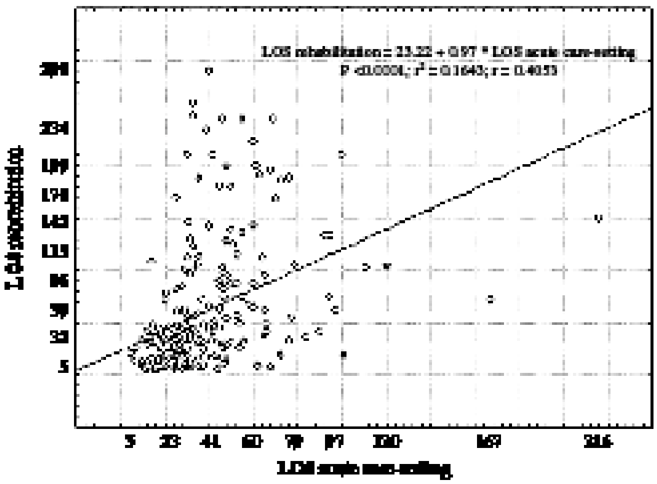

Figure 2.—Linear regression analysis between length of stay in acute-care setting (LOS acute care-setting) and length of stay in rehabilitation setting (LOS rehabilitation).

and LOS (mean 35.47±21.0 *vs.* 45.29±34.2; P=0.043) in the acute-care setting, and DRS (mean 13.10±6.5 *vs.* 16.81±6.43; P=0.001), LCF (mean 5.46±1.9 *vs.* 4.42±1.8; P=0.001) and FIM (mean 50.03±32.7 *vs.* 35.12±28.9; P=0.001) at admission to rehabilitation respect to other group.

Discussion

Our retrospective study shows that rehabilitation LOS in patients with TBI does not seem to be correlated with functional and cognitive outcome gains. Our initial working hypothesis was that longer rehabilitation LOS would lead to greater functional recovery and greater reduction of disability, measured at discharge from the rehabilitation centre. In contrast to others,[10] our results on 241 TBI subjects reveal a lack of relationship between gains score and rehabilitation LOS, as measured by the FIM, GOS, LCF and DRS scales. Hence longer rehabilitation LOS does not seem to lead to a better final motor and functional outcome.

Our population is comparable to other studies in the literature in terms of sex and age distribution, confirming that TBI prevalence is greater in young male adults.[30] In our survey 191 subjects were discharged within 90 days of admission to the rehabilitation setting and 220 (91%) within 150 days. Mean rehabilitation LOS is slightly higher than in the study population of Schwartz *et al.*[31] (58.82±58.0 *vs.* 40.70±42.2 days), but other authors have described different rehabilitation LOS in the TBI population: 21.20±12.2 days in Frey *et al.*[32] and 120±70.7 days in Houlden *et al.*[33] Contrary to other authors [16, 17, 19] our results show no association between age of TBI patients and rehabilitation LOS confirming our previous preliminary study.[34]

Frankel *et al.*[17] reported a statistically significant difference between older (age >44 years) and younger patients (age ≤44 years) in relation to rehabilitation but not acute-care LOS: rehabilitation LOS was on average five days longer for older than for younger patients but LOS in the acute-care setting did not differ significantly between the groups.

Some studies have investigated the role of admission functional score, as measured for example by the FIM,[6, 10, 12, 35, 36] in predicting rehabilitation LOS. To determine whether functional score does influence rehabilitation LOS, we assessed the correlation between rehabilitation LOS and the functional and cognitive scores measured at admission to and discharge from rehabilitation. Our results, according to Avesani *et al.*,[34] show that the most severely impaired patients at admission had significantly lower gains at discharge on the FIM, GOS, DRS and LCF scales. A significant correlation was found with both functional and cognitive rating scale scores at admission, but not with gains during rehabilitation. Hence, this study confirms a statistically significant relationship between rehabilitation LOS and motor, functional or cognitive scores at admission as measured by the FIM, GOS, DRS and LCF. As shown in Table II, the rehabilitation LOS is greater in patients with lower scores at admission, therefore we can assume that the functional outcome score at admission could be a useful predictor of LOS in the rehabilitation setting. DRS, GOS, LCF and FIM used in TBI patients to follow rehabilitative progress, show at rehabilitation admission linearly correlated with rehabilitation LOS as shown Figure 1. Some studies [7, 9, 37-39] have investigated the relationship between functional outcome score and acute-care LOS, showing that earlier rehabilitation admission is predictive of successful functional outcome. Our results confirm that longer acute hospitalization and severe TBI as showed at initial GCS are significantly related to longer rehabilitation LOS (P<0.001). We believe that the delay in rehabilitation admission sometimes depends both gravity of injury and medical complications of the

initial trauma (*i.e.*, respiratory or neurosurgical complications, duration of impaired consciousness, etc.) as suggested by Cowen *et al.*[10] and other factors in relation with the environment (*i.e.*, difficulty to discharge patients with severe disability, absence of the family, etc). Likewise, Cope and Hall [39] showed that in a group of TBI patients admitted to rehabilitation one month post trauma, the LOS was twice that of a group admitted earlier (by more than one month). According to the results obtained by Kunik *et al.*,[9] LOS increased by approximately one day for every five-seven days of delay in admission to rehabilitation. Cowen *et al.*[10] suggested that acute medical management affects rehabilitation outcomes in patients with TBI and that acute-care LOS could be an indirect measure of severity: longer total LOS in the severely impaired group mostly resulted from longer acute care. Cowen *et al.*[10] also showed that longer acute-care LOS resulted in statistically significantly lower FIM motor and cognitive scores on admission to rehabilitation. Moreover Slewa-Younan *et al.*[40] illustrated how length of acute hospitalization has been shown to be predictive of outcome (GOS) in a previous study of severely brain-injured patients. In a large retrospective cohort study of TBI survivors based on a multivariable model, Arango-Lasprilla *et al.*[6] identified FIM motor and cognitive scores at admission and acute-care LOS as being risk factors for extended rehabilitation LOS (defined as 67 days or longer in the rehabilitation setting). These results are likely a reflection of more medical and treatment complications among the more severely brain-injured patients. They also support the well-coordinated patient-centered approach during the acute management phase, including medical stabilization and preventive measures to improve outcomes in rehabilitation. Longer acute care intuitively implies more severe injury, and may also delay early rehabilitation and prolong immobilization. The role of the physiatrist in this setting is to coordinate the acute care rehabilitation process, provide expertise in the management of relevant rehabilitation and neuromedical issues, and determine an appropriate level of post-acute rehabilitation care.[7] Earlier, intense, structured rehabilitation intervention by a trained rehabilitation team can produce advantages in terms of motor and functional recovery and of short-term reduction in hospital LOS.[7, 37, 38, 41]

With regard to discharge, a high ratio of people (177, 73.2%) returned back home directly or continued with a rehabilitation program as an outpatient: these group of patients show a LOS in acute care setting significantly less to others and a GCS greater respects to others. At admission in Rehabilitation setting, the group that returned to home shows better outcome indicators to other group as showed by DRS, LCF and FIM scores. According to Cuthbert *et al.*[42] the decision to discharge home a person with moderate to severe TBI appears to be based primarily on severity-related factors. In contrast, the decision to discharge to rehabilitation rather than to subacute care appears to reflect sociobiologic and socioeconomic factors. One patient was excluded from the present study due to his very long rehabilitation LOS (540 days), old age and many socioeconomic problems. Longer LOS, older age, and white race increased the likelihood of not being discharged home. However, an extended LOS it cannot be excluded in some patient with poor outcome waiting a suitable discharge.

Study limitations

Our study has some limitations: 1) we did not determine the presence and any influence on rehabilitation LOS of medical complications which can occur during hospitalization (thrombosis, pneumonia, etc.), although we believe that these conditions do not involve many people in centers specifically dedicated to post-TBI rehabilitation;[11] 2) we have not considered the role of the family and social substratum and their impact on the discharge destination of TBI patients from the rehabilitation setting; 3) conditions did occur during acute-care LOS (length of coma, intracranial pressure elevations, etc.); 4) the study utilizes the whole FIM score but a separate FIM motor score from the FIM cognitive score may be more suitable.

Conclusions

On the base of our results, a longer rehabilitation LOS does not necessarily imply a better outcome of patients. In our study the result show an high percentage of TBI discharge to home: we believe that our results may be related to greater involvement and power of the social and family system in Italy, with the result that old, disabled people are able to be placed with their family or in a subacute care

facility at the end rehabilitation treatment.[43] There are many factors that may lead to the findings; many of them are involved whether the system of care keeps the patients longer in an acute setting, whether there are options such as skilled nursing or day treatment that will affect both the functional status and the recovery of patients. These differ from country to country depending on their health system as underline by others.[44] It is important to stress that many difficulties can, instead, be faced by severely disabled young people (*e.g.*, patients in a vegetative or minimally conscious state) seeking posthospital placement at the end of their rehabilitation program. This poses a major problem in Italy. These results may substantiate the usefulness of tailored rehabilitation programs for the TBI population, based on the severity of admission scores, and at the same time help determine appropriate admission timing and optimization of inpatient service utilization. Future studies are warranted to compare the outcomes of patients treated in inpatient setting admitted to different treatment programs.

We believe that our results may help healthcare providers and family members in rehabilitation team planning, in improving patient and family education, and in better use of healthcare resources. This topic is, nonetheless, the subject of an ongoing study.

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