BURNS 45 (2019) 42–47

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/burns

Hospital-acquired complications alter quality of life in adult burn survivors: Report from a burn model system[☆]

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ARTICLE INFO

Article history:
Accepted 17 October 2018

Keywords:
Burn
Complications
Long-term outcomes
Quality of life

ABSTRACT

Introduction: Successful burn care should facilitate comprehensive, functional recovery after an injury. But we have a poor understanding of which risk factors influence long-term outcomes after burn injury. Studies have correlated hospital-acquired complications (HACs) with poor long-term outcomes in some populations. The purpose of this study was to determine whether HACs alter patient-reported quality of life in adult burn survivors.
Methods: We followed 496 adults with major burn injury longitudinally as part of a burn outcomes study (1993–2014). Study participants completed SF-12® Health Surveys providing mental (MCS) and physical (PCS) component summary scores at discharge, 12- and 24-months following injury. We reviewed inpatient medical records for complications during the acute care of a thermal injury. Complications were identified using discharge summary and chart ICD-9 codes. We used descriptive statistics to compare demographic and injury characteristics. Stepwise linear regression analyses determined the impact of significant variables on longitudinal MCS and PCS scores. Burn and graft total body surface area, age, and gender were included as predictor variables in univariate models and added to multivariate models when they were significant.
Results: Patients who suffered urinary tract infection, venousthromboembolism, pulmonary complications and renal failure during hospitalization for their burn injury reported decreased quality of life as indicated by lower SF-12® PCS scores at 12 and 24months after injury.
Conclusions: We demonstrate that inpatient complications negatively impact long-term quality of life, especially physical functioning for patients with burn injuries. Our data confirm the need to consider the influence of hospital-acquired complications on patient-reported long-term outcomes and to support national efforts to reduce complications in burn patients.

☆ Presented at American Burn Association Annual Meeting, Chicago, IL in May 2015.

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https://doi.org/10.1016/j.burns.2018.10.010

1. Introduction

There are an estimated 486,000 people treated for burn injuries annually in the United States, leading to 40,000 hospital admissions [1]. With advances in critical care and surgical management, a patient with a burn size over 80% total body surface area (TBSA) confers a 50% survival rate, which has significantly increased over the past 50 years [2,3]. However, in spite of improved survival, national data indicates that infectious and non-infectious hospital-acquired complications (HACs), persist [2]; the most common hospital-acquired infections include ventilator-associated pneumonia, catheter-acquired urinary tract infection, respiratory failure, and wound and graft infection [4]. A report based on the American Burn Association National Burn Repository (ABA NBR), a voluntary multicenter burn database, indicates that in the burn population, pneumonia, cellulitis, urinary tract infections and respiratory failure are the most common HACs [4].

With improved survival rates, critically injured patients face long-term challenges with functional recovery, community reentry and quality of life [5–7]. Previous studies have demonstrated that patients who sustain thermal injury report lower quality of life in comparison to those who have not [5,8]. Complicating factors include premorbid mental health that negatively influence patient outcomes [9,10]. Long-term self-reported quality of life outcomes in patients surviving sepsis, acute lung injury and other inpatient complications have been reported [11–26] however, no publication has addressed correlations between hospital-acquired complications and patient-reported outcomes in the burn population. The purpose of this study was to determine whether hospital-acquired complications in patients admitted for acute management of a burn injury determine long-term quality of life. We also wanted to evaluate if there is an impact of multiple complications on patient reported quality of life. Our goal was to demonstrate the value of long-term care as part of the routine follow up of patients with burn injuries as proposed in the summary of the 2012 American Burn Association Burn Quality Consensus Conference [4].

2. Methods

2.1. *Study design*

This descriptive study of adult burn survivors was approved by the University of Washington Institutional Review Board (IRB). A prospective comprehensive demographic, injury and outcomes database, maintained as part of the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR) Burn Model System (BMS) program has been shown to be representative of the ABA NBR [27]. and has facilitated study of functional and psychosocial outcomes following burn injury [28]. These data were prospectively collected via in-person and/or telephone interview or by return mail from study participants injured between 1993 and 2014. The dataset for this study included a subset of BMS National Data Base participants who had been cared for at the UW Medicine Regional Burn Center (Seattle, WA).

2.2. *SF-12® Health Survey*

Study participants completed the Short-Form Health Survey (SF-12®) at several time points following study enrollment: pre-burn (collected at hospital discharge reflecting the month before the burn injury), 12 and 24-months following the injury date. The SF-12® Health Survey is a generic, 12-item patient-reporting questionnaire that provides information concerning functional health and well-being. It was derived from the SF-36® Health Survey to provide a shorter, validated tool to measure overall health-related quality of life with less burden on patient time. Responses are weighted and summed to provide two composite scores, the Physical Composite Summary (PCS) and Mental Composite Summary (MCS) scores [29,30]. For Americans, the median score is 50; higher scores denote a better quality of life, and lower scores are consistent with decreased quality of life; scores tend to be lower for females than males [31]. Both composite scores vary over the life span; PCS-12 scores trend lower with increasing age and MCS-12 scores trend upward with increasing age [4,27].

Patient complications were identified via a retrospective chart review. Review of individual chart discharge summary and of ICD-9 diagnoses identified the occurrence of hospital-acquired complications. Diagnoses include: urinary tract infection, myocardial infarction, venous thromboembolism/ pulmonary embolism, adrenal insufficiency, pressure ulcer, sepsis, renal failure, *Clostridium difficile* infection and central line-associated bloodstream infection.

2.2.1. *Study participants*

Study participants included burn survivors who had been admitted to the UW Medicine Regional Burn Center for management of their acute burn injury, provided written, informed consent for study participation and met one of the following inclusion criteria:

- 18–64 years of age with a burn size $\geq$20% TBSA burn with surgical intervention for wound closure.
- $\geq$65 years of age with a burn injury $\geq$10% TBSA burn with surgical intervention for wound closure.
- $\geq$18 years of age with a burn injury to their face/neck, hands or feet with surgical intervention for wound closure.
- $\geq$18 years of age with a high voltage electrical burn injury with surgical intervention for wound closure.

2.3. *Statistical analysis*

SAS (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP) was used for all analyses. Data are reported as mean $\pm$ standard deviation or median with interquartile range for continuous and n (%) for categorical variables. Demographic and injury information/ characteristics were analyzed using descriptive statistics. Patient demographics were compared via independent sample t-test and chi-square tests.

PCS-12 and MCS-12 scores were evaluated at pre-burn, discharge, 12- and 24-months after injury to determine a statistical difference based on sex, burn size (% TBSA), inhalation injury, days on ventilator, and acute care hospital length of stay.

Univariate linear regression models with PCS-12 and MCS-12 scores at each survey interval were conducted and those that were significant ($p < 0.05$) were used in multivariate linear regression models.

3. Results

3.1. *Demographic and injury characteristics*

A total of 496 adult burn survivors admitted to the UW Medicine Regional Burn Center from 1999 to 2014 and who met study inclusion criteria represent the study sample. Data collection rates varied over time with 95% complete data for the pre-injury evaluation and 100% at hospital discharge. Within the 2-year follow-up period, 58% of participants provided 12-month after injury data and 48% at 24-months after injury.

Descriptive data for participant and injury characteristics are summarized in Table 1. The mean age was 44 (15.4 SD) years old, with the majority (74.4%) being male. Burn size ranged from <1% to 70% TBSA (median 25%, 6–28 IQR). Subjects spent a median of 25 (17–40 IQR) days in the hospital; 61 (12.3%) were admitted to the inpatient rehabilitation unit.

Table 1 – Patient characteristics.

Age: mean (SD)	43.8 (15.4)
Burn size (% TBSA): mean (IQR)	14.95 (6–28)
LOS: median (IQR) (n=494)	25 (17–40)
Days on ventilator: mean (SD), (n=495)	3.8 (10.1)
Number of operations: mean (SD)	2.6 (2.8)
Number of inpatient rehabilitation days: mean (SD)	3.2 (10.2)
Sex: % (n) male	74.4 (369)
Race: % (n)	
White	81.1% (402)
Black	4.8% (24)
Pacific Islander	1.0% (5)
Asian	2.2% (11)
Native-American	4.6% (23)
Multi-Racial	1.2% (6)
Other	0.6% (3)
Unknown	0.4% (2)
Etiology of injury: % (n)	
Fire/flame	64.5% (320)
Grease	9.7% (48)
Scald	8.1% (40)
Contact with hot object	6.5% (32)
Electricity	5.2% (26)
Flash	2.2% (11)
Chemical	2.0% (10)
Tar	1.0% (5)
UV Light	0.4% (2)
Other burn	0.4% (2)
Pre-injury diagnoses	
PTSD	0.8%(4)
Depression	9.1% (45)
Anxiety	4.2% (21)
Pre-existing medical condition	13.2% (65)

Two hundred and twenty-three (45.0%) participants suffered no complications, 211 (42.5%) developed 1–3 complications, 52 (10.5%) participants had 4–6 complications, and 10 participants (2.1%) had more than six complications (Tables 2a and 2b). The breakdown of quantity of complications into these categories was chosen arbitrarily.

Complications for participants included urinary tract infection (11.9%), pulmonary embolism (5.4%), wound infection (27.6%), pressure ulcer (5.4%), cardiac complications (7.6%), adrenal insufficiency (1.0%), *C. difficile* infection (2.2%), renal failure (7.5%) and ventilator-associated pneumonia (30.6%). The prevalence of these events is consistent with reports of hospital-acquired complications in burn populations [2].

We also questioned if the cumulative effect of multiple events would be associated with lower *SF-12®* scores and poorer quality of life. The analysis demonstrated that those with more complications had significantly lower PCS (Table 3); MCS were lower for those who incurred 1–3 complications at the six and 12-month interval but normalized by 24 months (Table 3).

3.2. *SF-12® Health Survey results*

Multivariate linear regression models suggest that female sex and lower pre-burn mental composite scores negatively influenced Mental Composite Summary during follow-up; traditionally females have lower MCS scores than males (Tables 4 and 5) [31]. The follow-up Physical Composite Summary was not significantly different between male and female patients. For both sexes, the thermally injured PCS scores are lower than the national norm that is 49.3 for females and 50.81 for males [31]. Increasing age and lower pre-burn PCS was associated with lower after injury PCS ($p=0.000$) at all time points (Table 5). Pre-existing physical disability, the

Table 2a – Quantity of complications.

Frequency of complications	N
0 complication	256
1 complication	96
2 complications	52
3 complications	29
More than three complications	63

Table 2b – Frequency of complication type in chart review.

Complications	%	n
Pulmonary	30.6	153
Wound infection	27.6	137
UTI	11.9	59
Cardiac	7.6	38
Renal	7.5	37
Sepsis	6.5	32
VTE	5.4	27
Pressure ulcer	5.4	27
C. difficile	2.2	11
CLABSI	2.2	11
Hematoma	1.2	6
Adrenal insufficiency	1.0	5
Gastrointestinal bleed	1.0	5
Hemorrhage	0	0

Table 3 – Multivariate regression models of quantity of complications demonstrating statistically significant PCS. *Denotes $p < 0.05$.

	12 months coefficient (95% CI), p-value	24 months coefficient (95% CI), p-value
SF-12 PCS		
1–3 complications	−4.1 (−6.7 to−1.4), p=0.003*	−3.1 (−6.2 to 0.05), p=0.053
4–6 complications	−8.8 (−13.4 to−4.3), p=0.000*	−8.9 (−14.1 to −3.6), p=0.001*
>6 complications	−8.5 (−16.3 to 0.6), p=0.035*	−8.8 (−18.3 to 0.6), p=0.066
SF-12 MCS		
1–3 complications	−4.6 (−7.4 to −1.8), p=0.001	−2.6 (−5.7 to 0.6), p=0.112
4–6 complications	−4.1 (−8.7 to 0.6), p=0.09*	−1.1 (−6.5 to 4.2), p=0.673
>6 complications	2.4 (−5.7 to 10.4), p=0.565	4.1 (−5.5 to 13.6), p=0.401

presence of comorbidities at the time of injury, an inhalation injury, ventilator support and the need for admission to an acute rehabilitation facility were associated with significantly lower PCS at all time intervals. The same was not true for MCS follow-up (Tables 4 and 5).

Multivariate linear regression model demonstrated that urinary tract infection, VT/PE, *C. difficile* and renal failure were each associated with altered patient-reported outcomes at variable intervals (Table 6). Patients with a urinary tract infection displayed significantly lower PCS at the 24-month interval. Venous thrombosis/pulmonary embolism and renal failure proved to consistently lower PCS at all time points. *C. difficile* infection was the only complication that was significantly associated with lower MCS follow-up.

4. Discussion

Our association between hospital-acquired complications and long-term patient-reported quality of life metrics demonstrates that long-term sequelae negatively impact quality of life for adult burn survivors. The HACs experienced by the BMS National Database participants demonstrates a greater negative impact on the physical health than on mental health. In

Table 4 – SF-12 Mental and Physical Composite Scores based on sex, inhalation injury, pre-existing physical disability, comorbid disease, ventilator support and need for admission to acute rehabilitation facility. *Denotes $p < 0.05$.

	Sex		
	Male (n=369)	Female (n=127)	p-Value
12-months MCS mean (n), SD, CI	50.8(218), 9.9(16.5–68.5)	44.4(74), 12.6(7.6–65.8)	0.0001*
Inhalation injury			
	Injury present	Injury absent	
12-months PCS Mean (n), SD, CI	42.4(32), 9.8(24.2–64.3)	47.2(259), 10.9(13.3–62.1)	0.0034*
24-months PCS mean (n), SD, CI	42.0(29), 13.3(16.7–62.3)	47.7(207), 11.0(12.0–61.5)	0.0242*
Pre-existing physical disability			
	With disability	Without disability	
Pre-burn MCS mean (n), SD, CI	46.3 (64), 13.1 (13.6–70.4)	52.4 (406), 9.5 (9.4–65.2)	0.0000*
Pre-burn PCS mean (n), SD, CI	42.2 (64), 13.5 (7.6–68.7)	54.1 (406), 7.3(18.9–73.0)	0.0000*
12-months PCS mean (n), SD, CI	35.2(27), 10.4(13.8–64.3)	47.8(262), 10.3(13.8–64.3)	0.0000*
24-months PCS mean (n), SD, CI	38.5(25), 12.4(18.3–57.5)	48.0(211), 10.9(12.0–62.3)	0.0002*
Comorbidity			
	Present	Absent	
Pre-burn MCS mean (n), SD, CI	47.2(123), 12.4(13.6–70.4)	53.3(341), 8.7(9.4–65.2)	0.0000*
Pre-burn PCS mean (n), SD, CI	44.5(123), 13.2(7.6–66.3)	55.2(341), 5.5(20.1–73.0)	0.0000*
12-months PCS mean (n), SD, CI	39.6(65), 11.7(13.3–58.6)	48.8(223), 9.8(17.4–64.3)	0.0000*
24-months PCS mean (n), SD, CI	40.1(54), 12.3(12.0–60.3)	49.0(178), 10.2(14.4–61.3)	0.0000*
Ventilator support			
	Present	Absent	
12-months PCS mean (n), SD, CI	42.5(91), 11.4(13.3–64.3)	48.5(201), 10.1(13.8–62.1)	0.0000*
24-months PCS mean (n), SD, CI	43.3(83), 12.7(15.9–62.3)	49.0(154), 10.0(12.0–61.5)	0.0008*
Acute rehabilitation admission			
	Yes	No	
12-months PCS mean (n), SD, CI	37.6(40), 11.5(13.3–61.5)	48.1(252), 10.1(17.4–64.3)	0.0000*
24-months PCS mean (n), SD, CI	37.7(37), 15.2(12.0–60.2)	48.7(200), 9.6(15.9–62.3)	0.0000*

Table 5 – Multivariate regression models of patient characteristics demonstrating statistically significant PCS and MCS ratings. *Denotes p < 0.05.

Model predictor response Response time	Coefficient	Confidence interval	p-Value
PCS			
Age			
24 months	−0.10	−0.19–0.02	p = 0.018*
Pre-burn PCS			
12 months	0.46	0.33–0.6	p = 0.000*
24 months	0.45	0.29–0.62	p = 0.000*
MCS			
Pre-burn MCS			
12 months	0.4	0.27–0.54	p = 0.000*
24 months	0.48	0.34–0.62	p = 0.000*

Table 6 – Multivariate regression models of complications demonstrating statistically significant PCS and MCS. *Denotes p < 0.05.

Model predictor Response time point	Coefficient	Confidence interval	p-value
PCS			
Urinary tract infection			
12 months	−3.18	−6.8 to 0.46	p = 0.086
24 months	−7.6	−11.7 to 3.5	p = 0.000*
VT/PE			
12 months	−6.3	−12.2 to 0.44	p = 0.035*
24 months	−7.0	−13.8 to 0.33	p = 0.04*
Renal failure			
12 months	−5.6	−10.5 to 0.75	p = 0.024*
24 months	−6.2	−11.8 to 0.61	p = 0.03*
MCS			
Clostridium difficile			
24 months	9.2	1.9 to 16.4	p = 0.013*

particular, urinary tract infection, renal failure, venous thrombosis and pulmonary embolism demonstrate a significantly negative effect on physical composite scores. We speculate that patients who suffer a VTE/PE complication may live with the secondary effects caused by medications and increased medical monitoring and interventions, which collectively affect their physical health and well-being. *C. difficile* infection was the only complication that was associated with lower mental composite scores for unknown reasons, suggesting that the majority of long term affects effect patient's physical well-being.

Our observation that complications are more likely to negatively influence physical well-being compared with mental recovery mimics findings in a study that assessed patterns of recovery in burn patients over a year in Australia in which that authors demonstrate that PCS was significantly lower for a year following burn injury, whereas the MCS did not change significantly [32].

A limitation to our study includes the retention rates of 58% at 12 months and 48% at 24 months.

Further potential factors affecting data interpretation concern our use of discharge summaries and ICD-9 diagnoses to identify hospital-acquired events, which may not be standardized and may vary from individual to individual. Over the duration of this study, electronic health record documentation has become more precise with more detailed coding, which has affected the ease and consistency with which this information is collected. Future assessments of effects of hospital-acquired events on outcomes should be facilitated by mandatory ICD-10 utilization in theory, however, the use of the electronic medical record is not without flaws.

Numerous studies have evaluated the consequence of hospital-acquired complications and the resulting negative impact on patient-reported physical and mental quality of life, yet no one has examined this in the thermally injured patient population [12,14–17,19]. The negative impact of potentially preventable complications has wide reaching implications. This study confirms an association between hospital-acquired events and functional recovery in adult burn survivors two years following injury, underscoring the importance of avoiding adverse events. Our findings emphasize the importance of decreasing the occurrence of hospital-related complications as more than just an added expense that lengthens hospitalization, but one that has long-standing implications for patients after discharge. Whereas the burn community has long recognized that patients should be followed for up to 12 months after injury, our data also suggest that patients who have sustained a major burn injury have reduced physical function for at least 24 months and may warrant longer follow-up.

5. Conclusion

We have demonstrated that unplanned hospital events have long-term association with patient-reported poor quality of life. This further justifies the need to prevent such complications. Our results also indicate that burn patients struggle with functional recovery for at least 24 months after injury. As such we believe that longer follow up by experts in burn injury recovery could positively influence burn patient quality of life. Further prospective multi-center corroboration of our single center findings is warranted.

Authors' contribution

Lyndsay Deeter, MD: literature search, data collection, data interpretation, writing, critical revision.

Max Seaton, MD: data collection.

Gretchen J Carrougher RN, MN: literature search, data collection, data interpretation, critical revision.

Kara McMullen, MPH: data analysis.

Samuel P Mandell, MD, MPH, FACS: critical revision.

Nicole S Gibran, MD, FACS: study design, data interpretation, writing, critical revision.

Conflict of interest

None.

Acknowledgments

The contents of this report were supported, in part by grant number 90DP0029, from the U.S. Administration for Community Living, Department of Health and Human Services, Washington D.C. 20201. Grantees undertaking projects under government sponsorship are encouraged to express freely their findings and conclusions. Points of view or opinions do not, therefore, necessarily represent official Administration for Community Living policy.

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