Published in final edited form as:

J Burn Care Res. 2009 ; 30(2): 301–306. doi:10.1097/BCR.0b013e318198a241.

Assessment of Functional Limitation After Necrotizing Soft Tissue Infection

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Abstract

Previous literature on necrotizing soft tissue infections (NSTIs) has focused on its diagnosis and high mortality, but to our knowledge, none have reported on the functional outcomes of patients surviving this devastating disease. The purpose of this study was to evaluate the management and assess factors associated with decreased physical function in patients who survived this life-threatening infection. A retrospective review was conducted on patients treated for NSTI in whom an evaluation of functional status was performed between 2002 and 2006. Measurements were based on the *American Medical Association Guides* of impairment rating, and categorized into a functional class from “minimal or no limitation” to “severe limitation.” Multivariate analyses were performed to discern independent factors associated with functional limitation. Final disposition status after discharge was also recorded. A total of 297 patients were treated for NSTI during this time. Of these, 119 (41%) patients met inclusion criteria for review. Mean number of débridements and coverage procedures were 3.4 and 2.0, respectively. Although mean percent functional limitation was 7.1, which is classified as “minimal or no limitation,” 30% of patients had “mild” to “severe” functional limitation. Extremity involvement was independently associated with a higher functional limitation class ($P < .01$). Functional limitation may challenge recovery from NSTI in many survivors. In this series, the involvement of an extremity predicted a higher functional limitation class at the time of discharge. Development of validated functional assessment tools and accurate longitudinal follow-up are necessary to measure the functional impact of NSTI.

Advances in the understanding of pathophysiology of necrotizing soft tissue infections (NSTIs) have improved treatment and, more importantly, survival.^{1,2} The aggressive nature of NSTIs mandates early recognition of the problem and repeated wide débridements of affected areas.^{1,2} Those surviving their infection tend to require prolonged periods of hospitalization and have large and often complex wounds that require soft tissue coverage. However, little is known about the functional outcome of those that survive NSTIs. One important aspect of recovery is physical status, or physical limitation in those surviving their infection. To our knowledge, the recovery phase after NSTI has not been previously examined.

In the absence of a standardized and validated tool to measure physical status after NSTI, we sought in this initial project to use analogous concepts from better described areas of study. The similarities between burns and NSTI throughout their continuum of care, from tissue excision and coverage to the need for rehabilitation are remarkable. As such, tools developed for burns may be appropriate to classify functional outcomes after NSTI.

Engrav and coworkers previously adapted the concept of whole person impairment to burns to measure function after injury recovery.^{3,4} The grading scale established by the *American Medical Association (AMA) Guides to the Evaluation of Permanent Impairment* (5th ed)⁵ that includes range of motion and amputation level provides a comprehensive and standardized quantification method of impairment as measured by clinicians. We adapted this measurement tool to provide a quantitative assessment of physical limitation after NSTI, and assessed for potential factors associated with worse functional outcomes.

METHODS

We performed a retrospective review of all patients admitted to Harborview Medical Center with a diagnosis of NSTI from 2002 to 2006. Harborview Medical Center is a county teaching hospital with 427 beds affiliated with the University of Washington. It is the single level I trauma center for the states of Washington, Alaska, Montana, and Idaho, and a major regional referral center for acute surgical problems, including soft tissue infections. This study was approved by the Institutional Review Board of the University of Washington.

Study Population

All patients treated for NSTI at Harborview Medical Center during the study period were eligible for this study. Our analysis included patients with complete physical and occupational therapy records so that physical impairment levels could be calculated; all others were excluded from analysis. Patients admitted to our facility with NSTI are typically managed by a multidisciplinary approach. In the acute phase of treatment, NSTI patients are managed by the general surgical service with supportive care and serial operative débridements until the infection is controlled. After initial débridements, wounds are dressed with wet-to-dry dressing changes until drainage and exudation become minimal. Vacuum-assisted wound suction systems are only applied to clean, granulating wounds. In the subsequent wound coverage phase, patients with large and complex wounds are managed by the plastic surgery service. The options for coverage typically include (1) skin autograft, (2) soft tissue flap, or (3) healing by secondary intention. Wounds deemed marginal for definitive closure are first allografted with cryopreserved cadaver skin to test the viability of the wound bed. Once the wound bed is deemed appropriate for definitive coverage, autografting or other definitive soft tissue coverage procedures are performed. Vacuum-assisted wound suction systems are used selectively to help affix skin grafts spanning joints and deep recesses. All patients are evaluated by occupational and physical therapy teams once débridements are complete and started on aggressive daily therapy regimen until discharge.

Measurement of Physical Function Limitation

The *AMA Guides to the Evaluation of Permanent Impairment* (5th ed) defines impairment as “the loss, loss of use, or derangement of any body part, organ system, or organ function,”⁵ and provides a method to quantify impairment, expressed as a percentage of whole-person impairment. We adapted this method to quantify physical limitation for NSTI patients at discharge following the *AMA Guides*. In instances where amputation had been performed, the maximal percent limitation for joints below the amputation level is utilized. Skin rating was not performed in this study because measurements were made at the time of hospital

discharge. By then, the status of grafts and flaps could not be deemed “fixed and stable,” as defined by the *AMA Guides* for impairment rating. Percent functional limitation scores were retrospectively calculated by experienced therapists (MLM, BAC) based on detailed therapy assessments at hospital discharge.

Data Collection and Statistical Analysis

Baseline patient characteristics and illness severity data, including age, sex, ethnic background, extent of NSTI involvement, and acute physiology and chronic health evaluation (APACHE II) score,⁶ were recorded. Treatment outcomes included hospital length of stay (LOS), intensive care unit (ICU) LOS, ventilator days, number of operations, including débridement and coverage procedures, time to therapy consultation, number of therapy treatments, and discharge disposition. In the outpatient phase, numbers of clinic visits, duration of follow-up, and final discharge disposition were recorded.

Descriptive statistics were used to summarize recorded data. Physical status was categorized as follows: (1) minimum or no limitation (score 0–9%), (2) mild limitation (score 10–24%), (3) moderate limitation (score 25–54%), and (4) severe limitation (score ≥55%). Univariate analysis was performed to determine potential associations between illness or treatment factors and limitation class. Continuous variables were compared with the Kruskal-Wallis test and discrete variables were compared using χ^2 or Fisher’s exact tests where appropriate. All variables found to impact limitation class at the $P \leq .20$ level were entered into a multivariate model to determine independent associations with physical limitation class.

RESULTS

A total of 297 patients were admitted to Harborview Medical Center with a diagnosis of NSTI during the study period; 119 patients (41%) had complete data and met inclusion criteria for review. Causes for exclusion from this study are detailed by Figure 1 flowchart. The mean age was 44.5 years (SD 12.2, range 10–77) with a male predominance (66%) (Table 1). Illicit drug injection caused 40% of NSTI in this series, whereas a larger proportion (41%) had an unclear etiology. Commonly affected areas in decreasing order of frequency were upper and lower extremities, followed by groin/perineum/buttocks, and torso. Thirty-two (27%) patients were affected in multiple body regions. Thirty-seven (31%) patients were first evaluated at an outside facility. Admission APACHE II scores averaged 22.7 (SD 9.2, range 9–45), reflecting the fact that many were severely ill upon presentation. Percent body surface area affected was assessed before any planned coverage with a mean size of 3.9% body surface area.

The total number of débridements varied from 1 to 11, with a mean of 3.5 (SD 2.1) per patient (Table 2). Thirty-three (28%) patients underwent at least one débridement before transfer to our institution. After débridement was completed, patients underwent an average of two closure procedures (range 0–5): these results reflect the common practice at our institution of initially covering the wound bed with allograft skin to assess the suitability of the bed for subsequent autograft coverage. Most patients were successfully treated with skin graft alone (87%), whereas nine wounds were closed with a combination of skin graft and flap. All flap procedures were classified as either local or regional tissue flaps. Three patients were discharged with open wounds: two applied skin grafts failed to heal completely, and the third patient had a groin wound which was allowed to heal by secondary intention.

Average length of hospitalization was 38.5 days (SD 16 days), mean ICU LOS and ventilator days were 7.6 (SD 8.4) and 3.9 (SD 6.1) days, respectively. Physical and occupational therapy teams were involved in the patient’s management at a mean of 3 days

after transfer from ICU to acute care ward. Discharge disposition (in decreasing order of frequency) were as follows: home (71%), shelter (14%), nursing facility (10%), and rehabilitation center (4%).

Mean percent functional limitation was 7.1% (median 5%, range 0–60%). Based on the classification scheme, 83 patients were judged to have “minimum or no limitation,” 32 had “mild” physical limitation, three had “moderate” limitation, and one with “severe” limitation (Table 3). Nine out of 10 patients with the highest functional limitation scores had extremity involvement (three with upper extremity, four with lower extremity, and two with both upper and lower extremities affected). In each of these cases, NSTI spanned at least across one joint. Causes of physical limitation included wound contraction before coverage procedures, peripheral nerve dysfunction, and deconditioning. After discharge, patients had a median of two clinic visits. Median follow-up duration was 1 month. Fifty-seven patients (48%) were lost to follow-up. A high percentage of patients with increased physical limitation at discharge were lost to follow-up (Table 3).

By univariate analysis, involvement of an extremity was associated with a 1.8 times higher likelihood of functional limitation ($P < .01$). Other factors also associated with higher functional limitation were APACHE II score ($P = .18$), intensive care unit LOS ($P = .05$), and time to therapy consult ($P < .01$). The latter factors, however, had negligible coefficient factors (−0.1 to 0.05) (Table 4). All factors found to be associated with higher functional limitation at the $P \leq .20$ were entered into a multivariate analysis. By adjusted analyses, extremity involvement was independently associated with a higher functional limitation class (Table 5). To examine whether amputation had a major impact on the strength of these associations, we repeated these analyses on the 116 patients who did not require amputation. The association between extremity involvement and higher functional limitation class was unaffected by the omission of amputated patients.

DISCUSSION

Once survival is achieved, return to function becomes a critical outcome after NSTI. However, there has been little previous research on the factors associated with favorable and unfavorable NSTI functional outcome. Furthermore, there are currently no tools validated for the assessment of function in these patients. In this study, we adapted the impairment rating scale previously validated in burn patients to attempt to quantify physical limitation in NSTI survivors.

Although most patients in this series were categorized as having “no or minimal” limitation, a significant number (30%) had at least mild to “severe” functional limitation. Of the factors examined, the involvement of an extremity was clearly associated with a higher functional limitation class. The independent association between extremity involvement and physical limitation is certainly intriguing. Although it seems logical that soft tissue débridement could decrease the range of motion in the affected extremity, the most radical form of débridement (ie, amputation) did not appear to account for the association with higher physical limitation. Perhaps, it is other factors, such as pain, stiffness from immobilization, wound closure by skin graft, that cumulatively lead to decreased function. Physical status may also change significantly over time, and may be mitigated by an aggressive occupational and physical therapy program. Although quantifying physical impairment at the time of discharge is a necessary first step, serial measurements over time would more accurately describe of the impact of rehabilitation on this outcome.

Not surprisingly, a higher number of débridements was required compared with coverage procedures. The two-stage strategy for coverage was generally followed. Cadaver skin split-

thickness allografts have long been used in burn centers for temporary wound coverage when there are few available donor sites.⁷ Advances in preservation techniques and the establishment of skin banks have made cryopreserved skin allografts widely available.⁸ Allograft placement decreases bacterial colonization counts to acceptable levels, whereas microbial contamination is a recognized cause of skin graft failure.^{9–11} Allograft adherence is also used as a predictor for successful healing of the future autograft. Although the use of skin allografts has not been reported for NSTI, this technique appears suited for these wounds because they likely harbor high bacterial counts, even after serial débridements. Thus, temporary allograft coverage may decrease the rate of autograft loss, albeit at the price of one additional procedure for the patient. After NSTI, the best wound management strategy has not been described. This aspect of care would lend itself well to future comparative studies.

There are several limitations to consider in this study. We focused on patients managed in the recovery phase by the plastic surgery service, thus limiting the generalizability of the results. For instance, a patient with a foot amputation revised to a below-the-knee level amputation would not have been referred to the plastic surgery service for coverage. Similarly, our data do not address the outcomes of patients who underwent skin grafting by the primary admitting service. Moreover, wounds in difficult locations, such as the case of Fournier's gangrene, are often allowed to heal by secondary intention and may not have been referred for soft tissue coverage. Patients referred to plastic surgery, however, were the group of patients with sufficiently detailed and consistent therapy records to permit assessment of physical limitation at discharge. The absence of a validated assessment tool for physical status in this population also constitutes an important limitation, such that our adapted rating scale may underestimate physical limitation in these survivors.

At our institution, NSTI patients typically represent a medically underserved population with a high percentage of intravenous drug users. Not only is it difficult to estimate prehospital morbidity status, disposition, and follow-up are often suboptimal. In fact, nearly half of our cohort was lost to follow-up in the outpatient phase, severely limiting the ability to derive longitudinal outcome data in this patient population. We attempted to quantify physical limitation at the time of discharge to partially compensate for this challenge. Deficits and skin status are admittedly not fixed and stable as defined by the *AMA Guides* at the time of discharge. Final results, whether functional, cosmetic or otherwise, may differ as economically disadvantaged patients may not have the same access in the outpatient phase and risk deterioration in physical status. The currently high number of patients lost to follow-up presents a significant barrier to improved outcomes in NSTI survivors.

Improved knowledge about the NSTI disease process has increased our ability to effectively treat NSTI patients and reduce mortality. However, little emphasis has been placed on the details of patient management after the acute phase, and the evaluation of functional outcomes after recovery. This review has highlighted an association between extremity involvement and higher physical dysfunction class, which suggests that rehabilitation efforts should be directed at this subgroup. We consider our adaptation of the impairment rating scale only as an initial attempt to characterize physical status after NSTI. Further efforts are needed to develop suitable tools to measure outcomes in this group of patients. Once validated, prospective data collection will be possible to gain a more comprehensive understanding of outcome measures after NSTI.

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Figure 1.
Flowchart of patients admitted to Harborview Medical Center for NSTI during study period (2002–2006).

Table 1

Baseline demographic and illness characteristics (n = 119)

Variable	Number (%)
Mean age ($\pm$ SD)	44.5 ($\pm$ 12.2)
Male/female	78/41 (66/34)
Ethnicity	
White	97 (82)
Hispanic	6 (5)
African-American	12 (10)
Asian	2 (1.5)
Native American	2 (1.5)
Proximal cause of infection	
Drug injection	48 (40)
Fournier's gangrene	13 (11)
Soft tissue abscess	4 (3)
Insect or animal bite	5 (4)
Other, including unknown cause	49 (41)
Body location	
Upper extremity	49 (41)
Hand(s)	2 (2)
Lower extremity	49 (41)
Feet	5 (4)
Torso	23 (19)
Groin/perineum/buttocks	28 (24)
Multiple areas	32 (27)
Transferred from other facility	37 (31)
% body surface area ($\pm$ SD)	3.9 ($\pm$ 3.8)
APACHE II score ($\pm$ SD)	22.7 ($\pm$ 9.2)

APACHE, acute physiology and chronic health evaluation.

Table 2Treatment measures^{*}

Variable	Per Patient	Range
Operations		
Débridements	3.5 ($\pm$ 2.1)	1–11
Coverage procedures	1.9 ($\pm$ 0.8)	0–5
Total	5.4 ($\pm$ 2.3)	2–13
Ventilator days	3.9 ($\pm$ 6.1)	0–37
Intensive care LOS (d)	7.6 ($\pm$ 8.4)	0–46
Hospital LOS (d)	38.5 ($\pm$ 16.3)	16–115
Acute care phase (d)	17.8 ($\pm$ 10.7)	1–82
Time to therapy consult (d)	10.5 ($\pm$ 8.7)	1–43
Number of therapy treatments	14.3 ($\pm$ 14.0)	0–85

LOS, length of stay.

^{*} Data expressed as mean $\pm$ standard deviation.

Table 3

Physical limitation scores at discharge and follow-up data

Variable	Discharge Physical Limitation Class			
	0-minimal	Mild	Moderate	Severe
Patients per category	83	32	3	1
Median limitation score (25–75th percentile)	3 (0–5)	13 (11–17)	29 (27–43)	60 (n/a)
Median number of clinic visits (25–75th percentile)	2 (1–3)	1 (0–3)	1 (0–4)	1 (n/a)
Median follow-up length (months) (25–75th percentile)	1 (0.3–3)	1 (0–4.5)	2 (0–5.5)	0.5 (n/a)
Patients lost to follow-up (%)	40 (48)	14 (44)	2 (67)	1 (100)

Table 4

Univariate analysis of factors associated with higher discharge physical limitation class

Baseline and Treatment Factors	Coefficient Factor	<i>P</i>
Age	0.01	.40
Male	−0.29	.49
White ethnicity	0.03	.94
Drug injection	0.04	.93
Extremity location	2.7	<.01
Multiple sites	0.57	.21
Transferred from other facility	0.19	.66
% body surface area	0.04	.50
APACHE II score	0.03	.18
Total number of operations	0.09	.29
Ventilator days	0.02	.49
Intensive care LOS	0.05	.05
Hospital LOS	0.00	.87
Acute care phase	−0.03	.27
Time to therapy consult	−0.12	<.01

APACHE, acute physiology and chronic health evaluation; *LOS*, length of stay.

Table 5

Effect of extremity involvement on higher discharge physical limitation class, by multivariate analysis*

Functional Limitation Class	Adjusted Odds Ratio	<i>P</i>	95% Confidence Interval
Mild	2.7	.02	0.3–5.1
Moderate	20.3	<.01	13.0–27.7
Severe	22.6	<.01	13.8–31.3

* Reference group: no or minimal functional limitation.