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Risk Factors for the Development of Pneumonia in Older Adults With Burn Injury

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Abstract

Older adults with burns are at risk for worse outcomes because of factors related to age, comorbidities, and response to treatment. Although the impact of pneumonia has been previously described in burn patients, less is known in the older adult population. In this study, we used the National Burn Repository to characterize patient and injury factors associated with pneumonia development in older adults with burns. We examined the records of all patients in the National Burn Repository aged 55 years and older from 1995 to 2007. To better characterize the effects of age on outcomes, patients were stratified into three categories: 55 to 64 years, 65 to 74 years, and 75 years and older. Pneumonia was identified by listed complications and ICD-9 codes. Comorbidities were classified by Charlson Comorbidity Index Score. Unadjusted and multivariate regression analyses were performed to distinguish the impact of age, comorbidities, and injury factors on pneumonia development and mortality. A total of 23,794 patient records met inclusion criteria during the study period, and 2,052 (8.6%) had pneumonia. Patients who developed pneumonia were more likely to be men (65 vs 56%, $P < .001$), have higher TBSA (21 vs 13%, $P < .001$), have sustained inhalation injury (21 vs 7%, $P < .001$), and have comorbid condition (34 vs 13%, $P < .001$). On multivariate analysis, factors significantly associated with pneumonia development were male sex, percent TBSA, inhalation injury, and presence of comorbidity. Specifically, chronic lung and heart disease had adjusted odds ratio (OR) of 2.70 and 3.48, respectively, for development of pneumonia ($P < .001$). By logistic regression, adjusted OR for pneumonia were 0.89 (95% CI 0.74–1.06, $P = .18$) in the 65 to 74 years age group and 1.26 (95% CI 1.07–1.48, $P = .005$) in the oldest group compared with the 55 to 64 years age group. Pneumonia during hospitalization was associated with an adjusted OR of 1.91 for death (95% CI 1.61–2.27, $P < .001$) after controlling for the factors of age, sex, comorbidity, TBSA, and inhalation injury. Injury factors and the presence of comorbidities consistently predicted the development of pneumonia in this large national patient sample. Higher age category also predicted higher pneumonia risk, although this association was only significant in the highest age group. This study, thus, highlights the importance of comorbidities over chronological age in pneumonia development in older adults with burn injuries. (*J Burn Care Res* 2010;31:105–110)

Pneumonia is the most common infection in hospitalized burn patients and is frequently associated with death.^{1–4} Therefore, improved understanding of the risk factors of this complication may lead to improved success in pneumonia prevention, diagnosis, and treatment.^{5–7} Pneumonia is especially common in hospitalized older burn patients, as recent research has implicated the role of aging in excessive pulmonary inflammation following

burn injury.⁸ Although the contributions of inhalation injury and aging on pneumonia development have been clearly outlined in burn patients, prior studies have used single center data, thus limiting their generalizability.^{9,10}

The National Burn Repository (NBR) provides the unique opportunity to overcome single center and unique regional characteristics by examining burn injuries on a national level. NBR studies have recently generated significant epidemiologic and outcomes data related to specific injury patterns, such as self-inflicted injuries, or in specific subpopulations, such as women and children.^{3,11–14} Thombs et al¹⁵ previously documented the effect of preexisting medical comorbidities on burn mortality and length of stay, but their study did not focus on complications. We have previously evaluated the contribution of age on mortality in older injured adults in the NBR and identified the need to further examine complications, taking into account the impact of comorbidities.¹⁶ In this study, we utilize the NBR to characterize the association between age, comorbidities, and the development of pneumonia in older adults following burn injury.

METHODS

Study Overview

We performed a descriptive analysis of all patients aged 55 years and older included in the NBR (version 4) from January 1995 to December 2007. The selection of 55 years was based on data from the National Study on Cost and Outcomes of Trauma indicating that outcomes following injury begin to significantly change at age 55 years.¹⁷ Briefly, the NBR is a de-identified database maintained by the American Burn Association and consists of voluntarily reported entries by 73 self-designated burn centers in the United States and 4 in Canada. Burn centers were eligible for inclusion if they 1) volunteered their data, 2) consented for their data to be pooled with that of other centers, and 3) participated in a burn patient registry. Institution names and geographical location of individual reporting burn centers were previously detailed in the 2007 NBR report.¹⁸ This study was performed after approval of the University of Washington's Institutional Review Board. Principal exposures of interest were age categories and comorbidities, and main outcomes of interest were pneumonia development and mortality.

Patients and Definitions

All patients aged 55 years and older in the NBR database admitted for acute burn injury between January 1995 and December 2007 were reviewed. Study inclusion criteria included 1) survival for at least 72 hours after admission, and 2) either the presence of at least one ICD-9 code listed (including burns) or the use of the Trauma Registry of the American College of Surgeons reporting system in the current NBR version. Survival for at least 72 hours was chosen as cutoff to exclude patients with injuries that were deemed nonsurvivable and patients with minor burns who were discharged within that timeframe. Pneumonia during hospitalization was defined in either the complications data subset or the diagnosis data subset by ICD-9 codes 480 to 486. Preexisting medical conditions were defined by the Charlson et al¹⁹ comorbidity index (Table 1) using the ICD-9 codes in the diagnoses subset. The Charlson index was originally developed and validated in medical patients, but it has since been commonly used in analyses of critically ill patients, including burns, to assess the aggregate burden of comorbid diseases on outcomes.^{15,20–22} Smoking history was also queried in the NBR, by review of ICD-9 code (305.1), as this factor likely would have an impact on the development of pneumonia in hospitalized patients.

Data Analysis

To more precisely study the differences in injury characteristics and outcome based on age, patients were stratified into the following age groups: 55 to 64 years; 65 to 74 years; and 75 years and older. In accordance to the rules of the Health Insurance Portability and Accountability Act, the NBR assigns patients aged 90 years and older as an age = 90 years. Baseline patient and injury characteristics, proportion of patients with pneumonia diagnosis, and hospital outcomes including mortality and disposition were compared in patients with and without pneumonia using χ^2 for dichotomous and categorical variables or *t*-test for continuous variables. The association among patient, injury characteristics, and pneumonia was examined using multivariate logistic regression. Covariates included in this model were those that had a $P \leq .01$ on univariate analysis. All data analyses were performed using STATA 9.0. (College Station, TX).

RESULTS

Patient and Injury Characteristics

From 1995 to 2007, a total of 23,794 patients aged ≥ 55 years in the NBR met inclusion criteria for analysis, and of these, 2,052 (8.6%) patients developed pneumonia during hospitalization. Patient and injury characteristics of the entire study population are summarized in Table 2. Mean age in patients with pneumonia was nearly equivalent (70.3 vs 70.7 years, $P = .12$), with a higher proportion of men compared with the remainder of the cohort (65.4 vs 55.9%, $P < .001$). Patients with pneumonia had larger overall TBSA burned (20.7 vs 12.5%, $P < .001$) and full-thickness TBSA burned (15.6 vs 9.9%, $P < .001$). Burns in the pneumonia group were more frequently caused by flame/flash flame mechanism (45.5 vs 30.3%, $P < .001$), with a higher incidence of inhalation injury (21.2 vs 6.9%, $P < .001$). Thirty-four percent of patients who developed pneumonia had one or more comorbidities, as compared with 13.4% of patients without pneumonia ($P < .001$).

Impact of Age and Comorbidities on Pneumonia Complication

To distinguish the impact of age and comorbidities on the development of pneumonia, we performed a multivariate logistic regression that included all factors that differentiated the two cohorts by univariate analyses at the $P = .01$: age, sex, injury severity (TBSA and inhalation injury), fire/flame etiology, and presence of comorbidities. The results are summarized in Table 3. Because percent TBSA and percent full-thickness injury were highly correlated variables ($r = .85$), only percent TBSA was included in the multivariate regression model. Only the oldest age group (≥ 75 years), was significantly associated with a higher likelihood of pneumonia (adjusted odds ratio 1.26, 95% CI 1.07–1.48, $P = .005$). Male sex, increasing burn size, fire/ flame etiology, and inhalation injury were all significantly associated with higher likelihood of pneumonia development. Patients with any comorbid condition had a significantly higher likelihood of pneumonia development with an adjusted odds ratio of 2.84 (95% CI 2.40–3.37, $P < .001$). Increasing number of comorbidities was associated with higher adjusted odds ratio for pneumonia (Table 3).

We also examined the pneumonia risk associated with specific individual comorbidities. Chronic lung disease was associated with an adjusted odds ratio of 2.70 for pneumonia (95% CI 2.26–3.23, $P < .001$). Chronic heart and renal diseases were associated with adjusted odds ratios of 3.48 (95% CI 2.89–4.19, $P < .001$) and 3.05 (95% CI 1.99–4.68, $P < .001$) for pneumonia, respectively. We performed a separate multivariate regression analysis to determine whether individual comorbidities were more significantly associated with the development of pneumonia compared with the total number of comorbidities in each patient. Individual comorbidities were no longer significantly associated with pneumonia in the regression model that factored the number of comorbidities, indicating that the presence of

one or more comorbidities was a more important factor than having any particular comorbidity (data not shown). A total of 1029 patients had smoking history diagnosed, of which, 182 patients (17.7%) developed pneumonia. When it was factored into the multivariate model, smoking history was associated with an adjusted odds ratio of 1.28 for pneumonia development (95% CI 1.03–1.61, $P = .03$).

Hospitalization Course and Outcomes

Comparisons of hospitalization outcomes between patients with and without pneumonia are summarized in Table 4. Patients who developed pneumonia had a higher number of operations ($P < .001$), length of stay per TBSA (4.0 vs 3.2, $P < .001$), including intensive care length of stay (21.7 vs 4.9, $P < .001$), and days on mechanical ventilation (19.5 vs 3.1, $P < .001$). Forty-seven percent of patients who developed pneumonia underwent surgical tracheostomy compared with 7.1% for patients without pneumonia ($P < .001$). Overall mortality was significantly higher in patients with pneumonia (30.4 vs 9.5%, $P < .001$). The majority of patients without pneumonia were discharged to home (50.8%). In contrast, patients with pneumonia were more frequently discharged to a nonindependent living status (32.6% to extended care, 21.8% to another acute care facility, $P < .001$). We next created a multivariate logistic regression model to examine the impact of pneumonia complication on mortality, adjusting for injury and patient factors, including the presence of comorbidities (Table 5). In this model, pneumonia complication was associated with an increased adjusted odds ratio of 1.91 (95% CI 1.61–2.27, $P < .001$) for death. Higher number of comorbidities was also associated with progressively higher adjusted odds ratio for death (Table 5).

DISCUSSION

We have retrospectively analyzed risk factors for pneumonia using a large sample of older adults with burns, with the specific goal to distinguish the individual contributions of age and comorbidities. The most salient finding was the relative importance of comorbidities in the development of pneumonia. Higher age category was also associated with higher risk of pneumonia, although this association was only statistically significant in the oldest age group (≥ 75 years old). As such, higher number of comorbidities more consistently predicted pneumonia development compared with age. Interestingly, having one or more comorbidities was a more important factor than having any particular comorbidity. To our knowledge, this is the first report that has compared these factors with respect to pneumonia using a national sample of older burn patients.

The fact that patient age is less consistently associated with a higher incidence of pneumonia complications is a remarkable finding. It supports the notion that chronological age alone should not be the only determinant of decision making in older adults with burns. Jacobs et al²³ from the Eastern Association for the Surgery of Trauma published guidelines in 2003 for the care of injured older adults, in which they stated that “advanced age, in and of itself, is not predictive of poor outcomes following trauma, and therefore should not be used as sole criterion for denying or limiting care.” In practice, however, there are numerous reports in the literature that document a pattern of undertriage and undertreatment of older injured adults.^{24,25} In our previous NBR analysis, we documented a lower number of operations with advancing age despite similar injury sizes, suggesting that age bias may be influencing burn management.¹⁶ Different approaches to patient management based on chronological age may, thus, potentially limit the usefulness of end points such as mortality in retrospective analyses, regardless of the sample size.

Our finding that pneumonia complication is associated with death in burn patients corroborates with that of McGwin et al who recently developed a mortality prediction model using NBR data. These authors then validated their prediction model using the subset of

patients in the National Trauma Data Bank with burn injuries.³ In both registries, pneumonia complication was approximately associated with an adjusted odds ratio of 1.6 for death. Inclusion of pneumonia improved discrimination for death in receiver operating curves analyses, and this factor was selected in their final mortality prediction model. The presence of comorbidity, however, was left out of the final model as it did not improve discrimination for death. In contrast, we restricted our analysis to patients aged 55 years and older, where the incidence and influence of comorbidities were probably greater compared with the entire adult cohort.

An important limitation to this analysis is the lack of information regarding the timing or onset of pneumonia during hospitalization. The clinical implications of pneumonia are probably much different in early-onset ventilator-associated pneumonia, as opposed to pneumonia causing respiratory failure and ventilator dependence at a late stage of a protracted hospitalization. As such, we are cautious to not overstate the importance of the association between pneumonia and other complications, specifically mortality. Although the data appear suggestive, we cannot conclude that the association between pneumonia and consistently worse outcomes imply a causal relationship between the exposure and measured outcomes. Incorporating the onset of key complications such as pneumonia and renal failure into future NBR reports may allow better characterization of the relationship between injury and nosocomial complications and their temporal association with surgical tracheostomy and subsequent complications, including death.

Improvement in our understanding of the epidemiology of older adults with burn injuries is contingent on having a reliable and well-populated NBR database. To partly compensate for potential underreporting, we have restricted our analysis to patients who have at least one ICD-9 code listed in the NBR. However, this does not negate potential interpretation errors from both under- and overreporting into the NBR. Furthermore, the clinical diagnosis of pneumonia is difficult to establish, particularly in mechanically ventilated patients. This clinical challenge creates variability by which individual centers may define pneumonia. To improve the consistency of diagnosis and reporting, we propose that individual centers follow criteria established by consensus conferences and published guidelines when reporting to the NBR.^{5,26}

In conclusion, the NBR data indicate that pneumonia is a common complication of hospitalization in older adults with burn injuries. Injury factors, the presence of comorbidities, and highest age category predicted the development of pneumonia in this large national patient sample. This analysis demonstrates the relative contributions of comorbidities over chronological age as risk factors for pneumonia development.

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Table 1

Charlson weighted index for comorbidities*

Assigned Weights for Conditions	Conditions
1	Acute myocardial infarction
	Congestive heart failure
	Peripheral vascular disease
	Cerebrovascular disease
	Dementia
	Chronic pulmonary disease
	Connective tissue disorder
	Peptic ulcer disease
	Mild liver disease
	Diabetes
2	Hemiplegia
	Moderate or severe renal disease
	Diabetes with end-organ damage
	Any tumor
	Leukemia
	Lymphoma
3	Moderate or severe liver disease
6	Metastatic tumor
	Acquired immunodeficiency syndrome (AIDS)

* Total equals comorbidity score from Charlson et al.¹⁹

Table 2

Patient and injury characteristics, categorized by pneumonia development

Category	Pneumonia, N = 2,052	No Pneumonia, N = 21,742	P
Age (yr)	70.3 ± 10.4	70.7 ± 10.7	.12
Percent male	65.4	55.9	<.001
Race (%)			.004
White	77.0	77.1	
Black	16.3	14.7	
Hispanic	3.3	4.4	
Other	3.4	3.8	
Percent TBSA	20.7 ± 15.0	12.5 ± 13.2	<.001
Percent full thickness	15.6 ± 13.1	9.9 ± 12.4	<.001
Etiology (%)			<.001
Fire/flame	45.5	30.3	
Scald	6.6	12.5	
Contact	2.1	3.7	
Chemical	0.6	1.3	
Electrical	0.5	1.0	
Other/unknown	44.6	51.1	
Inhalation injury (%)	21.2	6.9	<.001
Presence of comorbidity	34.1	13.4	<.001

Table 3

Adjusted odds ratio for development of pneumonia

Category	Adjusted Odds Ratio	95% Confidence Interval	P
Age 65–74 yr *	0.89	0.74–1.06	.18
Age ≥ 75 yr *	1.26	1.07–1.48	.005
Male	1.20	1.04–1.39	.02
TBSA (per %)	1.02	1.02–1.03	<.001
Fire/flame etiology	1.51	1.26–1.81	<.001
Inhalation injury	2.38	2.02–2.79	<.001
Charlson score = 1 †	2.84	2.40–3.37	<.001
Charlson score = 2 †	2.47	1.91–3.19	<.001
Charlson score = 3 †	4.12	2.84–5.97	<.001
Charlson score ≥4 †	5.23	3.12–8.77	<.001

* Using age group 55–64 yr as reference category.

† Using Charlson score = 0 as reference category.

Table 4

Associations between pneumonia development and hospitalization outcomes

Outcome	Pneumonia, N = 2,052	No Pneumonia, N = 21,742	P
LOS *	36.0 ± 32.4	14.0 ± 17.9	<.001
LOS/TBSA *	4.0 ± 9.5	3.2 ± 6.3	<.001
Intensive care LOS *	21.7 ± 26.4	4.9 ± 12.7	<.001
Days on mechanical ventilation *	19.5 ± 23.7	3.1 ± 11.2	<.001
No. operations			
0	9.1	30.9	<.001
1–2	17.3	36.9	
3–4	32.5	24.0	
≥5	41.1	8.2	
Tracheostomy (%) *	47.0	7.1	<.001
Mortality (%)	30.4	9.5	<.001
Discharge disposition			
Home/other home	22.4	53.7	<.001
Extended care	32.6	17.0	
Rehabilitation/psychiatric facility	8.1	2.9	
Acute care facility	21.8	18.3	
Other/unknown	15.1	8.1	

* Calculated in survivors only.

LOS, length of stay.

Table 5

Adjusted odds ratio for mortality, factoring in pneumonia development

Category	Adjusted Odds Ratio	95% Confidence Interval	P
Age 65–74 yr *	2.30	1.94–2.77	<.001
Age ≥ 75 yr *	5.74	4.85–6.79	<.001
TBSA	1.09	1.09–1.10	<.001
Malesex	0.92	0.81–1.06	.245
Pneumonia development	1.91	1.61–2.27	<.001
Inhalation injury	2.73	2.36–3.17	<.001
Comorbidity score = 1 †	1.45	1.21–1.75	<.001
Comorbidity score = 2 †	2.32	1.83–2.96	<.001
Comorbidity score = 3 †	3.68	2.54–5.35	<.001
Comorbidity score ≥4 †	5.33	3.23–8.78	<.001

* Using age group 55–64 as a reference category.

† Using Charlson score = 0 as reference category.