



Risk Factors for In-Hospital Mortality in Smoke Inhalation-Associated Acute Lung Injury

Data From 68 United States Hospitals

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BACKGROUND: Mortality after smoke inhalation-associated acute lung injury (SI-ALI) remains substantial. Age and burn surface area are risk factors of mortality, whereas the impact of patient- and center-level variables and treatments on survival are unknown.

METHODS: We performed a retrospective cohort study of burn and non-burn centers at 68 US academic medical centers between 2011 and 2014. Adult inpatients with SI-ALI were identified using an algorithm based on a billing code for respiratory conditions from smoke inhalation who were mechanically ventilated by hospital day 4, with either a length-of-stay ≥ 5 days or death within 4 days of hospitalization. Predictors of in-hospital mortality were identified using logistic regression. The primary outcome was the odds ratio for in-hospital mortality.

RESULTS: A total of 769 patients (52.9 ± 18.1 years) with SI-ALI were analyzed. In-hospital mortality was 26% in the SI-ALI cohort and 50% in patients with $\geq 20\%$ surface burns. In addition to age > 60 years (OR 5.1, 95% CI 2.53-10.26) and $\geq 20\%$ burns (OR 8.7, 95% CI 4.55-16.75), additional risk factors of in-hospital mortality included initial vasopressor use (OR 5.0, 95% CI 3.16-7.91), higher diagnostic-related group-based risk-of-mortality assignment and lower hospital bed capacity (OR 2.3, 95% CI 1.23-4.15). Initial empiric antibiotics (OR 0.93, 95% CI 0.58-1.49) did not impact survival. These new risk factors improved mortality prediction by 9.9% ($P < .001$).

CONCLUSIONS: In addition to older age and major surface burns, mortality in SI-ALI is predicted by initial vasopressor use, higher diagnostic-related group-based risk-of-mortality assignment, and care at centers with < 500 beds, but not by initial antibiotic therapy.

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KEY WORDS: adult respiratory distress syndrome; burns; epidemiology; risk factors; smoke inhalation

ABBREVIATIONS: ABA = American Burn Association; APR-DRG = All Patient Refined Diagnosis-Related Group Classification System; AUC = area under the curve; CDB/RM = clinical database/resource manager; ICD-9 = International Classification of Diseases, version 9; SI-ALI = smoke inhalation-associated acute lung injury; TBSA = total burn surface area; UHC = University Health System Consortium

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Each year, burn injuries account for nearly 265,000 deaths globally and 3,500 deaths in the United States.^{1,2} Ninety percent of burn-related mortality is partially attributable to smoke inhalation-associated acute lung injury (SI-ALI).³ After smoke inhalation, direct cellular injury, airway obstruction, regional blood flow changes, toxin- and cytokine-mediated inflammation, and bacterial infection contribute to ALI.^{4,5} In contrast to cutaneous burns, few evidence-based guidelines exist for managing SI-ALI because of a lack of consensus on defining criteria resulting in wide variations in clinical practice.⁶ Despite advances in burn care and rehabilitation, SI-ALI-related mortality, 21.3% in 2015, remains substantial.⁷

Improving SI-ALI survival may be feasible by individualizing supportive care and prioritizing innovative therapies for high-risk victims.⁸ Identifying risk factors of mortality in SI-ALI may facilitate risk stratification, enhance inter-institutional comparisons, and enable benchmarking of quality care metrics. The best-characterized risk factors of mortality in SI-ALI are increasing age and burn size.^{7,9} The effects of other

patient and center-level determinants of survival remain underexplored.

Several health-care data repositories are available to investigate risk factors of mortality in SI-ALI.^{3,7,10} The National Burn Repository of the American Burn Association (ABA) provides comprehensive data on burn victims nationally at burn centers, but is limited by missing data and duplicate records.^{7,11} The Nationwide Inpatient Sample, an administrative data source covering one in five US nonfederal hospital discharges lacks details on some key variables.³ Recent quality improvement-targeted enhancements to some administrative databases, such as encounter-level, date-stamped interventions, have facilitated benchmarking, surveillance, and comparative-effectiveness research. Characterizing these interventions in patients with SI-ALI enables evaluation of unique processes of burn care otherwise not available. We developed an operational algorithm to identify patients with putative SI-ALI in an enhanced administrative database and investigated clinical risk factors of mortality.

Methods

Study Design

We performed a retrospective cohort study to identify inpatient encounters for SI-ALI using a prespecified algorithm to query the clinical database/resource manager (CDB/RM) of the University Health System Consortium (UHC; Chicago, IL), which is a collaborative of 117 academic medical centers and 300 affiliates, whose CDB/RM contains inpatient billing records and charges for drugs, laboratory, and other services by mapping charge masters of participating institutions. It has been a data source for several epidemiologic publications.¹² The study was exempted from institutional board review by the National Institutes of Health Office of Human Subjects Research Protections (Bethesda, MD).

SI-ALI Operational Algorithm

Following a trend analysis of *International Classification of Diseases*, version-9 (ICD-9), respiratory system burn injury diagnosis codes

(e-Table 1; Fig 1), adult (age ≥ 18 years) inpatient encounters discharged between October 2011 and March 2014, and associated with diagnosis 508.2 (respiratory conditions from smoke inhalation) were identified. Outside hospital transfers were analyzed separately.

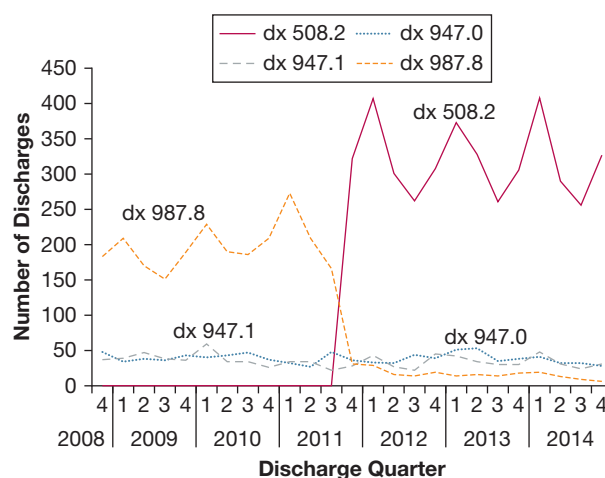


Figure 1 – Trends in four respiratory system burn injury diagnosis codes among discharges from 154 academic medical centers and affiliates between October 2008 and October 2014. A trend analysis of the most common International Classification of Diseases, version 9, diagnosis codes representing respiratory system burn injury in discharge abstracts at 154 centers in the University System Health Consortium was performed for the period between October 2008 and October 2014. The diagnosis code diagnosis (dx) 508.2 (respiratory conditions from smoke inhalation), which was introduced in October 2011, nearly replaced dx 987.8 (toxic effect of unspecified gas, fume, or vapor) as being the most frequently assigned. Diagnosis 947.0 (burn of mouth and pharynx) and dx 947.1 (burn of larynx, trachea and lung) remained relatively unchanged over time.

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