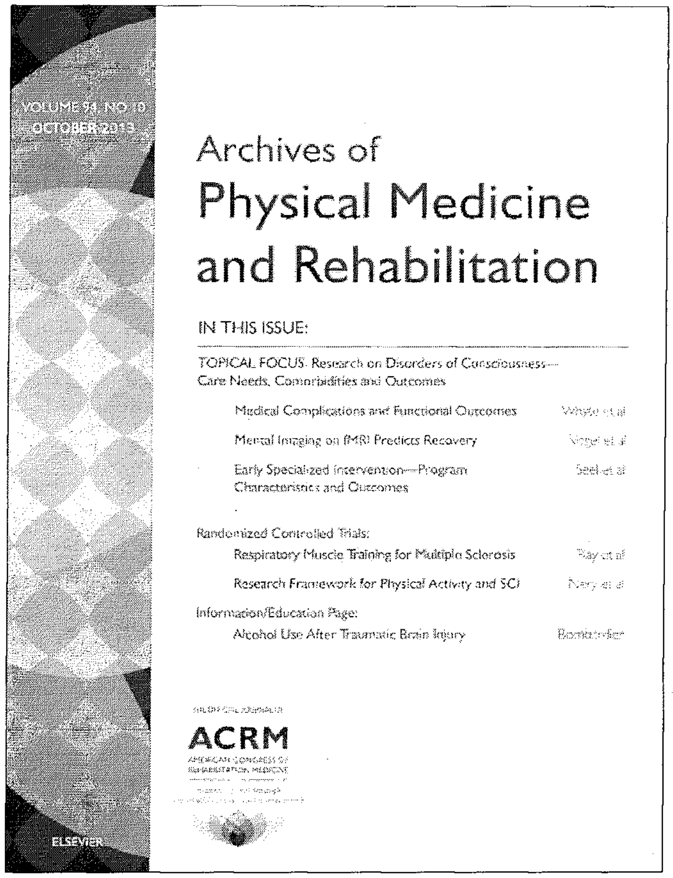
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IN THIS ISSUE:
TOPICAL FOCUS: Research on Disorders of Consciousness—Care Needs, Comorbidities and Outcomes
Medical Complications and Functional Outcomes
Mental Imaging on fMRI Predicts Recovery
Early Specialized Intervention—Program Characteristics and Outcomes
Randomized Controlled Trials:
Respiratory Muscle Training for Multiple Sclerosis
Research Framework for Physical Activity and SCI
Information/Education Page:
Alcohol Use After Traumatic Brain Injury
ACRM
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ORIGINAL ARTICLE

Medical Comorbidities in Disorders of Consciousness Patients and Their Association With Functional Outcomes

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Abstract

Objective: To identify, for patients in states of seriously impaired consciousness, comorbid conditions present during inpatient rehabilitation and their association with function at 1 year.

Design: Abstracted data from a prospective cross-sectional observational study with data collection occurring January 1996 through December 2007.

Setting: Four inpatient rehabilitation facilities in metropolitan areas.

Participants: The study sample of 68 participants is abstracted from a database of 157 patients remaining in states of seriously impaired consciousness for at least 28 days.

Interventions: Not applicable.

Main Outcome Measure: One-year cognitive, motor, and total FIM score.

Results: The most common medical complications during inpatient rehabilitation for the study sample are active seizures (46%), spasticity (57%), urinary tract infections (47%), and hydrocephalus with and without shunt (38%). Presence of $\geq$3 medical complications during inpatient rehabilitation, controlling for injury severity, is significantly ($P<.05$) associated with poorer total FIM and FIM motor scores 1 year after injury. The presence of hydrocephalus with and without shunt ($r=-.20$, $-.21$, $-.18$; $P\leq.15$), active seizures ($r=-.31$, $-.22$, $-.42$), spasticity ($r=-.38$, $-.28$, $-.40$), and urinary tract infections ($r=-.25$, $-.24$, $-.26$) were significantly ($P<.10$) associated with total FIM, FIM cognitive, and FIM motor scores, respectively.

Conclusions: Reported findings indicate that persons in states of seriously impaired consciousness with higher numbers of medical complications during inpatient rehabilitation are more likely to have lower functional levels 1-year postinjury. The findings indicate that persons with $\geq$3 medical complications during inpatient rehabilitation are at a higher risk for poorer functional outcomes at 1 year. It is, therefore, prudent to evaluate these patients for indications of these complications during inpatient rehabilitation.

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After severe traumatic brain injury (TBI) and non-TBI, patients experience seriously impaired consciousness that can last days, months, or years. The goal of inpatient rehabilitation for persons who remain in states of seriously impaired consciousness is to facilitate functional recovery and minimize functional impact of residual impairments. Efforts to achieve this goal include restoration of optimal health and prevention of secondary complications, because such conditions are likely to have deleterious effects on recovery and impede therapeutic efforts.

A study of 224 severe TBI survivors[1] admitted to intensive care examined the relation between nonneurologic complications (cardiovascular, respiratory, septic, abdominal/digestive, endocrinometabolic, and bleeding complications) and death during intensive care. Findings indicate that most subjects incurred sepsis (75%), with the next most common being respiratory infections (68%), hypotension (44%), severe respiratory failure (41%), and acute kidney injury (8%). Among the complications examined, hypotension, severe

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respiratory failure, septic shock, acute kidney injury, bleeding complications, and nonneurologic surgery were factors significantly related to greater risk of death during intensive care.

A statewide population-based mortality study (N = 18,998) of residents discharged alive from acute hospitalization indicates that TBI survivors were 2.5 times more likely to die after acute hospitalization discharge when compared with the general population.[2] Comorbidities found to significantly increase risk of death include seizures (standard mortality ratio [SMR] = 15.0), mental/behavioral disorders (SMR = 4.7), sepsis, digestive system diseases, stroke (SMR = 2.5), as well as circulatory system diseases, respiratory diseases, malignant neoplasms, and external causes, such as suicide, with an SMR of 2.4.

Once transferred to inpatient rehabilitation, medical complications impede therapeutic efforts and are difficult to detect, because the patient in a state of seriously impaired consciousness is not able to report symptoms. During inpatient rehabilitation, hydrocephalus is a common complication that occurs within 30% to 86% of patients examined between 3 and 12 months after severe brain injury (BI).[3] This rate of occurrence is thought to include both hydrocephalus and hydrocephalus ex vacuo.[4] Spasticity, for severe TBI, occurs in about 75% of the patients.[5] Less common complications include seizure, which occurs in about 10% of severe TBI survivors.[6]

Hypertension can be symptomatic of conditions, such as episodic pain or discomfort, and more complex conditions, such as dysautonomia,[7-10] which is a condition that occurs in about 26% of severe BI patients and is more common with older persons and persons incurring traumatic BI (32%) than patients with nontraumatic etiologies (eg, hypoxia = 16%).[9] Dysautonomia is characterized by the presence of ≥5 clinical criteria over a period of at least 2 weeks. The clinical criteria include tachycardia, tachypnea, systolic blood pressure >160mmHg, hyperthermia or hypothermia, excessive sweating, decerebrate or decorticate posturing, increased muscle tone, horripilation, or flushing.[9]

Although treating comorbid conditions optimize the central nervous system by decreasing metabolic costs, the relation between the presence of secondary medical complications during inpatient rehabilitation and long-term functioning is not well understood for persons who remain in states of seriously impaired consciousness for protracted durations. The objective of this article is to report findings from an examination of the relation between 5 common secondary medical complications and functional outcomes, as measured with the FIM, 1 year after severe BI.

Methods

Participants: study sample and study sites

The study sample of 68 patients was abstracted from a larger study database of 157 participants enrolled in an observational study aiming to characterize neurobehavioral recovery trajectories during inpatient rehabilitation relative to functional outcomes. All 157 participants were followed for 1 year after injury to obtain time to full consciousness, and 95 of these participants were interviewed with the FIM at 1 year. Twenty-seven of these 95 participants had missing information regarding medical complications during inpatient rehabilitation. The final sample for this article is, therefore, the 68 patients with complete medical complications data.

Participants, for the larger study, were recruited from 2 freestanding inpatient rehabilitation facilities, one long-term acute care hospital providing inpatient rehabilitation, and 1 Veterans Administration medical center providing inpatient rehabilitation, subacute rehabilitation, and acute care. Subjects were enrolled from 1996 to 2007, and human subjects institutional review board approval was obtained from each participating site.

The larger study sample enrolled all individuals incurring a severe BI and who were (1) admitted to 1 of 4 inpatient rehabilitation sites within 180 days of injury, (2) ≥18 years of age at time of study enrollment, and (3) in a state of seriously impaired consciousness for ≥28 days consecutively at time of study enrollment. Participants were determined to be in a state of seriously impaired consciousness if they did not demonstrate consistent and functional communication of basic needs, use of at least 1 common object, or evidence of behavior indicative of external awareness of their immediate environment.

Persons with TBIs and non-TBIs were eligible for enrollment in the larger study. TBI includes coup-contrecoup, blast, blunt, and penetrating injuries to the brain. Non-TBIs include vascular injuries and anoxia. Subjects were excluded if their BI was the result of cancer, tumors, inflammatory, infectious, and/or toxic metabolic encephalopathies.

Data collection procedures

At the time of study enrollment, each subject's emergency department, intensive care, acute care, and rehabilitation records were reviewed for sociodemographic information, medical history, injury etiology, and injury-related medical conditions. After review of each subject's records, a family/surrogate interview was conducted to collect any information not obtainable from the records and/or to confirm information regarding cause of injury. Data collection procedures did not identify when medical conditions occurred, only whether or not they were present at some time during inpatient rehabilitation. Licensed allied health clinicians, nurses, or trained research assistants completed all medical record abstraction. Data elements were abstracted from history and physical reports, discharge summaries, consult reports, and daily physician documentation. Medical complications tracked as present or absent were urinary tract infections (UTIs), hydrocephalus with or without shunt placement, hypertension, seizures, pneumonia, renal failure, and hypertonicity.

Because there is strong evidence that duration of seriously impaired consciousness may serve as a proxy for injury severity and could confound examinations of the influence of medical complications on long-term functional outcome recovery,[11-16] we needed to measure duration of seriously impaired consciousness. By necessity, this meant defining behavioral criteria for emergence from seriously impaired consciousness into full consciousness that could be measured during inpatient rehabilitation and follow-up interviews after rehabilitation discharge.

Although there is little evidence about the reliability and validity of clinical indices of behavior indicative of full consciousness,[17-21] there is currently, and was at the time of the study, start-up clinical consensus that a patient has emerged from seriously impaired consciousness when he/she demonstrates a consistent ability to (1) communicate interactively and/or (2) appropriately use 2 separate

List of abbreviations:

BI brain injury
PTE posttraumatic epilepsy
SMR standard mortality ratio
TBI traumatic brain injury
UTI urinary tract infection

objects.[22] To minimize the possibility of overestimating the duration of seriously impaired consciousness for clinical subgroups,[23,24] we added a third criterion and developed observation and interview methods to evaluate each patient for indications of emergence to full consciousness. Full consciousness was defined for the study as requiring external and internal awareness demonstrated behaviorally by consistent manifestation of at least 1 of 3 criteria: (1) functional interactive communication, (2) functional use of an object, or (3) another consistent demonstration of behavior indicating an awareness of the environment. An example of this third behavior would be a facial expression or other emotional response to emotionally laden information presented to the patient (ie, joke or sad story). We then developed an algorithm (see supplemental appendices S1 and S2, available online only at the *Archives* website: www.archives-pmr.org) and a corresponding set of probes and questions and scoring form that could be used during inpatient rehabilitation and monthly telephone follow-up interviews for the purpose of identifying a date for emergence into full consciousness. During inpatient rehabilitation, these screenings for indications of full consciousness were conducted 1 or 2 times per week by allied health clinicians. After inpatient rehabilitation, monthly follow-up telephone interviews with the surrogate/primary caregiver were conducted by a trained allied health clinician until 1 year after injury. The duration of seriously impaired consciousness is an informed estimate of the number of days between injury and the approximate date of emergence to full consciousness within the first year of recovery. Timeliness of monthly follow-up interviews varied from patient to patient depending on caregiver availability, and final outcome interviews were completed 12 to 15 months after injury.

The consciousness algorithm, corresponding telephone probes, and interview procedures developed for the study (see supplemental appendices S1 and S2) were used during inpatient screenings and telephone interviews conducted by clinicians with primary caregivers. The algorithm and probes were used to guide each interview and to elicit information sufficient for the clinician to make a determination about whether or not the patient had recovered full consciousness.

The final follow-up interview was conducted at 1 year and included a more comprehensive evaluation (ie, using the Galveston Orientation Amnesia Test) if the consciousness screening indicated a more comprehensive evaluation was necessary. This final interview also included information regarding functional status. This interview was conducted with the primary caregiver and, if able, the subject. If there was a discrepancy in responses between the subject and the primary caregiver, all responses were recorded but the caregiver's response was considered accurate.

FIM instrument

The FIM is a measure of functional independence containing 18 components ranging in value from 1 to 7, with 1 signifying complete dependence and 7 signifying complete independence. Patients scoring lower than 6 on any 1 FIM item generally require some level of supervision for day-to-day tasks (activities of daily living). The total FIM measure includes all 18 items. The highest total FIM score possible is 126.[25]

The cognitive FIM score represents a subset of the total FIM score pertaining to strictly cognitive components. There are 5 such components: comprehension, expression, social interaction, problem solving, and memory. Again, each ranges in value from 1 to 7; therefore, the highest cognitive FIM score possible is 35.

The motor FIM represents a subset of 13 components from the total FIM score, which pertains to physical function. These components include eating, grooming, bathing, upper and lower body dressing, toileting, bowel and bladder management, bed/chair/wheelchair transfers, tub/shower transfers, toilet transfers, locomotion, and locomotion on stairs. The highest motor FIM score possible is 91.

For the purposes of the logistic regression analysis, each FIM variable (total FIM, motor FIM, and cognitive FIM) was dichotomized based on the scores; therefore, persons with an average FIM score of 5 to 7 were in one group and persons with an average FIM score of 1 to 4 were in another. The cut points were chosen to also be clinically meaningful, because someone with a FIM score $\geq$5 typically requires less supervision/assistance than a person with a FIM score of 1 to 4. A FIM score of 5 to 7 on any of the 3 scales (total, motor, or cognitive) represents someone who requires supervision only or is completely independent, whereas a FIM score of 1 to 4 represents the need for total assistance to minimum assistance for given daily tasks.

Data analyses and data elements included in analyses

All analyses were performed with SPSS version 18,[a] and variables included in the analyses are defined in table 1. Descriptive analyses were conducted to describe the study sample and frequency of each medical complication.

Frequency distributions were used to select medical complications for inclusion in analyses. Medical complications collected and not included in analyses because of small sample sizes (N=68 vs n=157) are renal insufficiency (6.8% vs 9.3%), pneumonia (63% vs 59%), and presence of tracheotomy tube at inpatient rehabilitation admission (94% vs 92%).

The relation between secondary medical complications and FIM functioning 1 year after injury was examined by conducting 2 sets of analyses. The first set involved building regression models and also computing and defining cut criterion for a composite variable (eg, number of secondary medical complications) to be used in regression models.

The first step of our regression model building involved computing Spearman ρ correlations between all variables and the 3 FIM outcomes. Any medical complication variable significantly ($P<.05$) correlated with any outcome was then included in the next step, which involved creating a composite medical complication variable. We then inspected frequency distributions of this composite variable (figs 1–3) by outcomes to identify a cut point. The composite medical complication variable was dichotomized, where high complication indicates that the patient had $\geq$3 medical complications. Separate univariate linear regression models were then performed for each outcome using this composite complication variable.

To build multiple regression models, we used results from the univariate linear regression. Multiple linear regression was then performed for each outcome with all of the variables listed in table 1.

To further understand the relation between medical complications, the second set of analyses parceled out the composite medication complication variable. Correlations were computed for each variable that were included in the composite medication complication variable with each of the 3 outcomes.

Results

Descriptive findings for the study sample of 68 abstracted participants relative to the larger study database are provided in table 2. Similar to the larger study database, the abstracted study sample is composed largely of young men who had completed

Table 1 Abstracted data elements

Description	Definition	Type
Active seizures	Had active seizures during inpatient acute care hospitalization or inpatient rehabilitation (yes or no)	Medical complication
Hydrocephalus	Presence of hydrocephalus noted through chart review during inpatient acute care hospitalization or inpatient rehabilitation (yes or no)	Medical complication
Hydrocephalus requiring shunt	Presence of hydrocephalus noted through neurosurgery reports	
Spasticity	Had spasticity during acute care hospitalization or inpatient rehabilitation (yes or no)	Medical complication
UTI	Had urinary tract infection during acute care hospitalization or inpatient rehabilitation (yes or no)	Medical complication
Injury onset hypertension	Presence of hypertension as diagnosed in medical progress notes indicating that untreated blood pressure is about 140/90mmHg (yes or no)	Medical complication
Preinjury hypertension	Self-report by family in interview	Covariate
Preinjury hypotension	Self-report by family in interview	Covariate
Renal insufficiency	Had renal insufficiency during acute care hospitalization or inpatient rehabilitation (yes or no)	Medical complication
Pneumonia	Had pneumonia during acute care hospitalization or inpatient rehabilitation (yes or no)	Medical complication
Tracheotomy tube	Presence of tracheotomy tube on admission to inpatient rehabilitation (yes or no)	Medical complication
No. of medical complications	Number of the following complications present: UTI, hydrocephalus severity, active seizures, injury onset hypertension, and spasticity during acute care hospitalization or inpatient rehabilitation	Covariate
Time between date of injury and rehabilitation admission	Number of days between date of injury and admission to inpatient rehabilitation	Covariate: proxy for injury severity
Etiology	Had a closed head injury defined as closed head injury or blast injury OR other type of BI defined as open head injury, anoxic, or hemorrhagic	Covariate
Age at injury	Age in years at time of injury	Covariate
Income category	Income at time of injury based on categories: \$0–\$24,999, \$25,000–\$49,999, ≥\$50,000	Covariate
Positive blood alcohol level at injury	Had a positive blood alcohol level at time of injury (yes or no)	Covariate
Preinjury alcohol abuse	Had a history of alcohol abuse prior to injury (yes or no)	Covariate
Total days (not consecutive) of inpatient rehabilitation	Total number of days spent in inpatient rehabilitation during the first year of injury	Covariate: proxy for injury severity
Duration of unconsciousness	Total number of days patient was unconscious from date of injury to date for recovery of full consciousness within the first year	Covariate: proxy for injury severity
Did or did not have return to full consciousness within 1y of injury	Recovered full consciousness according to consciousness screening/algorithm within 1y of injury (yes or no)	Covariate: proxy for injury severity

some college without completing a degree prior to incurring a closed head injury. The sample included married and single subjects (never married, divorced, or widowed) who at time of injury were gainfully employed and lived in a household with an income of approximately \$50,000 per year. Most subjects had private or other types of health insurance benefits and received an

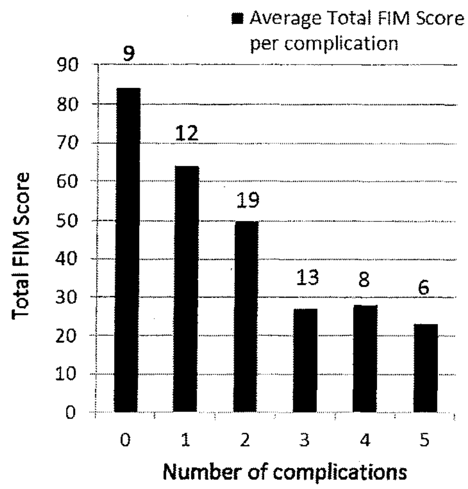

Fig 1 Average total FIM scores 1 year after injury according to the number of complications present during inpatient rehabilitation. Sample size of subjects for each number of complications is provided at the top of each bar. Total FIM could not be computed for 1 subject with 2 complications because a FIM cognitive item was missing. One outlier, with a total FIM score of 102, was removed from the group of subjects with 5 complications.

average ± SD of 64.1±47.0 days of inpatient rehabilitation. Persons with TBI and non-TBI because of anoxia composed most of the sample. The most common medical complications during rehabilitation for the sample are active seizures, spasticity, UTIs, and hypertension new since injury.

The first step of our regression model building involved computing Spearman ρ correlations between all variables and the 3 FIM outcomes (table 3). The medical complications (presence of active seizures, hydrocephalus, spasticity, and UTI), which were significantly ($P<.05$) correlated with at least 1 of the 3 outcomes,

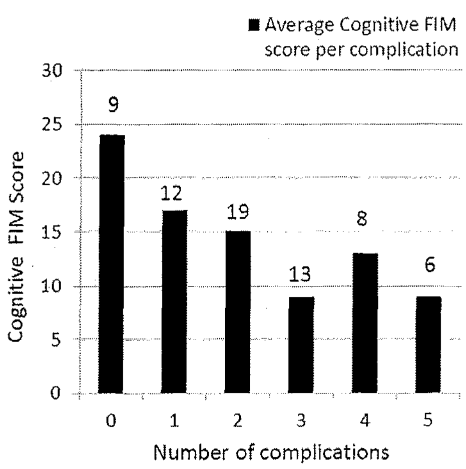

Fig 2 Average 1-year postinjury FIM cognition scores according to the number of complications present during inpatient rehabilitation. Sample size of subjects for each number of complications is provided at the top of each bar. A FIM cognitive item was missing; therefore, it could not be computed for 1 subject with 2 complications. One outlier, with a FIM cognitive score of 29, was removed from the 5 complication group.

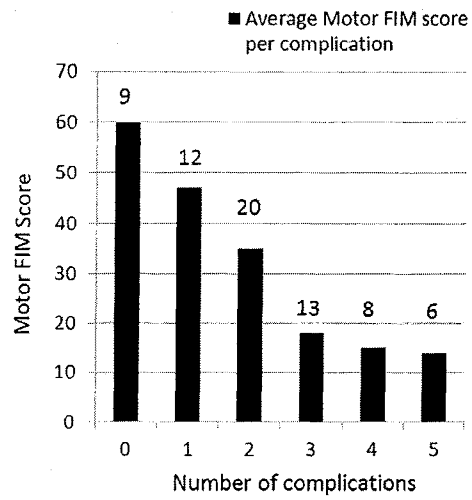

Fig 3 Average 1-year postinjury FIM motor scores according to the number of complications present during inpatient rehabilitation. One outlier, with a FIM motor score of 73, was removed from the group with 5 complications.

were included in the next step, which involved creating a composite medical complication variable. Frequency distributions (see figs 1–3), inspected to create this composite variable, indicate that most of the sample had at least 2 of the medical complications with notably fewer subjects having >3. Therefore, the composite medical complication variable was dichotomized, where high complication indicates that the patient had ≥3 medical complications. The discrepancy in sample size in figures 1 and 2 versus figure 3 is related to 1 subject missing complete FIM cognitive data. This in turn reduced the FIM cognitive and total FIM sample size by 1 when compared with FIM motor.

Correlational analyses conducted to examine the relation between the new composite variable of the number of complications with the 3 outcomes, indicate that the composite variable is correlated with all 3 FIM outcomes (FIM cognitive: −.38, $P=.001$; FIM motor: −.49, $P<.001$; total FIM: −.45, $P<.001$), suggesting that as the presence of medical complications during inpatient rehabilitation increases, functioning at 1 year decreases.

Univariate regression models for each variable with a significant correlation (see table 3) (except the medical complications variables) and the composite variable of the number of complications were conducted for each of the 3 FIM outcomes (table 4). Because all of these variables are significantly related to each outcome, all variables were included in multiple regression models (table 5).

Multiple linear regression analyses include high or low number of medical complications, BI not the result of a closed head injury, and >45 days between date of injury and admission in each of the 3 outcome models. High number of complications, controlling for etiology, and days between injury and admission are significantly related to FIM motor and total FIM scores 1 year after injury. This evidence, synthesized with correlational findings in table 3, indicates that when injury severity is controlled for, presence of hydrocephalus (with and without shunt), active seizures, spasticity, and UTIs during inpatient rehabilitation are associated with lower functioning 1 year after injury. Each of the 4 medical complications included in the composite variable is also

Table 2 Comparison of abstracted sample to full sample

Variable	Abstracted Sample (% of total; N=68)	Full Sample From Larger Study Database (% of total; n=157)	Student *t* Test Statistic or χ^2 Values (*P*)
Male sex	42 (61.8)	105 (66.9)	0.927† (.336)
Mean age ± SD at injury	35.40±17.00	37.15±17.00	−1.384* (.168)
Education	No high school diploma, 5 (7.5)	9 (6.6)	4.094† (.769)
	High school diploma, 16 (23.9)	34 (25.0)	
	Community college/trade school, 11 (16.5)	22 (16.2)	
	Some college no degree, 23 (34.3)	42 (30.9)	
	Bachelors degree, 8 (11.9)	14 (10.3)	
	Graduate/professional degree, 4 (6.0)	9 (6.6)	
Marital status at injury	Married, 28 (41.2)	66 (44.9)	6.143† (.293)
	Divorced/separated, 8 (11.7)	14 (9.6)	
	Single/widowed, 32 (47.1)	65 (44.2)	
Income categories	<$24,999, 11 (20.0)	25 (22.5)	3.810† (.149)
	$25,0000–$49,999, 10 (18.2)	26 (23.4)	
	>$50,000, 34 (61.8)	60 (54.1)	
Employment/occupation	Technical/sales/ administrative, 6 (16.2)	17 (17.9)	0.134† (.988)
	Manager/professional, 9 (24.3)	23 (24.2)	
	Operator/laborer, 11 (29.7)	27 (28.4)	
	Services, 11 (29.7)	28 (29.5)	
Employment status	Full-time employed, 29 (43.9)	74 (53.2)	12.031† (.061)
	Full-time student, 12 (18.2)	14 (10.1)	
	Part-time employed, 9 (13.6)	16 (11.5)	
	Homemaker, 5 (7.6)	9 (6.5)	
	Unemployed, 6 (9.1)	15 (10.8)	
	Retired, 5 (7.6)	10 (7.2)	
Insurance status	Uninsured, 3 (4.7)	6 (4.6)	0.737† (.947)
	HMO/PPO/private insurance, 39 (61.0)	81 (61.8)	
	Other insurance, 22 (34.4)	44 (33.6)	
Etiology			6.240† (.284)
Open head injury	3 (4.4)	4 (2.6)	
Aneurysm	1 (1.5)	4 (2.6)	
Blast	3 (4.4)	5 (3.3)	
Hemorrhage	3 (4.4)	8 (5.3)	
Anoxia	8 (11.8)	26 (17.1)	
Closed head injury	50 (73.5)	105 (69.1)	
Active seizure	31 (45.6)	55 (44.4)	0.010† (.918)
Hydrocephalus	26 (38.2)	44 (34.6)	0.446† (.504)
Spasticity	38 (56.7)	59 (52.7)	1.546† (.214)
UTI acute phase	32 (47.1)	56 (44.4)	0.193† (.661)
Hydrocephalus requiring shunt	21 (30.9)	29 (22.8)	0.527† (.769)
Injury onset hypertension	29 (42.6)	52 (43.0)	0.006† (.939)
Preinjury history of hypertension	10 (14.9)	30 (21.4)	3.709† (.157)
Renal insufficiency	4 (5.9)	6 (3.8)	19.136† (<.001)
Pneumonia	42 (61.7)	76 (48.4)	0.639† (.424)
Tracheostomy	60 (88.2)	130 (82.8)	0.392† (.531)
Preinjury history of hypotension	2 (3.0)	4 (2.9)	4.591† (.101)
Mean days ± SD between injury and inpatient rehabilitation admission	54.19±37.01	70.46±95.37	0.315* (.753)

(*continued on next page*)

Table 2 (*continued*)

Variable	Abstracted Sample (% of total; N=68)	Full Sample From Larger Study Database (% of total; n=157)	Student t Test Statistic or χ^2 Values (P)
No return of consciousness within 1y	18 (28.6)	49 (38.9)	4.990† (.025)
Positive blood alcohol level at time of injury	15 (23.4)	21 (16.5)	4.793† (.029)
History of alcohol abuse prior to injury	8 (12.5)	15 (11.8)	0.095† (.759)
Mean no. of days ± SD of unconsciousness	134.70±105.67	162.70±269.50	−0.962* (.339)

Abbreviations: HMO, Health Maintenance Organization; PPO, Preferred Provider Organization.
* t test statistic.
† χ^2 test statistic.

individually associated (P<.05) with lower FIM motor functioning and total FIM functioning scores 1 year after injury (see table 3).

Discussion

For persons admitted to inpatient rehabilitation who have been in states of seriously impaired consciousness for at least 28 days after incurring a severe BI, the findings provide initial information about the relation of medical complications present during inpatient rehabilitation and function 1 year after injury. The reported findings are aligned with clinical expectations in that the higher the number of medical complications, the poorer the functional outcomes at 1 year. Findings indicate that persons with ≥3 medical complications during inpatient rehabilitation are at risk for poorer functional outcomes at 1 year.

Individual medical complications present during inpatient rehabilitation and associated with lower scores of functioning at 1 year are hydrocephalus, active seizures, spasticity, and UTI. The relation between hydrocephalus, seizure, and spasticity on function is fairly clear, but the relation between UTI and function is less clear.

Reported findings support an aggressive diagnostic approach to identifying and treating hydrocephalus. Although hydrocephalus can be difficult to detect in this population, it is known that patients in states of seriously impaired consciousness who are more likely to incur hydrocephalus are those patients who experienced elevated intracranial pressure during intensive care, papilloedema, or cranioplasty.[3,26] Given that patients cannot report symptoms during inpatient rehabilitation, basic clinical indicators, such as blood pressure or temperature, combined with declines in neurobehavioral functioning, as reflected in declining scores on

Table 3 Correlations* with FIM 1 year after injury (N=68)

	Correlations (P)		
Variables	FIM Total	FIM Cognitive	FIM Motor
Seizure	−.312 (.010)	−.221 (.070)	−.416 (.000)
Hydrocephalus	−.202 (.099)	−.211 (.085)	−.176 (.151)
Hydrocephalus with shunt	−.155 (.205)	−.167 (.173)	−.125 (.308)
Spasticity	−.379 (.002)	−.277 (.023)	−.395 (.001)
UTI	−.254 (.036)	−.241 (.047)	−.258 (.033)
Hypertension postinjury	.173 (.158)	.164 (.181)	.198 (.105)
Pneumonia	.013 (.906)	.060 (.60)	.001 (.992)
Renal failure	−.073 (.556)	.024 (.846)	−.230 (.062)
Trach present during acute phase	.099 (.360)	.013 (.907)	.158 (.143)
History of preinjury hypertension	.100 (.423)	.068 (.585)	.174 (.158)
History of preinjury hypotension	.250 (.041)	.259 (.034)	.212 (.085)
No. of medical complications	−.451 (.000)	−.383 (.001)	−.493 (.000)
Time from injury to admission	−.230 (.086)	−.181 (.179)	−.284 (.032)
Etiology	.265 (.029)	.291 (.016)	.229 (.060)
Age	−.072 (.562)	−.082 (.507)	−.147 (.232)
Income	.269 (.047)	.252 (.063)	.159 (.246)
Positive blood alcohol level at injury	−.045 (.727)	−.040 (.751)	−.054 (.669)
History of alcohol abuse prior to injury	−.115 (.364)	−.131 (.302)	−.111 (.381)
Total days in inpatient rehabilitation	.303 (.014)	.256 (.040)	.324 (.008)
Days of unconsciousness	−.288 (.052)	−.105 (.486)	−.347 (.018)
Return of consciousness in 1y	−.679 (.000)	−.655 (.000)	−.593 (.000)

* Two-tailed Spearman ρ correlation.

Table 4 Univariate regression analyses results (N=68)

1y FIM Outcomes	High No. of Medical Complications*	Etiology (closed head vs other)	Days Between Injury and Admission†
Cognitive FIM	−6.554 (−11.002 to −2.105)‡	6.513 (1.130 to 11.896)‡	−4.394 (−9.463 to 0.675)
Motor FIM	−26.450 (−39.541 to −13.359)‡	16.113 (−.777 to 33.003)	−15.886 (−30.986 to −0.787)‡
Total FIM	−33.004 (−49.618 to −16.389)‡	22.626 (1.398 to 43.855)‡	−20.280 (−39.435 to −1.126)‡

NOTE. Values are β (95% confidence interval).
* Three or more of the following: seizures, urinary tract infection, hydrocephalus, hydrocephalus requiring a shunt, and increased tone.
† Divided into equal to or less than the median amount of time between date of injury (referent) and admission versus >45 days (index).
‡ Statistically significant results.

a neurobehavioral measure, such as the Disorders of Consciousness Scale, or decline in level of alertness or arousal, could also serve as indicators of the presence of hydrocephalus. Suspected hydrocephalus should be distinguished from hydrocephalus ex vacuo, a dilation of the ventricles and the subarachnoid space as a result of cerebral atrophy or tissue loss, using repeated computed tomography, magnetic resonance imaging, and/or cerebral spinal fluid output measures.[26]

The probability of a person experiencing a seizure after a severe BI is about 10%,[6] and antiepileptics can be effective in protecting against early (provoked) seizures within 7 days of injury. No antiepileptic treatment, however, has been found to protect against the development of posttraumatic epilepsy (PTE), which is generally accepted to be a condition where recurrent unprovoked seizures separated by more than 24 hours occur.[27] Seizures or PTE late after injury (ie, 1wk) occur in 13% to 50% of patients in states of seriously impaired consciousness.[27] Although an absence of seizure activity indicates that the use of long-term anticonvulsant prophylaxis is not warranted,[28] suspected seizure activity can also be difficult to detect and should be ruled out and aggressively treated.

Reported findings suggest that spasticity should also be evaluated and treated to minimize barriers to long-term function. A physical therapist and occupational therapist should conduct a detailed assessment of spasticity, which occurs in people with upper motor neuron syndrome. Spasticity, an exaggerated or hyperexcited tonic and phasic stretch reflex and tendon reflexes of skeletal muscle in response to passive stretching,[5,29] occurs in about 75% of persons incurring severe TBI; for severe stroke, it has been reported to occur in 17% to 43% of patients.[5] Focal interventions, such as splinting, daily range of motion, and botulinum toxin, should be pursued to target spasticity in specific regions,[5] whereas pharmacologic agents (eg, dantrolene sodium, baclofen, tizanidine, benzodiazepines) will improve physical functioning globally; if used long term, medication pumps should be considered, because they can be less sedating.

The reported findings regarding UTIs are aligned with previous findings for this same patient population,[30] in that UTIs were found to be associated with requiring more physical assistance and less time out of bed 1 year after injury. Although the prevalence of UTI in this population is not known, it is a common consequence of catheterization often used with neuropathic bladder programs. Thus, it is plausible that recurring UTIs might indicate a high prevalence of catheterization, which would certainly impact mobility and is a risk factor for UTI with stroke.[31] Presence of UTIs has also been found to be adversely related to outcomes 3 months after stroke.[32] Thus, findings also support aggressive approaches to treating neuropathic bladder and preventing infections.

Study limitations

Subject recruitment was conducted from multiple sites with different capabilities, but the study is a cross-section of a population and subject to selection bias that may over- or underestimate associations. The medical complications tracked did not include all possible nonneurologic conditions (eg, cardiovascular), and these could also be associated with long-term functioning. Given the study design and restricted set of medical complications, findings should be considered preliminary, and they may not be generalizable to all severely brain injured patients. Another study limitation is related to a relatively small sample size that precluded inclusion of more potentially meaningful comparisons in the multiple regression models (eg, 1-y outcomes by sites). Despite these limitations, the findings provide information about the association between secondary medical complications and function 1 year after injury.

Conclusions

The reported findings indicate that persons in states of seriously impaired consciousness having a higher number of medical complications are associated with lower functional levels 1 year after injury. The findings indicate further that persons with ≥3 medical complications during inpatient rehabilitation are at a higher risk for poorer functional outcomes at 1 year. It is,

Table 5 Multiple linear regression results (N=68)

1-y FIM Outcomes	High No. of Medical Complications	Etiology (closed head vs other)	Days Between Injury and Admission
Cognitive FIM	−4.620 (−10.063 to 0.824)	7.494 (4.564 to 13.424)*	−0.392 (−6.048 to 5.263)
Motor FIM	−21.605 (−37.487 to −5.724)*	18.777 (1.476 to 36.079)*	−1.300 (−17.801 to 15.201)
Total FIM	−26.225 (−46.306 to −6.144)*	26.271 (4.394 to 48.148)*	−1.692 (−22.557 to 19.172)

NOTE. Values are β (95% confidence interval).
* Significant at α=.05.

therefore, prudent to evaluate these patients for indications of these complications and treat the complications during inpatient rehabilitation.

Further investigation should focus on further understanding of the relation between how early detection and treatment of these conditions could improve long-term functioning. Additional research is also needed to identify more effective methods for early detection and treatment of these conditions.

Supplier

a. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.

Keywords

Brain injuries; Comorbidity; Consciousness disorders; Rehabilitation

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Supplemental Appendix S1 Consciousness Screening Telephone Probes and Consciousness Algorithm

Instructions: The probes subsequently provided are to be used during the telephone consciousness screenings conducted with the subject's primary caregiver. The probes are used in addition to the consciousness screening form (ie, a separate form to code data collected during the screenings) and correspond to the consciousness algorithm. The probes and algorithm are used during the telephone interview to determine if the subject has recovered full consciousness. The use of the probes below during the telephone interview will help you derive a sufficient description of the subject's level of functioning. This description will, in turn, help you, the rater/interviewer, determine if the subject has recovered full consciousness according to the study criteria.

The information subsequently provided in boxes corresponds to the consciousness algorithm used to determine level of consciousness. The questions/probes under each box correspond with that section of the consciousness algorithm.

The questions provided under each box do not represent a comprehensive list of possible probes. If additional questions are required to help the caregiver expand and elaborate on his/her description of the subject's functioning, then you should also ask additional questions. Please write down the additional questions that you ask the caregiver.

PROBES

Algorithm Box A: Did the subject open his/her eyes or demonstrate increased motoric activity (ie, demonstrate arousal) indicating intermittent wakefulness (ie, preservation of sleep-wake cycle)?

- ☐ **Corresponding Probe:** Does the subject demonstrate periods of alertness throughout the day?
- ☐ **Corresponding Probe:** Are there periods during the day that the subject's eyes are open?
- ☐ **Corresponding Probe:** Does the subject seem to demonstrate a schedule of sleep times and wakeful times?

Algorithm Box B: Did the subject clearly demonstrate and reproduce or sustain at least 1 of these behaviors:
1. Follow simple commands within his/her motoric ability
2. Gestural or verbal yes/no, regardless of accuracy
3. Intelligible verbalization
4. Movements or affective behaviors relevant to environmental stimuli

- ☐ **Corresponding Probe:** Does the subject have a system for communicating?
- ☐ **Corresponding Probe:** Does the subject have a system, either verbal or nonverbal, for communicating basic needs? Describe how they use it. Is it used consistently?
- ☐ **Corresponding Probe:** What types of simple commands are they following?
- ☐ **Corresponding Probe:** Describe the method of yes/no response.
- ☐ **Corresponding Probe:** Describe the types of things the subject is saying.
- ☐ **Corresponding Probe:** Does the subject demonstrate facial expressions or emotions to certain people? Do they laugh or cry, etc, to things they see on TV? If a joke is told will they laugh?
- ☐ **Corresponding Probe:** Are any of the behaviors described above consistent? Can you count on them every time the opportunity for the behavior arises?

Algorithm Box C: Does the subject demonstrate functional interactive communication or functional use of ≥ 1 objects or behavior that shows awareness of self and/or environment?

- ☐ **Corresponding Probe:** Is the subject able to communicate any basic needs consistently (ie, discomfort, bathroom, hunger, activity like turning on the TV)?
- ☐ **Corresponding Probe:** How does the subject communicate these needs?
- ☐ **Corresponding Probe:** Does the subject use any objects appropriately?
  - ○ **Example:** If you place a washcloth in the subject's hand what do they do?
  - ○ **Example:** Does he/she try to bring a toothbrush to his/her mouth?
  - ○ **Example:** What do they do if you place the remote control in their hand?
  - ○ **Example:** Are there any motoric issues that would prevent the subject from using objects appropriately (ie, tone, paralysis)?
- ☐ **Corresponding Probe:** Are the behaviors described above consistent? Can you count on them every time the opportunity for the behavior arises?
- ☐ **Corresponding Probe:** Does the subject consistently respond to people entering the room? What is that response (tracking them, facial expressions, verbalizations, etc)?
- ☐ **Corresponding Probe:** How do they respond to different smells in the house (baking cookies, strong cologne, cigarette smoke, etc)?
- ☐ **Corresponding Probe:** Does the subject show appropriate emotional responses to information around them (laughing/smiling at a joke, crying at sad news)?
- ☐ **Corresponding Probe:** Does the subject attempt to use objects appropriately?

Algorithm Box D: Is cortical blindness or bilateral ptosis suspected?

- ☐ **Corresponding Probe:** Does the subject respond to visual information? Describe what responses you see.
- ☐ **Corresponding Probe:** Does the subject react to things coming quickly toward his/her face?
- ☐ **Corresponding Probe:** Does the subject have difficulty opening his/her eyelids or keeping them open? If you help the subject to open the eyes is there increased response to visual information?

Algorithm Box E: Does the subject withdraw from pain/noxious stimuli or demonstrate occasional nonpurposeful movement?

- ☐ **Corresponding Probe:** How does the subject respond to pain? Does he/she pull his/her arms into his/her chest (decorticate posturing)? Does he/she extend his/her arms to the side and arch the head and back (decerebrate posturing)?

Algorithm Box F: Does the subject demonstrate localization to auditory information or sustain visual focus on an object/person?

- ☐ **Corresponding Probe:** If someone comes in the room does the subject follow that person around the room with his/her eyes?
- ☐ **Corresponding Probe:** Does the subject respond to different sounds in the room? Describe the response.
- ☐ **Corresponding Probe:** How does the subject respond when someone is talking to him/her?

Algorithm Box G: Does the subject demonstrate visual or auditory startle?

- ☐ **Corresponding Probe:** Does the subject inconsistently respond to light being shined in his/her eyes? Do his/her pupils get smaller?
- ☐ **Corresponding Probe:** Does the subject startle very easily? Give examples of what makes him/her startle.

Supplemental Appendix S2 Consciousness Algorithm

Instructions: Algorithm is used to assist clinician with classification of seriously impaired consciousness and determination of emergence into full consciousness. Clinician should document whether they have determined the subject to be fully conscious or not fully conscious on the consciousness coding form.