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Impact of Cognition on Burn Inpatient Rehabilitation Outcomes

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Abstract

Background: A significant proportion of burn injury patients are admitted to inpatient rehabilitation facilities (IRFs). There is increasing interest in the use of functional variables, such as cognition, in predicting IRF outcomes. Cognitive impairment is an important cause of disability in the burn injury population, yet its relationship to IRF outcomes has not been studied.

Objective: To assess how cognitive function affects rehabilitation outcomes in the burn injury population.

Design: Retrospective study.

Setting: Inpatient rehabilitation facilities in the United States.

Participants: A total of 5347 adults admitted to an IRF with burn injury between 2002 and 2011.

Methods or Interventions: Multivariable regression was used to model rehabilitation outcome measures, using the cognitive domain of the Functional Independence Measure (FIM) instrument as the independent variable and controlling for demographic, medical, and facility covariates.

Main Outcome Measurements: FIM total gain, readmission to an acute care setting at any time during inpatient rehabilitation, readmission to an acute care setting in the first 3 days of IRF admission, rate of discharge to the community setting, and length of stay efficiency.

Results: Cognitive FIM total at admission was a significant predictor of FIM total gain, length of stay efficiency, and acute readmission at 3 days ($P < .05$). Cognitive FIM total scores did not have an impact on acute care readmission rate or discharge to the community setting.

Conclusions: Cognitive status may be an important predictor of rehabilitation outcomes in the burn injury population. Future work is needed to further examine the impact of specific cognitive interventions on rehabilitation outcomes in this population.

Level of Evidence: II

Introduction

An estimated 486,000 patients with burn injury receive medical treatment annually, resulting in approximately 40,000 hospitalizations to acute care hospitals [1]. Advancements in acute care burn management such as aggressive surgical wound care, intensive care, and specialized interdisciplinary clinic training have contributed to improved survival rates in patients with severe burn injury [2]. A significant proportion of this population will develop extensive comorbidities precluding community discharge from the acute care hospital [3]. As a result, approximately 5000 (1 in 8) hospitalized patients are discharged to inpatient rehabilitation facilities (IRFs) [4].

Recent changes in healthcare policy have resulted in an increased focus on quality metrics by IRF providers, including re-hospitalization rates to acute care facilities [5]. In addition, there is an increasing interest in the utility of predictor variables and their association with rehabilitation functional outcomes to improve patient outcomes [3]. Relevant variables in the IRF setting include demographic, medical, and facility data. Identification of factors that are associated with rehabilitation outcomes in the burn injury patient population can provide a method to stratify patients who are at high risk for poor rehabilitation outcomes and to allow for targeted therapies.

Some preliminary research has already examined predictor variables and IRF outcomes in the burn population. Variables that predict the best rehabilitation outcomes are younger age, employed, married, and higher functioning (higher Functional Independence Measure [FIM] total admission scores) with shorter acute care stays [6]. Comorbidity and complication indices do not seem to improve our ability to predict IRF outcomes in the burn population [3]. Function, as measured by the FIM instrument, is one of the more robust and reliable predictors, as it is associated with the following IRF outcomes: functional gain, length of stay efficiency, discharge to community, transfer to acute facility within the first 3 days of IRF stay, and overall acute care readmission rate [6–8].

The FIM instrument is made up of 2 domains, namely, motor and cognitive. Adults with burn injury have been reported to have worse cognitive FIM total scores on admission than other rehabilitation populations, particularly in the memory domain [9]. In one analysis of burn patients admitted to an IRF setting, 79% had cognitive FIM deficits on admission, and 27% had cognitive deficits at discharge [10]. Several potential etiologies for cognitive impairment exist. These include hypotension secondary to shock, infection, metabolic abnormalities, and anoxia. In animal models, changes in cerebral circulating cytokines and associated cytotoxic swelling after severe burns have been demonstrated [11,12]. Postacute neuropsychiatric symptoms have also been reported in the burn population, including delirium, temporary amnesia, hallucinations, and seizures [13]. However, cognitive sequelae of burns are not widely studied in the clinical inpatient rehabilitation setting [9,14–16].

Cognition has been shown to be a significant predictor of rehabilitation outcomes in other patient populations, including initial strokes and hip fractures in elderly patients [17,18]. However, this relationship has not been studied in the burn injury patient population. The primary objective of this study was to assess whether cognitive function has an impact on IRF outcomes in the burn population. As cognitive therapies are not routinely used for burn patients, this could support further research related to early interventions and more detailed cognitive screening.

Methods

We conducted a retrospective analysis of burn injury patients discharged from IRFs between 2002 and 2011 using the Uniform Data System for Medical Rehabilitation (UDSMR) database. UDSMR is a nonprofit organization that maintains demographic, medical, and rehabilitation data for approximately 70% of the IRFs in the United States [19]. Data in the UDSMR database are collected from the Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI).

Patients were included if they had a primary diagnosis of burn injury, defined by the impairment group code for burn injury on the IRF-PAI [20]. Patients were excluded if they were less than 18 years of age, were discharged against medical advice, died during their IRF stay, or received treatment in a zero-onset day facility. Zero-onset day facilities are defined as IRFs with more than 5% of patients admitted to IRF on the date of burn injury, which have been reported not to be representative of the general population of IRFs at the facility level [21].

Patient level variables included age, gender, race/ethnicity, marital status, preadmission employment status (employed, student, not working, or retired), preadmission living situation (living at home, not living at home), primary payer source (private, Medicaid, Medicare, or other), time from injury to IRF admission (onset days), total burn surface area (TBSA) decile, and cognitive FIM total rating. TBSA values were missing in approximately one-half of the subjects. This is likely secondary to varying coding practices among IRFs and the fact that TBSA documentation is not required by the UDSMR. Excluding cases without TBSA values could potentially bias the study sample. Therefore, multiple imputation analysis was used to account for variability in the missing data and to maintain the characteristics of the data set. Multiple imputation has been shown to increase the validity and precision of missing data [22]. Data were imputed by prior peer-reviewed methodology, using International Classification of Diseases, Ninth Revision codes that designate the percent TBSA to the nearest decile [6].

The primary aim of this study was to assess whether cognitive function at admission to an IRF is associated with inpatient rehabilitation outcomes in the burn injury patient population. Cognition was assessed using the cognitive FIM total rating. The FIM instrument assesses the severity of functional disability, and allows comparison of outcomes across IRFs in a standardized manner, and has been previously validated in the burn population [8]. FIM comprises 18 items that are categorized into motor and cognitive domains. The cognitive domain consists of 5 items including memory, verbal comprehension, verbal expression, social interaction, and problem solving [23]. Within each domain, there is evaluation of the level of assistance needed by the patient, with a 7-point scale ranging from full assistance ("1") to independent function ("7"). This study focused on the cognitive domain of the FIM instrument as a predictor of rehabilitation outcomes.

Rehabilitation outcomes examined included FIM total gain, acute readmissions at all time points, acute readmissions after 3 days, discharge to community, and length of stay efficiency. FIM total gain is calculated by subtracting the patient's admission FIM total score from the discharge FIM total score. Length of stay efficiency is calculated by dividing FIM total gain divided by IRF length of stay, and is an indicator of the efficacy of inpatient rehabilitation. These outcomes have been used previously to assess inpatient rehabilitation outcomes in the burn injury population and other IRF populations [3,6].

Multivariable regression models, using Stata statistical software, were used to determine whether cognitive FIM total at admission was a significant predictor of IRF outcomes. To control for potential confounders, all models included demographic, medical, and facility covariates. Each outcome was analyzed separately, with nonsignificant covariates excluded. A P value of less than .05 for each variable was considered statistically significant.

Results

A total of 6870 burn injury patients were identified; of these, 5347 met inclusion and exclusion criteria and were included in the analysis. Descriptive characteristics of the sample are presented in Table 1. The mean age of the population was 51.6 years (±18.9 years); 68% were male; 72% were of white ethnicity; 60% were unmarried; and the most frequent primary payer source was Medicare (34%). Before hospitalization, the population was predominantly unemployed or retired (56%), and the majority lived at home (98%). The median TBSA decile was 20%-29%. Cognitive FIM total scores were lowest in the memory and problem-solving subdomains, with an average FIM total score of 27 of 35.

Linear and logistic regression results for each IRF outcome are presented in Table 2. Only statistically significant characteristics of each category (except cognitive FIM total) are shown. Of the IRF outcomes presented, FIM gain ($\beta = 0.700$), length of stay efficiency ($\beta = -0.065$), and early acute transfers ($\beta = 0.763$) had a statistically significant association ($P < .05$) with cognitive FIM total. Cognitive FIM total had a positive association with FIM total gain; as cognitive FIM total score increased by 1 point, the total FIM gain increased by 0.7 point. Conversely, cognitive FIM total score had an inverse relationship with length of stay efficiency. As the cognitive FIM total score increased by 1 point, length of stay efficiency decreased by 0.065 point. Finally, cognitive FIM total negatively predicted early acute transfers; as cognitive FIM total score increased by 1 point, the odds of early acute transfers decreased by 24%.

Discussion

To our knowledge, this is one of the first studies to evaluate the impact of cognitive FIM total admission scores on inpatient rehabilitation outcomes in the burn injury patient population. We found that cognitive FIM total scores of burn injury patients admitted to IRFs have statistically significant associations with FIM total gain, length of stay efficiency, and early readmission back to an acute care setting from the IRF. Cognitive FIM total has a positive association with FIM total gain and a negative association with length of stay efficiency and early acute transfers.

The IRF outcomes with the largest effect sizes are FIM total gain and early acute transfers. Greater admission cognitive FIM total scores predict greater FIM gain. Notably, a 24% decreased chance of early acute transfers for each one-point increase in admission cognitive FIM total score. These are arguably clinically significant outcomes for patients. However, in contrast to the stroke population, there has not been a formal determination of what constitutes a minimal clinically important difference in FIM scores in the burn injury population IRF setting [24,25]. This will need to be further evaluated in future studies.

In addition, post-hoc examination of individual cognitive FIM items did not reveal a difference in predictive power for IRF outcomes. Thus, it may not be helpful to separate the different cognitive subdomains (ie, memory versus problem solving). Furthermore, length of stay efficiency, although statistically significant, was of small magnitude and not immediately clinically intuitive, which is a reflection of how the variable is calculated. A decreased probability of early acute transfers leads to an increased length of stay. As length of stay efficiency is equal to FIM gain divided by length of stay, this would lead to a decreased length of stay efficiency.

It has been reported previously that patients with burn injury have lower cognitive FIM total scores on admission compared with other inpatient rehabilitation groups, particularly in the memory domain [11]. However, cognitive deficits are underappreciated clinical sequelae of burns [9,11]. Most often, rehabilitation of burn patients focuses on acute medical management and prevention of metabolic disturbances, pain, dermatologic, orthopedic, and peripheral neurologic complications. Impairments in cognitive processing and emotional regulation have been described; however, this is often in the context of posttraumatic stress disorder and depressive symptoms after burn injury, rather than cognitive dysfunction unrelated to psychosocial manifestations [15,17]. One retrospective study examined neuropsychological outcomes of pediatric burn patients after hypoxic episodes; however, cognition was not evaluated in an IRF setting and was limited by a lack of routine cognitive testing in patients after acute care [26]. Another retrospective review looked at cognitive functioning in military service burn patients, but in the setting of the subset diagnosis of mild traumatic brain injury [27].

There are a number of plausible mechanisms that may result in impaired cognition in burn injury patients. Burn injury patients can experience a profound and prolonged hypermetabolic or catabolic response to the burn injury itself. This can be complicated by poor nutritional state and dehydration, which can lead to shock and hypoperfusion [28]. Shock, coupled with prolonged time in the field before resuscitation, contributes to hypoxic brain injury even before acute hospital admission. Central nervous system damage and histopathologic changes have been found in electrical burns [16]. Furthermore, patients can report high levels of pain that require aggressive pain management often involving long-acting opioids, which can affect cognitive processing [29]. There has also been extensive research on the impact of burn injury on metabolic and signaling pathways in the brain in animal models. The body’s physiologic stress response can affect the hippocampus and memory [30]. Circulating pro-inflammatory cytokines, including tumor necrosis factor–α, interleukin-1β, and interleukin-6, have been shown to be increased in brain tissue after severe burn injuries in rat models [12]. In canine models sustaining severe burns, there are magnetic resonance imaging findings of vasogenic and cytotoxic edema, and pathologic demonstration of necrosis and vacuolation of nerves [13]. Although rare, stroke has been demonstrated as a complication in moderate burns with septic conditions [31].

This study suggests that impaired cognitive function may have an impact on rehabilitation outcomes in the IRF setting, and may be critical for clinical decision making and resource allocation. For example, burn patients with better cognitive status are 24% less likely to be transferred to acute hospital care within the first 3 days of admission to an IRF, for each additional point on cognitive FIM total on admission. Unfortunately, the reason for acute readmission is not included in this data set. The etiology for an increased acute readmission rate for those with impaired cognition is likely multifactorial. A hypermetabolic and poor nutritional state could lead to dehydration, shock, and need for pressors and intensive care. Increased risk of delirium, worsened by medications, could lead to falls, fractures, and head strikes requiring emergency evaluation. Poor skin barrier and risk of infections similarly predispose to infections and bacteremia.

Furthermore, increasing cognitive FIM total scores predict greater gains in total FIM from admission to discharge. This indicates an association with improving functional outcomes such as mobility, bowel/bladder management, self-care, and communication. This can be explained by the relation of memory, social interaction, and problem solving with the goals of burn rehabilitation. For instance, proper positioning and range-of-motion exercises are important for bone and joint contracture prevention, which is critical for transfers and ambulation [32]. Alert and cooperative patients will be better able to engage with therapists in active range-of-motion exercises.

Previous research has aimed to establish the benefits of IRF level of care for burn patients. This includes improved range of motion, hand function, and balance [33]. Furthermore, burn patients admitted earlier to an IRF level may have greater functional gains and decreased lengths of stay [34]. The results of this study lend support for more intensive cognitive evaluation in the burn injury population; early and consistent screening by speech therapists for cognitive deficits in burn patients may need to become routine. Through future research, cognitive rehabilitation, using meta-cognitive strategies previously well established in the traumatic brain injury and stroke population, may be shown to improve outcomes in burn patients [35]. Targeted interventions to reduce cerebral inflammation or to stabilize nitric oxide levels in the hippocampus could be investigated in burn populations undergoing rehabilitation [12,36]. Finally, although critical for patient safety and recovery, this information is also important for IRF providers considering Medicare’s Prospective Payment System, which makes adjustments of federal rates based on short stays of less than 3 days [5].

The findings of this study must be interpreted within the context of its limitations. The data drawn from the UDSMR database does not include information on the type of burn sustained, which may affect cognitive FIM total scores on admission. For example, electrical burns have been shown to induce neurologic sequelae and to alter central nervous system function [16]. Other data, such as the dosing and types of cognitive impairing medications taken by burn patients, are similarly not recorded, and represent a potential area of future investigation. Moreover, TBSA values were missing in close to one-half of the subjects, likely secondary to variations in coding practices. To help minimize bias and to strengthen statistical power, multiple imputation analysis was performed, which assumes that missing values are not missing completely at random and are conditional on other observed data. The cognitive FIM assessment is a global measure of cognition and may not ascertain all aspects of mental processing. Further studies may use additional and more specific neurocognitive tests such as the National Institutes of Health Toolbox Cognition Battery.

One limitation of FIM gain as an outcome is that patients tend to be discharged when they reach maximal levels of independent function; thus there is a ceiling to FIM total score. Although FIM gain is controlled for in calculation of length of stay efficiency, FIM scores are collected only on admission and discharge. Therefore, we are unable to assess differential changes in FIM at different parts of patients’ stay. In addition, this study is a retrospective analysis using previously collected data, and IRF outcomes and FIM total scores could be subject to reporting bias. However, in this setting, the FIM instrument has good reliability. This is because the UDSMR has a 2-part credentialing process that requires clinician training as well as monitoring of facility data to examine data drift and maintain reliability of the FIM instrument.

Conclusion

Cognitive FIM total admission scores in the burn population are a significant predictor of IRF outcomes, including FIM total gain and early acute transfers. Cognitive impairment has been shown to be an important and likely underappreciated cause of disability in burn injury patients undergoing inpatient rehabilitation, with most cognitive rehabilitation strategies targeting other populations. As such, these data strengthen the argument for more robust cognitive screening on admission to inpatient rehabilitation in the burn injury population. Future research is needed to evaluate the effects of novel or established cognitive rehabilitation interventions on functional outcomes for the burn injury population.

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Table 1

Sample characteristics

Characteristic	Mean ± SD, or %
No. of subjects	5347
Age (y)	51.6 ± 18.9
Gender (% female)	32.46
Race/ethnicity (% white)	72.48
Marital status (% married) *	40.02
Preadmission employment status	
Employed *	40.63
Student or homemaker	3.17
Sheltered/not working/retired	56.20
Preadmission living situation	
Living at home	97.66
Not living at home	2.34
Payer source	
Private pay	20.80
Medicare	34.43
Medicaid	16.74
Other	28.03
% TBSA	27.6 ± 2.1
Onset days	45.7 ± 44.6
FIM admission cognitive	
Total	26.8 ± 7.0
Memory	5.1 ± 1.7
Problem solving	5.0 ± 1.7
Social interaction	5.4 ± 1.5
Expression	5.7 ± 1.5
Comprehension	5.6 ± 1.4

TBSA = total burn surface area; FIM = Functional Independence Measure.

*Defined as anyone who self-reported in the data.

Table 2

Regression results for each inpatient rehabilitation facility outcome

Outcome	Variable	Coefficient	*P* Value	95% CI
FIM gain	FIM cognitive	0.700	.008	0.182-1.218
	Age squared	−0.005	<.001	−0.006 - −0.004
	Age interaction*	−0.026	<.001	−0.037 - −0.016
	Change in onset days	−0.035	<.001	−0.046 - −0.023
	Medicare	−2.540	.004	−4.262 - −0.817
	Workers' compensation	2.266	.004	0.744-3.788
	Unemployed	−1.849	.002	−3.033 - −0.665
	Operating beds	0.047	<.001	0.029-0.064
	Constant	24.083	<.001	16.747-31.419
LOSE	FIM cognitive	−0.065	<.001	−0.089 - −0.041
	FIM motor	0.017	<.001	0.011-0.024
	Age interaction*	0.001	<.001	0.000-0.001
	White ethnicity	0.154	.009	0.039-0.270
	Married	0.199	<.001	0.096-0.302
	Change in onset days	−0.009	<.001	−0.010 - −0.007
	TBSA‡	−0.087	<.001	−0.138 - −0.035
	Medicare	−0.497	<.001	−0.685 - −0.309
	Medicaid	−0.298	<.001	−0.444 - −0.152
	Constant	4.630	<.001	3.863-5.398
Community discharge†	FIM cognitive	1.009	.16	0.997-1.021
	FIM motor	1.086	<.001	1.056-1.117
	FIM motor squared	0.999	.009	1.000-1.000
	Married	2.191	<.001	1.841-2.609
	Unemployed	0.686	<.001	0.561-0.840
	Retired	0.680	.004	0.522-0.885
	Change in onset days	0.997	<.001	0.995-0.999
	Medicare	0.662	<.001	0.518-0.846

Outcome	Variable	Coefficient	*P* Value	95% CI
	Constant	0.347	<.001	0.212-0.568
All acute transfers	FIM cognitive	1.003	.66	0.990-1.016
	FIM motor	0.959	<.001	0.952-0.966
	Age squared	1.000	.01	1.000-1.000
	Women	0.823	.04	0.685-0.989
	Change in onset days	1.003	<.001	1.001-1.005
	Constant	0.483	<.001	0.332-0.703
Early Acute Transfers	FIM cognitive	0.763	<.001	0.658-0.884
	Admission class	4.223	<.001	2.557-6.976
	Age squared	1.060	.02	1.010-1.113
	Constant	0.012	<.001	0.009-0.016

CI = confidence interval; FIM = Functional Independence Measure; LOSE = length of stay efficiency; TBSA = total burn surface area.

* Interaction between FIM cognitive and age.

† Community discharge model; uses an odds ratio.

‡ TBSA <10% (note that these are deciles: 0 is <10%, 1 is 10%-19%, etc).