Burn Center Management of Necrotizing Fasciitis

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Necrotizing fasciitis is a rapidly progressive soft-tissue infection associated with significant morbidity and mortality. Necrotizing fasciitis is similar to invasive burn wound infection in that diagnosis requires histologic examination of affected tissue and treatment requires aggressive surgical debridement followed by skin autograft. Transfer to a burn center facilitates the management of necrotizing fasciitis, where requisite surgical and nursing expertise is available. We reviewed the experience of one burn center in the management of necrotizing fasciitis over a 5-year period. Ten patients were transferred to the burn center from other medical facilities for care, arriving a mean of 8.9 days after initial hospital admission. The diagnosis was made by a surgical service or consultation before transfer in all cases; initial admission to a medical rather than a surgical service delayed surgery in five cases. All patients had surgical debridement before transfer but required a mean of 5.1 additional operations at the burn center. Although the mean extent of involvement was 14.8% body surface area, the mean length of burn center stay was 34.9 days. Complications were frequent, including pulmonary failure requiring mechanical ventilation ($n = 6$), renal insufficiency or failure ($n = 5$), hypotension requiring pressers ($n = 4$), deep venous thrombosis ($n = 3$), and pulmonary emboli ($n = 1$). Overall mortality was 2 of 10 patients (20%). Both fatalities were associated with delay in initial surgical procedure and in transfer to the burn center. The similarity of necrotizing fasciitis and invasive burn wound infection makes the burn center the ideal setting for the treatment of this disease. We advocate the addition of necrotizing fasciitis to the list of conditions currently recognized by the American Burn Association as appropriate for burn center transfer and care. (J Burn Care Rehabil 2003;24: 127–132)

Necrotizing fasciitis is an uncommon but rapidly progressive soft-tissue infection involving the superficial fascia (subcutaneous tissue) while initially sparing the overlying skin and underlying musculature.[1,2] Originally associated with Group A β-hemolytic streptococcal infection, necrotizing fasciitis may also be caused by Staphylococcus, Vibrio, or Aeromonas species or by anaerobic bacteria. Polymicrobial infection is common.[3,4] The role of synergy between aerobic and anaerobic bacterial species in the pathogenesis of necrotizing fasciitis is noteworthy.[5]

Necrotizing fasciitis may present as a sequelae of pharyngitis or varicella or as a complication of surgical or endoscopic procedures, including caesarian section, vaginal delivery with episiotomy, percutaneous endoscopic gastrostomy, laparoscopy, dental extraction, or liposuction.[1,6–11] More commonly, the onset of necrotizing fasciitis can be related to trivial trauma such as insect bites.

The diagnosis of necrotizing fasciitis is difficult, and the successful treatment of necrotizing fasciitis is resource intensive. The initial minimal skin involvement frequently leads to the incorrect diagnosis of atypical cellulitis, causing delay of definitive surgical management. In 1984, Stamenkovic and Lew[12] established the use of surgical biopsy with frozen section analysis as the gold standard for the diagnosis of

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Presented at the meeting of the American Burn Association, Lake Buena Vista, Florida, March 24 to 27, 1999.
The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or of the Department of Defense.
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0273-8481/2003

DOI: 10.1097/01.BCR.0000066790.57127.61

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 MAY 2003	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Burn center management of necrotizing fasciitis	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Barillo, D. J. McManus, A. T. Cancio, L. C. Sofer, A. Goodwin, C. W.	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX 78009	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**6**	

necrotizing soft tissue infection. The same technique is used by burn surgeons to establish the diagnosis of invasive burn wound infection.[13]

The primary treatment of necrotizing fasciitis is radical surgical debridement. Multiple surgical procedures are often required to completely eradicate the disease, resulting in large open wounds. Split-thickness skin grafting is then required for wound closure. In this regard, the surgical management of necrotizing fasciitis is identical to the care of full thickness burn injury.

A third similarity between burn injury and necrotizing soft tissue infection is the potential for shock and the need for fluid resuscitation. Burn patients will develop hypovolemic shock if not resuscitated and may later develop septic shock from infectious complications. Patients with necrotizing fasciitis often present with circulatory instability out of proportion to extent of skin involvement, requiring fluid resuscitation.[5,14,15] As in the case of a burn patient with invasive wound infection, the patient with necrotizing fasciitis is at risk for multiple organ failure secondary to sepsis.[14] In this article, we describe the recent experience of 1 burn center in the management of patients with necrotizing fasciitis.

MATERIALS

Retrospective review of all admissions to the Army Burn Center for a recent 5-year period was undertaken. Ten patients with the diagnosis of necrotizing fasciitis were identified, comprising 0.6% of all acute admissions within this timeframe. All patients with necrotizing fasciitis were transferred to the burn center after initial care at other medical facilities.

Burn center charts were reviewed to abstract data relating to the history, treatment, and outcome of patients with necrotizing fasciitis. Where available, transfer or discharge summaries from the referring facilities were also reviewed. Statistical methodology was unpaired two-tailed *t*-test.

RESULTS

Demographics of the study population are presented in Table 1. There were five male and five female patients. The mean age was 46.4 years, with a range of 27 to 72 years. Extent of TBSA involvement as documented at burn center discharge ranged from 6 to 30% with a mean of 14.7% TBSA.

The onset of necrotizing fasciitis was related to a trivial or unknown injury in six cases and to a small (2% TBSA) contact burn in one case. Two cases resulting from liposuction surgery have been previously described in detail.[1] One case had no identifiable cause.

Four patients had no known risk factors for necrotizing infection. Three patients had one risk factor, and three patients had two or more risk factors. Factors classically associated with increased risk of necrotizing fasciitis include diabetes mellitus, immunosuppression, alcoholism, intravenous drug use, malnutrition, peripheral vascular disease, age greater than 50 years, and gastrointestinal

Table 1. Patients with necrotizing fasciitis treated at a burn center

Patient No.	Age/Sex	Initiating Event	Risk Factors for Ecrotizing Fasciitis	Final Percent Body Surface Area (TBSA)	Hospital LOS, Referring Facility	Days at Burn Center	Total	Outcome
1	27 M	Karate kick	None	15	8	53	61	Survived
2	68 M	Scratched foot	Age, tuberculosis, HTN	11	5	13	18	Survived
3	60 M	Hand abrasion	Age	30	9	46	55	Survived
4	31 F	Liposuction surgery	None	22	8	41	49	Survived
5	48 F	Liposuction surgery	None	9	6	13	19	Expired
6	72 F	Unknown	Age, HTN	8	4	51	55	Survived
7	33 M	Pimple	None	6	5	22	27	Survived
8	43 M	Scrotal lesion	Alcoholism	15.5	7	37	44	Survived
9	56 F	Perineal cellulitis	Age, diabetes, obesity	20	35	22	57	Expired
10	26 F	Contact burns to feet, 2% TBSA	Diabetes	11	2	51	53	Survived
Mean	46.4 years			14.8	8.9 days	34.9 days	43.8 days	

HTN, hypertension; *LOS*, length of stay.

malignancy.[1] Other reported risk factors include chronic renal failure, pulmonary tuberculosis, hypertension, recent surgery, significant trauma, obesity, the postpartum period, and previous radiotherapy.[3–6,9–11,15,16]

There were eight survivors and two nonsurvivors. Both fatalities were female. There was no statistical difference in age, extent of body surface area involvement, hospital day of first operation, or hospital day of burn center transfer between survivors and nonsurvivors. Day of transfer and day of surgery data was skewed by the fact that one of the fatalities had a delayed admission to the referring hospital. This patient had inadvertent bowel perforation from liposuction surgery but was not hospitalized until the seventh postoperative day.[1] Burn center transfer took place on hospital day 6 but postoperative day 13. The second nonsurvivor was transferred after 35 days of care at another hospital.

All patients were admitted to other hospital facilities before burn center admission. Most patients were initially admitted to a medical rather than a surgical service. There were no significant differences in age, final extent of involvement, number of operative procedures before transfer, or hospital day of transfer between patients admitted to medical or surgical services. A mean of 2.7 surgical debridement procedures per patient were performed prior to burn center transfer (range, 0 to 4; Table 2)

Admission to a medical rather than a surgical service significantly delayed initial surgical debridement in five cases. All patients admitted to a surgical service had operative debridement on hospital day 1 compared with a mean of hospital day 3.2 (range, 1 to 6 days) for patients initially admitted to a medical service ($P = .027$).

Wound culture or grams stain data were available from the referring hospital in eight cases (Table 3). Five patients grew Streptococcus species and 1 additional patient had gram-positive cocci that was not further identified at the time of transfer. Patient 5 had inadvertent intestinal perforation from an office liposuction procedure and grew several enteric species on wound culture. Pretransfer culture results were not available for patients 9 and 10.

After transfer, cultures grew flora typical of hospitalized patients, including *Pseudomonas aeruginosa*, other gram-negative enteric bacteria, Bacillus species, coagulase-negative Staphylococci, and *Candida albicans*. Wound colonization was managed with the same topical agents used for burn care, including silver sulfadiazine, mafenide acetate, nystatin, and clotrimazole. Three patients had blood cultures positive for Staphylococcus species, and one patient had blood cultures positive for *Klebsiella Pneumonia*.

Complications experienced by the treated cohort at the referring facility or the burn center are listed in Table 4. With the exception of patients 4 and 8, all patients were noted to be hypotensive or septic in either the pretransfer or burn center chart; however, the definition of sepsis was not quantified. As a more objective measure, there were four patients who developed hypotension severe enough to require administration of pressers in addition to fluid resuscita-

Table 2. Resource use in management of necrotizing fasciitis

	No. of Operations			Blood Products at Burn Center			Burn Center Wound Care				
Patient No.	Referring Hospital	Burn Center	Total	PRBC	FFP	PLT	Mafenide Cream	Mafenide 5% Aqueous	Silver Sulfadiazene	Allograft	Other
1	4	8	12	49	15	2 6-packs	x	x			Nystatin
2	3	3	6	5	0	0		x			
3	4	10	14		Multiple			x		x	Clotrimazole
4	4	5	9	22	14	0	x	x	x	x	
5	3	4	7	18	12	2 6-packs		x		x	Mycelex
6	1	4	5	17	10	2 6 packs				x	
7	2	2	4	8	0	0		x	x		
8	4	2	6	13	0	0		x			
9	Multiple	5		25	20	0			x		
10	0	8	8	14	1	0		x		x	
mean	2.7	5.1	7.1	19	8						

FFP, Fresh frozen plasma; *PLT*, Platelets; *PRBC*, Packed red blood cells.

Note: Blood product use and topical therapy before burn center transfer not consistently recorded.

Table 3. Culture Data

Patient No.	Pretransfer Culture Results	Burn Center Culture Results: Culture Plate (Surveillence Culture)	Burn Center Culture Results: Wound Biopsy or Surgical Specimen	Blood Culture
1	Group A Streptococcus (knee joint)	*P. aeruginosa*, *Escherichia coli*, Bacullus sp.	*P. aeruginisa*, *C. albicans*	Coag-negative Staphylococcus
2	Strep pyrogenes (wound culture)	None sent	One negative biopsy	None sent
3	Group A strep (wound culture)	*P. aeruginosa*, *S. sapro*, fungal elements, Bacillus sp	*E. cloacae*, fungal elements Coag-negative Staphylococcus	Multiple (−)
4	Gram-positive cocci (wound culture)	*P. aeruginosa*, Bacillus Sp. fungal elements, Nonhemolytic Strep	C. albicans, Coag-negative Staphylococcus	Multiple (−)
5	Wound: *C. albicans*, *Bacteriodes. Cl. Rheumatica Proevotella ruminicola*, Citrobacter, Enterococcus and Klebsiella species	*C. albicans*, *E. cloacae*, Coag-negative Staphylococcus	*K. pneumoniae*, *E. cloacae* fungal elements	Klebsiella. pneumoniae
6	Streptococcal sp. (bulla and operative specimens)	No data	Gp D Strep, nonenterococcal	Multiple (−)
7	Negative intraoperative gram stain	Coag-negative Staphylococcus	Multiple (−)	Multiple (−)
8	β-hemolytic group A strep (source not noted)	Bacillus sp.	None	Multiple (−)
9	Not available	Bacillus sp., *P. aeruginosa*	*P. aeruginosa*, *K. pneumoniae*	*S. aureus*
10	Not available	*C. albicans*, nonhemolytic Streptococcus sp.	*K. pneumonia*, Bacillus sp, Candida sp, Coag-negative Staphylococcus	*S. aureus*

tion. Six patients required mechanical ventilation for respiratory failure. Five patients developed renal insufficiency (serum creatinine above 2 mg/dl). Of these, one patient required dialysis, and the two patients who died did not have dialysis at the family's request as an end-of-life issue. Three patients had deep venous thrombosis diagnosed by duplex ultrasound and one patient had a pulmonary embolus diagnosed with pulmonary angiography.

DISCUSSION

In this small series, the care of necrotizing fasciitis patients mirrored that required by burn patients. In addition to the previously mentioned need for biopsy diagnosis, surgical debridement, and skin grafting, patients with necrotizing fasciitis also required multiple blood transfusions, grew flora that was sensitive to the topical antimicrobial agents used for burn care, and benefited from the availability of temporary wound coverings, such as allograft and aqueous 5% mafenide acetate solution.

In the present series, each patient required transfusion of a mean of 19 units of packed red cells and 8 units of fresh-frozen plasma during burn center care. Wilson,[17] who is credited with the origin of the term necrotizing fasciitis, reported that 19 of 23 patients he treated for necrotizing fasciitis developed anemia. This was ascribed to rapid destruction of red cells from hemolytic bacteria (hemolysins) and from surgical incisions "which may cause the spill of large quantities of blood." Elliot et al[16] retrospectively reviewed the care of 198 patients with necrotizing fasciitis and reported that the average patient required 17.5 units of transfused blood. Although the current emphasis in burn care is to minimize the use of blood products, there is no argument that burn centers have both the expertise and the requisite blood bank support to care for patients that require multiple transfusions during their hospital stay.

The microbiologic flora recovered from the patients in this series were pathogens familiar to the burn team and responsive to the usual burn topical antimicrobial agents. Silver sulfadiazine, 10% mafenide acetate cream, and clotrimazole were effectively used for wound care. Of note is the use of 5% mafenide acetate aqueous solution (Sulfamylon®, Mylan Inc., Pittsburgh, PA). Aqueous mafenide has a broad spectrum of activity for gram-positive and gram-negative organisms, and is particularly useful for temporary coverage of débrided wounds. The drug is applied in liquid form, obviating the need for removal of a thick layer cream at the time of dressing change. This facilitates wound inspection for signs of

Table 4. Complications during treatment of necrotizing fasciitis

Patient No.	Before Burn Center Transfer	After Burn Center Transfer
1	Tachycardia with fever (104.2° F) and delerium	*C. difficile* colitis, large bowel ileus, atrial flutter
2	Clinically septic on admission (not further defined)	Control of infection required above-the-knee amputation
3	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation, seizure, elevated creatinine (2.7 mg/dl)	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation, *Clostridium difficile* colitis, pulmonary embolus, pleural effusions, elevated creatinine (2.7 mg/dl)
4	None	Deep venous thrombosis of lower extremity
5	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation, elevated creatinine (2.2 mg/dl)	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation, oliguric renal failure, expired before initiation of dialysis
6	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation, small bowel infarction, deep venous thrombosis of lower extremity
7	Septic shock (not defined) at referring facility, renal failure requiring dialysis, respiratory failure requiring mechanical ventilation	Renal failure requiring dialysis, respiratory failure requiring mechanical ventilation
8	Deep venous thrombosis of lower extremity, atrial fibrillation	Elevated serum creatinine (2.2 mg/dl) not requiring dialysis
9	Hypotension requiring pressors, respiratory failure requiring mechanical ventilation, renal insufficiency not requiring dialysis	Respiratory failure requiring mechanical ventilation, renal failure, dialysis withheld (do not resusitate), death
10	Stress gastritis	Stress gastritis, spontaneous abortion, control of infection required above-the-knee amputation, respiratory failure requiring mechanical ventilation, renal tubular acidosis

residual or spreading infection. Aqueous mafenide acetate is also useful as a moist covering over split-thickness skin grafts at the time of wound closure.[18]

In the present study, the mortality rate for patients with necrotizing fasciitis was 20% (2 of 10 patients). In both fatalities, there was a delay in diagnosis and a delay in burn center transfer. In other series, mortality rates range from 6 to 74%[1,3–5,9–11,14,16,17,19] with a mean of 38%.[9,19] For cases reported to the Centers for Disease Control between 1989 and 1991, the overall mortality rate was 28%.[11] Diabetes mellitus as a comorbid condition may increase mortality rates to 63 to 71%.[3,9] Other predictors of poor outcome include degree of organ dysfunction at time of admission, elevated serum lactate, or elevated serum creatinine.[16] When the admission serum creatinine is above 2 mg/dl, mortality is doubled.[16]

The lack of progress in the treatment of this disease is underscored by the low mortality rate of 8.7% reported by Wilson[17] in his original series of 23 patients in 1952. An increase in the virulence of the responsible microorganisms has been postulated.[20] More likely, the increase in mortality from necrotizing soft tissue infection is caused by delay in definitive therapy (surgical debridement) when patients are admitted to nonsurgical services and multiple antibiotic regimens are administered for a diagnosis of atypical cellulitis. The availability of successive generations of new antibiotics has not altered mortality rates, and Burge[15] has noted that the mortality from treatment with antibiotics alone is 100%. Ward[21] states that "the key to the successful management of necrotizing fasciitis is the immediate referral for surgical opinion of patients with atypical cellulitis."

In the present series, admission to a medical rather than a surgical service significantly delayed the timing of initial surgical debridement. Survival from necrotizing soft-tissue infection is directly related to the rapidity and completeness of surgical debridement,[4,14] with the goal of definitive surgery, "no matter how radical," to completely eradicate the infection at the first operation.[14] After initial surgery, a second-look operation is mandatory, and debridement should be undertaken every 24 to 48 hours until the disease process is halted.[16] Stamenkovic and Lew[12] reported an overall mortality of 47.4% in a series of 19 patients with necrotizing fasciitis. In a subgroup of eight patients where the diagnosis was confirmed by biopsy and followed by immediate surgical debridement, the mortality was 12.5%.[12] Freischlag et al[5] noted that when time to operative treatment was less than 24 hours, a 36% mortality rate was seen compared with a mortality rate of 70% when surgery was delayed for more than 24 hours. In a series of 198 patients, Elliot et al[16] found that survivors had first debridement an

mean of 1.2 days after admission vs 3.1 days for nonsurvivors. Delay in either diagnosis or initial surgery increased mortality from 23 to 30% ($P = .075$), and inadequate surgical debridement increased mortality to 50%. Lille et al[4] found that when surgery was performed within 24 hours of admission, the mortality rate was 6%, blood transfusions were required in 22% of the patients, and each patient required a mean of 2.9 operations. Delayed surgery resulted in a mortality rate of 25%, a transfusion rate of 55%, and a mean of 3.6 operations per patient. All patients in the delayed operative group were initially admitted to a nonsurgical service.[4] Burge[15] states that in favorable cases, early aggressive surgery and antibiotics can yield mortality rates a low as 0 to 7%. Burge and Watson invoke William Shakespeare in describing adequate surgical margins: debridement should be "bloody, bold and resolute" (Macbeth, Act 4, Scene 1).[15,22]

Necrotizing fasciitis is a surgical disease. Optimum outcomes are achieved only when surgical consultation and intervention occurs in a timely fashion. Major complications are frequent. Although patients with necrotizing fasciitis are often managed in surgical or trauma intensive care units, the adjunct management, including the nursing care of large wounds, is difficult to perform in these settings. The burn team, by virtue of expertise in both critical care and wound care management, is uniquely matched to the needs of patients with necrotizing fasciitis. To this end, we recommend the addition of necrotizing soft-tissue infection to the list of conditions recognized by the American Burn Association as appropriate for referral to a burn treatment facility.

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