Infections in Diabetic Burn Patients

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OBJECTIVE — Diabetic burn patients comprise a significant population in burn centers. The purpose of the study was to determine the demographic characteristics of diabetic burn patients and their rate of community-acquired and nosocomial infections.

RESEARCH DESIGN AND METHODS — This was a 46-month retrospective chart and patient registry review comparing diabetic with nondiabetic burn patients. Statistical analysis consisted of means ± SD, descriptive statistics, one-way ANOVA, and χ^2 tests.

RESULTS — Of 1,063 adult burn patients (aged 15–54 years), 68 (6%) diabetic burns were compared with burns of 995 adult nondiabetic patients. Of 193, 62 (32%) senior (≥55 years of age) diabetic burns were compared with 131 nondiabetic senior burns. The major mechanism of injury for the diabetic patients was scalding and contact, in contrast to that of nondiabetic patients who were injured mainly by scalding or flame burns. Adult diabetic patients had a significantly increased frequency of foot burns compared with adult nondiabetic patients (32 of 68 [68%] versus 144 of 995 [14%], $P = 0.001$). Adult diabetic burns had a significant increase in sepsis ($P < 0.002$) and community-acquired burn wound cellulitis ($P < 0.001$) compared with adult nondiabetic patients; and senior diabetic patients had a significantly increased frequency of urinary tract infections compared with senior nondiabetic burn patients ($P < 0.04$). The most common organisms in diabetic burn infections were *Streptococcus*, *Proteus*, *Pseudomonas*, *Candida species*, and *MRSA* (methicillin-resistant *Staphylococcus aureus*). Forty-two percent of the diabetic patients were admitted during the winter months and 25% in the spring. Only 49 of 130 (38%) diabetic burn patients presented for treatment within 48 h after injury compared with 669 of 1,126 (62%) nondiabetic patients ($P = 0.001$).

CONCLUSIONS — Peripheral neuropathy may have precipitated and delayed medical treatment in lower-extremity burns of diabetic patients. Hospitalized diabetic burn patients were also at an increased risk for nosocomial infections, which prolonged hospitalization. Diabetic patient education must include not only caution about potential burn mishaps but also educate concerning the complications from burns that may ensue.

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Approximately 17 million (6.2%) of the U.S. population are diabetic; this disease is the seventh leading cause of death in the U.S. (1). The American Diabetes Association lists the hazards of treating diabetic feet with hot water bottles, heating pads, and hot water soaks but does not alert the readers to the actual severity and consequences of injuries that can ensue (1). There have been numerous anecdotal literature reports about diabetic foot burns from electric heating pads, foot spas, and water baths (2–9). Diabetic patients are known to experience more infections in clean wounds than nondiabetic patients and to heal more slowly, especially in the extremities (10–11). The purpose of this study was to determine the demographic characteristics of diabetic burn patients at a large urban hospital and compare their propensity for nosocomial infections with that of the general burn population.

RESEARCH DESIGN AND METHODS

— A 46-month (April 1999 through January 2003) retrospective chart review of patient encounters at the burn center identified 1,794 burn patients. The hospital is a metropolitan county facility with 464-bed capacity serving a population of 3 million. All patients were seen regardless of ability to pay, with no barriers or impediments for medical care. Private insurance, Medicare, Medicaid, public aid, or the patients covered treatment costs. Patients were either transferred from other hospitals, brought in directly from the scene of injury, or seen in the emergency room and clinic. The Sumner L. Koch Burn Center is accredited by the American College of Surgeons and the American Burn Association. This study was approved by the John H. Stroger, Jr. Hospital of Cook County Institutional Review Board.

Burn care

Resuscitative fluids were administered dependent on requirements for all injuries using modified Parkland formula guidelines. All patients were treated with closed silver sulfadiazine–embedded gauze dressings or Collagenase Santyl (Advance Biofactures, Lynbrook, NY), an enzymatic debriding product, until either the wound healed or surgical intervention was initiated. Arterial blood gases, carboxyhemoglobin levels, chest X rays, and flexible fiberoptic bronchoscopy was performed in patients suspected of having an inhalation injury. Less than 16% of diabetic and nondiabetic burn patients required intravascular or urethral catheters for burns ≥20% of total body surface area (TBSA) and/or inhalation injury where fluid monitoring was essential or patients had perineal or pelvic burns. Within 48 h of admission, patients received continuous enteral nutritional support or a hospital diet formulated on the basal energy expenditure, with an incremental calorie

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Abbreviations: *MRSA*, methicillin-resistant *Staphylococcus aureus*; TBSA, total body surface area; UTI, urinary tract infection.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

input determined by body weight and energy size.

Infectious complications

During the course of hospitalization, the diagnosis of infection was based on blood, urine, wound, sputum, or bronchoscopic cultures. Community-acquired burn wound cellulitis was defined as local wound erythema, edema, pain, occasional fever, and elevated white blood cell count in the setting of a delayed presentation (≥48 h). Nosocomial burn wound infections showed 10^5 organisms upon biopsy. Bacteremia was classified as a positive blood culture in a patient with an intravascular catheter without a fever; occasionally the white blood cell count was elevated. Sepsis was defined as a positive blood culture without contaminants in conjunction with clinical symptoms of fever and an elevated white blood cell count. A urinary tract infection was defined as a positive clean catch or catheterized urine sample with or without a fever or elevated white blood cell count. Pneumonia was identified according to the Society of Critical Care Medicine criteria: a positive sputum or endotracheal sample with positive radiographic findings, pulmonary symptoms, fever, and an elevated white blood cell count.

In the event of a clinical infection, empiric treatment with antibiotics was initiated until definitive culture and sensitivities were obtained. Patients with cellulitis of the burn wound were started on oxacillin, since the most common organism was *Staphylococcus aureus*. Although this was also a common etiological agent in the diabetic patients, diabetic burn wound cellulitis was usually caused by multiple organisms, including *Streptococcus*, *Proteus*, *Pseudomonas*, *methicillin-resistant Staphylococcus aureus* (*MRSA*), *Enterococcus*, and *Enterobacter*. More broad-spectrum coverage, such as piperacillin sodium, piperacillin sodium,tazobactam sodium, or ampicillin sodium/sulbactam sodium, were antibiotics of choice. Anaerobe cultures were ordered only if the burn wound had the distinctive odor on presentation.

Statistical analysis

Statistical analyses were performed utilizing Statistica (STATSOFT, Tulsa, OK). Analysis was performed comparing the diabetic burn population to the nondiabetic burn population in two age-groups for length of stay, percentage TBSA, infectious complications, outcomes, mechanism, and method of injury. Summary descriptive statistics encompassed means, standard deviation, the nonparametric χ^2 2×2 summary frequencies (Pearson's, maximum likelihood, and McNemar), one-way ANOVA, and post hoc comparison with the Tukey test for unequal numbers. $P < 0.05$ was considered significant.

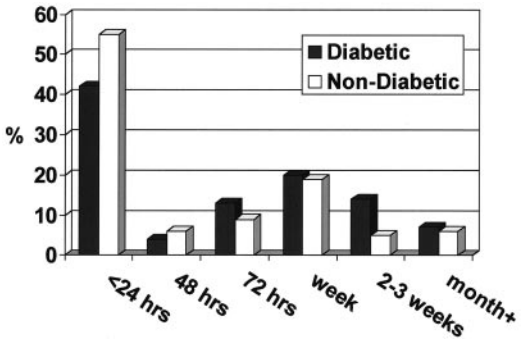

Figure 1—*Burn wound age on admission in diabetic and nondiabetic patients. Only 40% of diabetic burn patients presented for treatment in the first 48 h after injury.*

RESULTS

General comparison of all diabetic burn patients to all nondiabetic burn patients

Of 1,794 burn patient encounters, 130 (10.4%) were diabetic. They represented 16 of 607 (3%) outpatients, 7 of 113 (6%) in-house consultations, and 109 of 1,047 (10%) admissions. Because only 1 of 538 pediatric patients had diabetes, the pediatric population was excluded from this study. For comparison purposes, the patients were grouped into the adult (15–54 years of age) and senior (≥55 years of age) groups. In the adult group, 68 of 1,063 patients (6%) were diabetic. In the senior group, 62 of 193 patients (32%) were diabetic. The diabetic burn patients were significantly older (54 ± 13 vs. 27 ± 20 years, $P < 0.0001$), with a larger percentage of TBSA (11 ± 19 vs. 6 ± 11%, $P < 0.001$) than the nondiabetic burn population. Diabetic burn patients also had significantly increased cardiovascular comorbidity: 33 (25%) vs. 52 (3%) in the general nondiabetic burn population; 73 (55%) of the diabetic burn patients had hypertension compared with 94 (8%) of the nondiabetic burn patients ($P = 0.01$). The majority of the nondiabetic burn patients presented within 48 h of injury (995, 63%), whereas only 49 (40%) of the diabetic patients presented this early (Fig. 1). Another 38 (31%) presented between days 3–7, and 19 (15%) presented 2–3 weeks later. The readmission rate for adult diabetic burn patients was 8 (12%) versus 33 (3%) for nondiabetic adults. The diabetic senior patients had a readmission rate of 7 (54%) compared with a readmission rate of nondiabetic seniors of 6 (5%).

If one compared infections in all diabetic burn patients to infections in nondiabetic burn patients (130 vs. 1,126 patients), the diabetic patients had a greater frequency of bacteremia (12 [9.2%] versus 38 [2.5%]), sepsis (13 [10%] vs. 28 [2.5%]), urinary tract infection (UTI) (14 [11%] vs. 33 [3%]), pneumonia (12 [9.2%] vs. 71 [6.3%]), burn wound cellulitis (35 [27%] vs. 120 [11%]), and nosocomial burn wound infection (10 [8%] vs. 40 [4%]). The diabetic patients with burn wound cellulitis were more likely to have multiple organisms cultured, such as *Streptococcus*, *Proteus*, *Pseudomonas*, *MRSA*, and *S. aureus*. In contrast nondiabetic burn patients presented with either *S. aureus* or *Pseudomonas*. For nosocomial infections such as pneumonia, UTI, wound infection, bacteremia, and sepsis, diabetic patients had organisms such as *Klebsiella*, *Acinetobacter*, *Proteus*, *Pseudomonas*, *MRSA*, *S. aureus*, *Enterococcus*, and *Enterobacter*. Nondiabetic burn patients had *Klebsiella*, *Streptococcus*, *Pseudomonas*, *S. aureus*, *Escherichia coli*, *Enterococcus*, and *Enterobacter*.

There were few visual problems in this burn population; most patients had corneal abrasions, glaucoma, cataracts, or blindness, and there was no difference between the diabetic and nondiabetic patients in terms of frequency (8 diabetic patients [6%] vs. 31 nondiabetic patients [3%]). The majority of diabetic subjects who presented with foot burns had peripheral neuropathy, which not only pre-

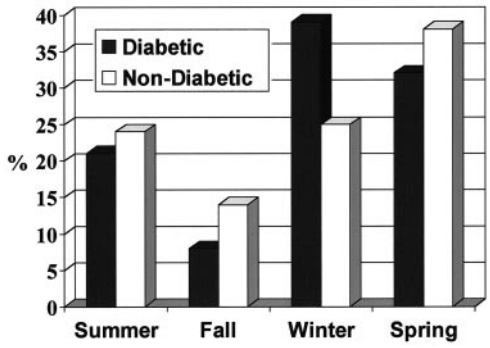

Figure 2—*Percentage of seasonal variation in diabetic and nondiabetic burn admissions. The majority of the diabetic population presented in the winter and spring.*

disposed them to foot injury but also contributed to the delay in treatment. Diabetic patient HbA_{1c} levels were 8.8 ± 3% (normal range 4.4–6.7).

The majority of diabetic burn patients came to the burn center during the winter compared with other diabetic burn patients, who came throughout the year (Fig. 2). The main mechanisms of injury for the diabetic patients were scalding and contact, whereas the nondiabetic burn patients were either scalded or had a flame injury (Fig. 3).

There was no significant difference between the diabetic and nondiabetic burn patients in length of stay, percentage of TBSA, burn intensive care unit days, intensive care/percentage of TBSA, step down days, days/percentage of TBSA, number of procedures, total centimeters of grafted area, and mortality.

Comparison of diabetic and nondiabetic burn patients by age-group

Table 1 compares the diabetic and nondiabetic burn patients in two groups by age:

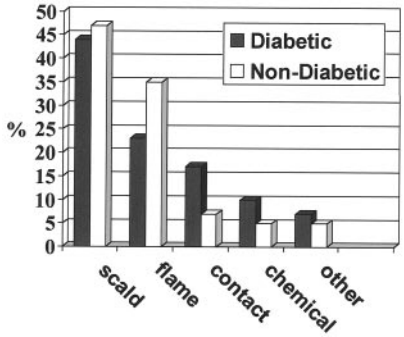

Figure 3—*Percentage of mechanism of injury in diabetic and nondiabetic burn patients. Although scald injuries occurred in diabetic patients at the same rate as in the nondiabetic patients, they had a higher rate of contact injuries.*

adults ≥15–54 years and seniors ≥55 years. Although there is an equal number of diabetes in both groups, there are twice as many control subjects in the nondiabetic senior group and ~10 control subjects for each diabetic patient in the adult group. Diabetic burn patients comprised 6% of the adult population and 32% of the senior population. While the senior group had a similar age range, the adult diabetic patients were older than the nondiabetic subjects. The ratio of men to women was generally 3:1; however, there was an equal distribution of women and men in the senior groups. The majority of the patients were African American. Most of the patients had a 5–12% TBSA. Diabetic burn patients were more likely to have hypertension and cardiovascular disease in both age-groups compared with nondiabetic subjects ($P < 0.01$). Diabetic burn patients in both groups developed respiratory failure to a greater degree than the nondiabetic subjects, a fourfold increase in seniors and twofold increase in adults. Adult diabetic patients were more likely to have longer hospitalizations compared with other adult nondiabetic subjects. Diabetic seniors had more procedures compared with the other groups. The adult nondiabetic patients had the highest rate of substance use in the four groups. There was no statistically significant difference in mortality among the groups.

Diabetic patients in both age-groups were more likely to have bacteremia, sepsis, UTI, and burn wound cellulitis than nondiabetic subjects. Although more

Table 1—*Demogrqphic characteristics of diabetic and nondiabetic burn patients by age-group*

	Adult (15–54 years)		Senior (55–91 years)	
Parameter group	Diabetic	Nondiabetic	Diabetic	Nondiabetic
Patients*	68 (6)	995 (94)	62 (32)	130 (68)
Age (years)	46 ± 9	34 ± 11	64 ± 7	66 ± 9
Sex (male/female)	68/32	76/24	53/47	68/32
Race (AA/H/other)	67/13/20	55/27/18	79/9/19	64/14/22
TBSA	12 ± 23	7 ± 12	10 ± 12	9 ± 16
Inhalation*	7 (10.5)	92 (9)	3 (5)	16 (13)
Respiratory failure*	5 (8)	38 (4)	12 (19)	7 (5)
Length of stay (days)	11 ± 12	8 ± 9	14 ± 17	11 ± 12
ICU/TBSA	0.6 ± 0.9	1.4 ± 3	1.3 ± 1.5	1.1 ± 1.3
Days/TBSA	3 ± 4	2 ± 2	2 ± 3	3 ± 4
Procedures*	1.8 ± 1.5	1.5 ± 1.3	2.5 ± 2.8	1.6 ± 1.4
Total graft (cm^2)	1,168 ± 3,780	1,189 ± 2,762	1,552 ± 2,260	886 ± 1,242
Foot involvement*	31 (49)	145 (15)	18 (30)	28 (22)
Substance use*	11 (8)	230 (23)	6 (10)	21 (16)
All nosocomial infections*	8 (12)	54 (5.4)	16 (26)	12 (9)
Cellulitis*	22 (33)	97 (9.8)	12 (20)	14 (11)
Wound infection*	3 (5.0)	30 (3.0)	6 (10)	7 (5.7)
Bacteremia	5 (7.4)	29 (3.0)	6 (9.4)	5 (3.8)
Sepsis	6 (9.0)	20 (2.0)	6 (9.4)	5 (3.8)
UTI	3 (4.5)	16 (1.6)	11 (17)	9 (7)
Pneumonia	5 (7.4)	48 (4.8)	6 (9.4)	11 (8.4)
Hypertension*	33 (49)	49 (5.0)	39 (63)	39 (30)
Cardiac disease*	9 (13)	25 (2.5)	24 (39)	24 (18)
Admit glucose (mg/dl)	176 ± 85	102 ± 29	204 ± 85	117 ± 26
Mortality*	1 (1.5)	18 (2.0)	3 (5)	9 (3)

*Data are *n* (%) and means ± SD. ICU, intensive care unit.

Table 2—*Comparison of organisms cultured in community-acquired burn wound cellulitis and nosocomial infections in the diabetic and nondiabetic burn population*

	Burn wound cellulitis		Nosocomial infections	
Parameters	Diabetic	Nondiabetic	Diabetic	Nondiabetic
Klebsiella	1 (3)	0	6 (24)	21 (28)
Acinetobacter	1 (3)	0	6 (26)	9 (12)
Citrobacter	1 (3)	0	1 (5)	6 (8)
Streptococcus	5 (16)	2 (2)	2 (9)	14 (19)
Proteus	5 (16)	0	4 (17)	6 (8)
Pseudomonas	3 (9)	3 (3)	5 (21)	17 (23)
MRSA	4 (12)	1 (1)	5 (21)	10 (13)
MSSA	6 (18)	4 (4)	6 (27)	22 (30)
E. coli	1 (3)	0	1 (5)	15 (22)
Enterococcus	2 (7)	1 (1)	6 (27)	18 (27)
Enterobacter	2 (7)	2 (2)	4 (24)	18 (27)
H. influenza	0	0	1 (5)	8 (12)
Serratia	0	0	0	3 (7)
Staphylococcus coagulase negative	1 (5)	1 (1)	2 (14)	0
Candida	0	0	6 (25)	2 (6)

Data are *n* (%). MSSA, methicillin-sensitive *S. aureus*. Nosocomial infections were clinical isolates that in conjunction with the clinical presentations originated in the following sources: wound, blood, sputum, or urine.

adult diabetic patients had pneumonia compared with nondiabetic subjects, all seniors had a high rate of pneumonia. Adults did not differ in the frequency of nosocomial burn wound infection in this study. There was a slight difference in the infectious organisms that patients acquired in the community and in the hospital, as seen in Table 2. While the most frequent infections for burn wound cellulitis in the nondiabetic patients were *S. aureus* and *Pseudomonas*, diabetic patients came in with multiple organisms: *Streptococcus*, *Proteus*, *Pseudomonas*, *MRSA*, and *S. aureus*. Nosocomial infections (bacteremias, sepsis, pneumonias, UTI, and burn wound infections) in diabetic and nondiabetic participants had the same frequency of the following organisms precipitating the infection: *Klebsiella*, *Pseudomonas*, *S. aureus*, *Enterococcus*, and *Enterobacter*. Diabetic burn patients had a higher frequency of *Acinetobacter*, *Proteus*, *MRSA*, and *Candida*, while *Streptococcus*, *E. coli*, and *Hemophilus Influenza* were more likely the culprits in nondiabetic burn patient infections.

Compared with adults, senior diabetic burn patients had a trend toward an increase in wound infections, bacteremia, and sepsis but not pneumonia. Respiratory failure was slightly higher in the diabetic seniors compared with the other groups, and they were also more likely to have a higher rate of cardiovascular morbidity ($P < 0.01$). Diabetic burn adult and senior patients had the same frequency of foot, upper and lower extremity, and head and torso injuries. The admission glucose serum level was elevated in the diabetic burn patients compared with the nondiabetic patients ($P < 0.002$), especially if they had an infection. Both adult and senior diabetic patients had elevated blood glucose levels with infection (157 ± 50 vs. 272 ± 99 mg/dl) and without infection (180 ± 90 vs. 176 ± 62 mg/dl); nondiabetic seniors (128 ± 24 mg/dl) also had hyperglycemia on admission. The numbers were small; however, there was a trend for all patients with hyperglycemia (>110 mg/dl) on admission to have a twofold increase in nosocomial infections compared with patients with normal admission blood glucose levels. Neither HbA_{1c} nor elevated admission glucose values of diabetic burn patients were predictive of the risk for later infections during the hospitalization.

CONCLUSIONS — In this study, adult and senior diabetic burn patients were more likely to be admitted with community-acquired burn wound cellulitis and to develop nosocomial infections, such as bacteremia and sepsis, once they were hospitalized in comparison with nondiabetic burn patients. Senior diabetic and nondiabetic populations were well matched for age and percentage of TBSA. The analysis for the adult diabetic burn patients indicated that they were generally older and had a higher percentage of TBSA than the nondiabetic burn population. Diabetic burn patients were more likely to have cardiac and hypertensive comorbidities compared with nondiabetic burn patients in both age-groups. This study did not delineate whether the increased comorbidities of the diabetic burn patients contributed to longer hospitalizations, which then predisposed them to nosocomial infections. Elevated glucose levels were present in all diabetic burn patients on admission and were frequently difficult to control during hospitalization. As expected, with nosocomial infections, some patients required more rigorous hyperglycemic control with insulin drips. This study indicated that the diabetic burn population was more susceptible to infectious complications before hospitalization and required longer hospitalization than the nondiabetic burn population. None of the studied diabetic burn patients sustained significant anaerobic infections.

Although they frequently presented with multiple organisms, *S. aureus* was a major infective agent in burn wounds (12). The burn wound was generally acute and a surface lesion; only the occasional patient presented with anaerobic or fungal infections in the burn wound since anaerobes die readily on exposure to air. There have been specific associations of diabetic patients with anaerobic cholecystitis and osteomyelitis (13). Diabetic burn patients were more likely to develop *Clostridium difficile* with diarrhea for which they were treated with metrinidazole. It was not possible to determine whether there was any predilection of any organism for a particular infection site since a patient often had a variety of organisms growing in different sites. This study did not evaluate any precipitating factors that may have contributed to invasion with any particular organism. The older diabetic patients, however, were more likely to sustain their burns during falls in the shower or bath; with perineal, buttock, and upper thigh burns, they required urinary catheters, which predisposed them to UTIs.

This study confirms the findings presented in another diabetic burn study but includes the older diabetic population,

which had been previously excluded. McCampbell et al. (14) matched diabetic burn patients to control subjects by sex and date of admission; diabetic patients in the current study were matched by age and date of admission. In both studies, diabetic patients had more procedures, infections, and delay in treatment than the nondiabetic cohort. The current study expands on issues not addressed previously, such as the frequency of foot burns in the burn population, community-acquired cellulitis, and the demographic characteristics of diabetic burn patients who were >65 years of age.

It is of interest that even though these two studies used different control groups, the conclusions were the same: diabetic burn patients have more nosocomial infectious complications and longer hospitalizations than nondiabetic burn patients. It is, therefore, imperative that the diabetic population is educated about the hazards and complications of burn injuries. More preventive patient education addressing thermal injury, frostbite, wound healing, and infectious complications in diabetic patients would be indicated to decrease the accidental injury rate requiring hospitalization.

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