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Necrotizing Soft-Tissue Infections: Differences in Patients Treated at Burn Centers and Non-Burn Centers

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Abstract

Necrotizing soft-tissue infections (NSTI) are often life-threatening illnesses that may be best treated at specialty care facilities such as burn centers. However, little is known about current treatment patterns nationwide. The purpose of this study was to describe the referral patterns for treatment of NSTI using a multistate discharge database and to investigate the differences in patients with NSTIs treated at burn centers and nonburn centers. The National Inpatient Sample is an all-payer inpatient database from 37 states containing data from 14 million hospital stays each year. We identified all patients with NSTI using International Classification of Disease version 9 codes for necrotizing fasciitis (728.86), gas gangrene (040.0), and Fournier's gangrene (608.83) for the years 2001 and 2004. Patients were dichotomized by location of definitive treatment—either burn centers or nonburn centers. Burn center status was ascertained from the current American Burn Association burn center directory. Patient characteristics, payer status, hospital course, mortality rates, and disposition were compared between patients treated at burn centers and nonburn centers. In 2001 and 2004, a total of 10,940 patients were identified as having a NSTI. The majority (87.1%) of these patients received definitive care at nonburn centers. Patients treated at burn centers were more likely to be transferred from another hospital (OR 2.0, CI 1.8–2.2) and were more likely to have Medicaid (22.6% vs 16.3%, OR 1.39) or be uninsured (18.8% vs 13.7%, OR 1.38). Patients treated at burn centers had more surgical procedures (4.6 vs 4.3, $P < .01$), and higher hospital charges ($101,800 vs $68,500, $P < .01$). Total length of stay was also longer at burn centers (22.1 vs 16.0 days, $P < .01$). Based on a national discharge database, the majority of patients with NSTI are treated at nonburn centers. However, patients treated at burn centers were more likely to be transferred from non-burn centers, had longer lengths of stay, and underwent more operations, all of which are likely attributable to a greater severity of infection.

Necrotizing soft-tissue infections (NSTIs) are often dramatic and life-threatening illnesses that require prompt surgical debridement and subsequent expert critical care and wound management. Treatment of these potentially lethal infections requires emergent surgical debridement and several subsequent operations for debridement as well as soft tissue reconstruction. Critical care expertise is mandatory in the management of these patients and access to resources for proper rehabilitation after recovery from their acute illness. Given the prolonged need for complex multidisciplinary care these patients require, patients with NSTI's may be best managed at specialized wound management facilities such as burn centers.[1]

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Treatment of other complex surgical problems at specialized regional centers has been shown to improve outcomes. In trauma, risk of death is decreased when patients are treated at trauma centers vs non-trauma centers,[2] and cost per life year saved is comparable with expenditures for other major health issues.[3] In cancer surgery, operative mortality may be less at specialized hospitals for procedures such as esophagectomy, pancreatic resection, and pulmonary lobectomy.[4] In the case of pancreaticoduodenectomy, patients treated at specialized hospitals have increased late survival[5] in addition to better perioperative outcomes.[6] Selected cardiovascular procedures also have reduced death rates at high-volume centers.[7]

Little is known about current referral and treatment patterns for patients with NSTIs. We sought to examine national trends in the location of management of NSTIs and, specifically, to compare the characteristics and outcomes of patients with NSTIs treated at burn centers and nonburn centers using a large multistate discharge database.

METHODS

Study Overview

We conducted a retrospective cohort study of patients with necrotizing soft tissue infections and compared illness severity and outcomes of patients treated at burn care facilities with patients treated at nonburn care facilities.

Data Sources

For this study we used the Nationwide Inpatient Sample (NIS) of the Healthcare Cost and Utilization Project. Healthcare Cost and Utilization Project is a partnership of federal and state governments as well as hospital associations and private data organizations. The NIS is the largest all-payer inpatient database in the United States, comprising data from about 14 million hospital stays every year. Currently this includes data from 994 hospitals in 37 states.[8] We used NIS data from the years 2001 and 2004 for this study.

Data Collection and Analysis

We identified patients with NSTIs in the NIS using International Classification of Disease version 9 (ICD-9) discharge codes associated with necrotizing soft tissue infections: necrotizing fasciitis (728.86), gas gangrene (040.0), and Fournier's gangrene (608.83). Patients were dichotomized by location of definitive treatment—either burn centers or nonburn centers. Burn center status was ascertained from the current American Burn Association burn center directory. The directory includes 125 self-designated burn care facilities without regard to verification status. Hereafter these facilities will be referred to as burn centers.

Baseline patient characteristics including gender, age, and race were obtained from the database. Racial/ethnic subgroups included in the database were White, Black, Hispanic, Asian/Pacific Islander, Native American, and Other. We also reviewed details and outcome of treatment including number of operations, intensive care unit days, hospital length of stay (LOS), in-hospital mortality, disposition status, and total hospital charges. A number of patients in our initial search had either 0 or 1 operations performed, which may be inconsistent with an actual necrotizing soft-tissue infection and may be more representative of simple abscesses. This could also represent severely ill patients that died before making to the operating room. We chose to exclude those patients who survived more than 48 hours but only had 0 or 1 operation. Initial transfer status and payer status were also identified. Payer status was classified as either commercial (private insurance and health maintenance

organizations) or noncommercial (Medicare, Medicaid, self-pay, no charge, or other). All commercial insurance was combined into one category for the logistic regression analyses.

Since there is no standard scoring system for necrotizing fasciitis severity, and body surface area is typically not reported, we used the presence of organ failure as a surrogate of disease severity. The ICD-9 codes for respiratory (96.7), neurologic (348.3, 293, 348.1), hematologic (287.4, 287.5, 286.9, 286.6), hepatic (570, 573.4), renal (584), and cardiovascular (785.5, 458) organ failure were used in accordance with previous reports.[9]

Characteristics and outcomes of patients treated at burn centers and nonburn centers were first compared using univariate analyses. We then performed two separate multivariate logistic regression analyses. In the first analysis, we examined the association between a number of patient and injury characteristics and treatment location; in the second analysis we examined the association between treatment location and mortality risk, although controlling for a number of patient and disease factors which could confound this relationship. All statistical analyses were performed using SAS/Stat software (Version 9.1.3 of the SAS System for Windows, (c) 2002–2003, Cary, NC).

RESULTS

Patient Characteristics

Of the more than 28 million patients in the NIS database, a total of 10,940 patients (0.04%) were identified as having a NSTI. Baseline patient characteristics of the study populations are shown in Table 1. The majority of patients with NSTI received definitive care at nonburn centers (87.1%). Mean ages were 49.8 years (SD 0.6) in the burn center patients and 54.6 years (SD 0.2) in the nonburn center patients (P <.001). There was a predominance of male patients at both burn centers and nonburn centers (66.3% vs 63.5%, P <.001). The distribution of racial/ethnic subgroups was similar between the two groups, though there were significantly more Hispanic patients treated at burn centers and more native American patients treated at nonburn centers. Patients admitted to a burn center were more likely to have Medicaid (22.6% vs 16.3%, P <.01) or be self-pay (18.8% vs 13.7%, P <.01) compared with patients at nonburn centers (Table 1).

Organ Failure

The proportion of patients with organ failure during their hospital stay was similar at burn centers and nonburn centers (31.0% vs 30.7%). Patients at nonburn centers had significantly higher rates of pulmonary failure (8.2% vs 4.0%, P <.001) (Table 2). As expected, each additional organ failure conferred greater mortality in both burn center and nonburn center patients, with burn center patients having higher mortality for one-organ system failure and three or more organ system failures (Table 3).

Outcomes

Average length of stay was greater at burn centers vs nonburn centers (22.1 (SD 1.0) days vs. 16.0 (SD 0.29) days, P <.0001). Burn center patients had a significantly higher mean number of surgical procedures during their hospital stay (4.6 vs 4.3, P <.0001). Total hospital charges were also higher, on average, at burn centers ($101,800 vs $68,500, P <. 0001). Average charges adjusted for length of stay and the number of procedures were also higher at burn centers ($82,900 vs $71,200, P <.0001). Disposition to short-term hospitals and home healthcare was similar between the two groups, but patients at nonburn centers were more likely be discharged to other types of facilities (ie, nursing homes) (28.0% vs 25.5%, P = .04). The mortality rate in the overall study population was 10.9%, with patients

treated at burn centers having a higher overall rate of mortality (13.8% vs 10.5%, $P = .0005$) (Table 4).

Association of Number of Procedures With Treatment at a Burn Center

The number of procedures each patient underwent was divided into three categorical variables (Table 5). Those patients undergoing four to six procedures (OR 2.03, CI 1.74–2.37) or 7 to 15 procedures (OR 1.49, CI 1.24–1.78) were more likely to be treated at a burn center.

Multivariate Analysis of Association With Burn Center Care

Next we performed a multivariate analysis to better characterize the patient and injury factors associated with treatment at a burn center. On multivariate analysis, patients treated at burn centers tended to be younger (OR 0.989 per year of age, CI 0.986–0.991), and were less likely to be female (OR 0.87, CI 0.78–0.96). Patients treated at burn centers were more likely to be transferred from another hospital (OR 1.96, CI 1.75–2.19), and were more likely to have noncommercial insurance (OR 1.38, CI 1.20–1.59). Organ failure during hospital admission was not associated with treatment at a burn center (OR 1.01, CI 0.91–1.12) (Table 6).

Predictors of Mortality

We also performed a multivariate analysis of predictors of mortality using age, gender, transfer status, organ failure, and payer status. In this multivariate analysis, being transferred from another hospital was associated with higher mortality (OR 1.28, CI 1.07–1.54). Age (OR 1.03 per year of age, CI 1.03–1.04), female gender (OR 1.45, CI 1.27–1.66), and organ failure (OR 6.65, CI 5.78–7.66) were also predictive of mortality. Patients insured by Medicaid (compared with commercial insurance) had a higher risk of mortality (OR 1.25, CI 1.03–1.51) (Table 7).

DISCUSSION

A number of recent studies have compared patient outcomes at specialty or high-volume hospitals vs outcomes at more traditional, nonspecialty “community” hospitals. MacKenzie et al[2] compared outcomes of trauma patients treated at Level I Trauma centers with those treated at large nontrauma-designated hospitals, and found that in-hospital mortality and 1-year mortality was significantly decreased at designated level I trauma centers. A study of Florida trauma centers likewise found improved outcomes with regionalization of trauma care and despite higher costs at trauma centers the authors noted that the cost per life year saved was comparable with other major health problems such as breast cancer and coronary artery disease.[3] Extensive work done by Birkmeyer et al[4–6] has documented improved outcomes for a number of major general surgical and cardiothoracic[7] procedures done at larger volume hospitals.

Given the complexity of NSTI infections and their need for aggressive surgical and prolonged critical care management, NSTIs may be similarly best managed at centers capable of providing this specialized care. Trends in the incidence of NSTIs are unclear, as the Centers for Disease Control stopped surveillance for these infections in 1991 and has only recently undertaken efforts to reclassify invasive streptococcal infections as notifiable diseases.[10–12] Previous studies have examined increased burn center involvement in the care of patients with NSTIs.[1] In this study, we sought to examine the patient and injury factors associated with treatment at burn centers and to determine if outcomes differed between burn and nonburn centers.

The majority of patients with NSTIs in this analysis received their definitive care at nonburn centers. However, patients at burn centers were much more likely to have been transferred from another institution. Within burn centers, patients transferred from another facility had significantly higher mortality than those not transferred, even after adjusting for other factors. This suggests that the cohort of patients requiring transfer to burn centers may be a higher-risk population.

Patients treated at burn centers had higher overall average lengths of stay, number of surgical procedures, hospital charges, and mortality rates. All of these would seem to be markers for greater disease severity, but attempts to quantify disease severity independent of treatment proved difficult. There was no information in the discharge data on physiologic measures such as shock, nor on the extent of the wounds. However, patients undergoing large numbers of procedures (4 or greater) were significantly more likely to be treated at a burn center. One could theorize that patients needing more frequent trips to the operating room may have more severe and extensive disease. The mortality rate at burn centers for NSTI in this database was consistent with rates previously reported at individual centers.[1,13–15] The mortality at nonburn centers was significantly less than not only the burn centers in our study, but also lower than most reported mortality data in the literature. This further suggests that patients treated at burn centers were more severely ill.

Payer status was also found to be an independent predictor of treatment location. Self-pay patients and especially Medicaid patients were more likely to be treated at burn centers. This raises the specter that transfer to a burn center may have been motivated, in part, by payer status as has been found in recent studies of treatment of trauma and burn patients.[16,17] In addition, Medicaid payer status was an independent predictor of mortality at burn centers. There was no evidence in our data that patients insured by Medicaid had less intensive or aggressive care for their NSTI. This association may be due, instead, to delays in seeking care because of worse healthcare access,[18] or higher rates of comorbidities in poorer patients.[19]

A principal limitation of this and other large administrative databases is the lack of specific indicators of patient condition. For instance, we could not retrieve specific laboratory values, which can be useful in scoring systems such as the APACHE scores. Although the number of surgical procedures was available, it was impossible to assess the extent (eg, in square centimeters) of debridement. We attempted to use ICD-9 codes for various organ failure as markers for disease severity, as was done in other outcomes research.[9] Higher numbers of organs in failure correlated with increased mortality in both patient cohorts in this study, and further study of this trend could help establish a scoring system for predicting mortality in patients with NSTIs and organ failure.

An additional limitation is that burn centers were self-identified, without regard to verification by the American Burn Association. We hypothesized that transferring hospitals would not be referring based on burn verification status but by whether the receiving hospital purported to have resources available for care of patients with extensive wounds. Self-identified burn centers may not meet established guidelines for quality of burn care, and may actually include centers that see predominately burns and are less experienced in the care of NSTIs.

CONCLUSION

NSTIs are serious illnesses that are often treated in specialized centers such as burn units. Based on this large national discharge database, the majority of patients are treated at nonburn centers. However, patients treated at burn centers were more likely to be transferred

from nonburn centers, had longer lengths of stay, underwent more operations, and had higher hospital charges. Those patients transferred from other hospitals to burn centers did worse than patients admitted directly to burn centers, so increased vigilance may be warranted when awaiting the arrival of patients from outside institutions. Differences in outcomes between patients treated at burn centers and nonburn centers are likely attributable to greater severity of infections seen at burn centers, but further study is needed to better delineate severity of illness at admission. Further investigation into the issue of severity scoring may be helpful in future studies of NSTIs and may help establish criteria for transfer to specialized tertiary care centers such as burn centers.

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Table 1

Characteristics of patients with necrotizing soft-tissue infections treated in burn and nonburn centers

	Burn Centers (N = 1409), %	Nonburn Centers (N = 9531), %	*P*
Age (yrs)	49.8	54.6	<.001
Gender (% male)	66.3	63.5	<.001
Race: White	66.6	60.6	.0004
Black	18.4	22.8	
Hispanic	9.3	7.7	
Other	5.8	4.0	
Payer status: commercial	29.7	31.6	<.001
Medicare	28.9	38.5	
Medicaid	22.6	16.3	
Self-pay/other	18.8	13.7	
Transfer status (% transferred)	22.4	11.5	<.001

Table 2

Prevalence of organ failure in patients with necrotizing soft-tissue infections treated in burn and nonburn centers

Type of Organ Failure	Burn Centers (%)	Nonburn Centers (%)	*P*
Any organ failure	31.0	30.7	.82
Pulmonary	4.0	8.2	<.001
Neurologic	1.0	0.7	.62
Hematologic	4.6	5.6	.74
Hepatic	0.5	0.4	.09
Renal	13.4	13.9	.47
Cardiovascular	12.2	10.9	.01

Table 3

Mortality by number of organ systems in failure among patients with necrotizing soft-tissue infections treated in burn and nonburn centers

Organ Systems	Burn Centers (% Mortality)	Nonburn Centers (% Mortality)	*P*
0	5.1	4.4	.26
1	26.7	16.8	<.001
2	41.2	38.8	.62
3+	77.3	47.9	.009

Table 4

Outcomes of patients with necrotizing soft-tissue infections treated in burn and nonburn centers

	Burn Centers Mean (SD) or %	Nonburn Centers Mean (SD) or %	*P*
Length of stay (d)	22.1 (26.7)	16.0 (19.0)	<.0001
# Surgical procedures	4.6 (3.1)	4.3 (3.3)	<.0001
Hospital charges ($)	101,800 (122,000)	68,500 (91,300)	<.0001
Adjusted hospital charges ($)*	82,900	71,200	<.0001
Disposition			
Home	36.3	29.3	<.0001
Subacute care	25.5	28.0	.04
Mortality	13.8	10.5	.0005

*Adjusted for length of stay and number of surgical procedures.

Table 5

Association of number of procedures for necrotizing soft-tissue infections with treatment at a burn center

No. Procedures	Odds of Treatment at Burn Center	Confidence Interval	*P*
2–3	1.19	1.000–1.414	.05
4–6	2.03	1.739–2.365	<.0001
7–15	1.49	1.242–1.777	<.0001

Table 6

Predictors of treatment at burn center for patients with necrotizing soft-tissue infections

Variable	Risk Ratio	Confidence Interval	*P*
Age	0.989	0.986–0.991	<.0001
Female gender	0.866	0.780–0.960	.0062
Insurance; Medicare	0.818	0.719–0.930	.0022
Medicaid	1.39	1.22–1.59	<.0001
Self-pay, other	1.38	1.20–1.59	<.0001
Transfer from another hospital	1.96	1.75–2.19	<.0001
Organ failure-any system	1.01	0.911–1.12	.820

Table 7

Adjusted risk of mortality in patients with necrotizing soft-tissue infections treated in burn and nonburn centers

Variable	Odds Ratio	Confidence Interval	*P*
Treatment location*	1.68	1.32–2.02	<.0001
Age	1.03	1.03–1.04	<.0001
Female gender	1.45	1.27–1.66	<.0001
Transfer status	1.28	1.07–1.54	.0067
Organ failure	6.65	5.78–7.66	<.0001
Payer status			
Medicare†	1.10	0.878–1.38	.155
Medicaid	1.25	1.03–1.51	
Self-pay/other	1.11	0.854–1.44	

*Reference = nonburn center.

†Reference = commercial status.