

Necrotizing Infection of the Upper Extremity: A Veterans Affairs Medical Center Experience (2008-2017)

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Necrotizing infection of the upper extremity is a rare pathology with a substantial risk of amputation and mortality that requires a high index of suspicion and expeditious referral to a hand surgeon.

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Necrotizing infection of the extremity is a rare but potentially lethal diagnosis with a mortality rate in the range of 17% to 35%.¹⁻⁴ The plastic surgery service at the Malcom Randall Veterans Affairs Medical Center (MRVAMC) treats all hand emergencies, including upper extremity infection, in the North Florida/South Georgia Veterans Health System. There has been a well-coordinated emergency hand care system in place for several years that includes specialty templates on the electronic health record, pre-existing urgent clinic appointments, and single service surgical specialty care.⁵ This facilitates a fluid line of communication between primary care, emergency department (ED) providers, and surgical specialties. The objective of the study was to evaluate our identification, treatment, and outcome of these serious infections.

METHODS

The MRVAMC Institutional Review Board approved a retrospective review of necrotizing infection of the upper extremity treated at the facility by the plastic surgery service. Surgical cases over a 9-year period (June 5, 2008-June 5, 2017) were identified by CPT (current procedural technology) codes for amputation and/or debridement of the upper extremity. The charts were reviewed for evidence of necrotizing infection by clinical description or pathology report. The patients' age, sex, etiology, comorbidities from their problem list, vitals, and laboratory results were recorded upon arrival at the hospital. Time from presentation to surgery, treatment, and outcomes were recorded.

FIGURE 1 Patient 1 Computed Tomography Showing Air in the Tissues



RESULTS

Ten patients were treated for necrotizing infection of the upper extremity over a 9-year period; all were men with an average age of 64 years. Etiologies included nail biting, "bug bites," crush injuries, burns, suspected IV drug use, and unknown. Nine of 10 patients had diabetes mellitus (DM). Most did not show evidence of hemodynamic instability on hospital arrival (Table). One patient was hypotensive with a mean arterial blood pressure < 65 mm Hg, 2 had heart rates > 100 beats/min, 1 patient had a temperature > 38° C, and 7 had elevated white blood cell (WBC) counts ranging from 11 to 24 k/cmm. Two undiagnosed patients with DM (patients 1 and 8) expressed no complaints of pain and presented with blood glucose > 450 mg/dL with hemoglobin A_{1c} levels > 12%.

Infectious disease and critical care services were involved in the treatment of several cases when requested. A computed tomography (CT) scan was used in 2 of the patients (patients 1 and 4) to assist in the diagnosis (Figure 1). The patient with the largest debridement (patient 4) had a CT that was not suspicious for necrotizing infection the day prior to emergent surgery. Patient 3 was found to have a subclavian stenosis on CT

FIGURE 2 Patient 10 Necrotizing Infection of the Antecubital Fossa



A, preoperative; B, postoperative.

FIGURE 3 Patient 4 Necrotizing Infection of the Upper Extremity



A, preoperative; B, postoperative.

angiography early in the postoperative course and was treated with a carotid to subclavian bypass by the vascular service.

Seven patients out of 10 were treated with surgery within 24 hours on hospital arrival. The severity of the pathology was not initially recognized in 2 of the patients earlier in the review. A third patient resisted surgical treatment until the second hospital day. Four patients had from 1 to 3 digital amputations, 2 patients had wrist disarticulations, and 1 had a distal forearm amputation. The proximal amputations were patients with DM who went to the operating room within 24 hours of admission. Cultures grew a wide range of microorganisms, including methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-susceptible *Staphylococcus aureus* (MSSA), β -hemolytic *Streptococcus*, *Streptococcus viridans*, *Klebsiella pneumoniae*, and *Prevotella*.

Antibiotics were managed by critical care, hospitalist, or infectious disease services and adjusted once final cultures were returned (Table). The patients all had a minimum of 2 procedures (range 2-5), including debridement and closure (Figures 2A and 2B and 3A and 3B). There were no perioperative deaths.

DISCUSSION

Necrotizing infection of the upper extremity is a rare pathology with a substantial risk

of amputation and mortality that requires a high index of suspicion and expeditious referral to a hand surgeon. It is well accepted that the key to survival is prompt surgical debridement of all necrotic tissue, ideally within 24 hours of hospital arrival.^{2-4,6} Death is usually secondary to sepsis.³ The classic presentation of pain out of proportion to exam, hypotension, erythema, skin necrosis, elevated WBC count, and fever may not be present and can delay diagnosis.^{1-4,6}

DM is the most common comorbidity, and reviews have found the disease occurs more often in males, both which are consistent with our study.¹⁻³ Diabetic infections have been found to be more likely to present as necrotizing infection than are nondiabetic infections and be at a higher risk for amputation.⁷ The patients with the wrist disarticulations and forearm amputation had DM. A minor trauma can be a portal for infection, which can be monomicrobial or polymicrobial.^{1,4} Once the diagnosis is suspected, prompt resuscitation, surgical debridement, IV antibiotics, and early intensive care are lifesaving. Hyperbaric oxygen is not available at MRVAMC and was not pursued as a transfer request due to its controversial benefit.⁶

There were no perioperative 30-day mortalities over a 9-year period in patients identified as having necrotizing infection of the upper extremity. This is attributed to an

TABLE Necrotizing Infection Data

Patient	Vitals	Labs	Etiology	Location	TOS	Culture	Treatment
1	T: 36.6 HR: 98 BP: 120/67 RR: 18	WBC: 24 Hb: 15 Glucose: 461 HbA _{1c} : 12.2% Na: 136 Cr: 0.9	burn	Right middle finger	17 h	<i>Klebsiella oxytoca</i>	OR x 3 (3-ray amputations); MICU; ID (imipenem, vancomycin, then ertapenem x 4 wk)
2	T: 36.7 HR: 72 BP: 154/63 RR: 16	WBC: 16 Hb: 11 Glucose: 293 Na: 135 Cr: 1.3	Crush fingertip	Right middle finger	19 h	<i>Prevotella bivia</i>	OR x 3 (wrist disarticulation); ID (vancomycin, cefepime, metronidazole; then ertapenem x 4 wk)
3	T: 36.1 HR: 64 BP: 164/83 RR: 18	WBC: 9 Hb: 13 Glucose: 93 Na: 135 Cr: 0.7	Crush fingertip	Right index finger	5 h, 38 min	<i>Morganella morganii</i> , <i>Proteus vulgaris</i> , <i>Bacteroides thetaiotaomicron</i>	OR x 2 (index finger amputation) ID (vancomycin, piperacillin/tazobactam, then po levofloxacin and metronidazole 2 wk tl abx); vascular for carotid to subclavian bypass
4	T: 37.1 HR: 80 BP: 78/47 RR: 20	WBC: 15 Hb: 12 Glucose: 130 Na: 124 Cr: 16	Bug bite	Right upper arm	5 d, 8 h, 20 min	<i>Staphylococcus aureus</i> , B-hemolytic <i>Streptococcus</i>	OR x 5 (upper arm/forearm debridement, STSG); MICU; ID (cefepime and clindamycin, then vancomycin x 10 d postop)
5	T: 36.6 HR: 93 BP: 120/79 RR: 18	WBC: 12; Hb: 14; Glucose: 157 Na: 136; Cr: 0.8	Unknown	Right middle finger	4 d, 57 min	MSSA and B-hemolytic <i>Streptococcus</i>	Bedside incision and drainage, OR x 1 (finger amputation at MCP); ID (oxacillin x 2 wk)
6	T: 37.2 HR: 78 BP: 120/59 RR: 18	WBC: 9 Hb: 11 Glucose: 425 Na: 132 Cr: 5.9	Unknown	Right ring finger	20 h, 34 min	<i>Klebsiella oxytoca</i> , diphtheroids, <i>Staphylococcus aureus</i> , <i>Prevotella</i> , <i>Fusobacterium</i>	OR x 2 (wrist disarticulation); vancomycin, then po levofloxacin, 2 wk tl abx
7	T: 36.6 HR: 102 BP: 113/59 RR: 20	WBC: 19 Hb: 13 Glucose: 110 HbA _{1c} : 6.6% Na: 134 Cr: 1.0	Unknown	Left axilla	11 h, 15 min	<i>Prevotella melaninogenica</i>	OR x 2 (debridement, STSG); MICU, ID (vancomycin, cefepime, metronidazole x 1 wk, then ampicillin-sulbactam x 4 d, po amoxicillin 4 d)
8	T: 37.2 HR: 101 BP: 119/70 RR: 18	WBC: 15 Hb: 15 Glucose: 659 Na: 125 Cr: 1.6 HbA _{1c} : 13%	Nail biter	Right middle finger	5 h, 49 min	MSSA, <i>Streptococcus viridans</i> , <i>Prevotella bivia</i> , B-hemolytic <i>Streptococcus</i>	OR x 2 (distal forearm amputation); MICU, ID (metronidazole, piperacillin/tazobactam, then cefadroxil and metronidazole; total 2 wk antibiotics)
9	T: 38.3 HR: 100 BP: 96/61 RR: 20	WBC: 19 Hb: 9 Glucose: 251 Na: 136 Cr: 1.3 CRP: 30	Nail biter	Right small finger	25 h, 5 min	B-hemolytic <i>Streptococcus</i>	OR x 2: (right small ray amputation); ID (daptomycin and piperacillin/tazobactam, then po metronidazole x 2 wk and ceftaroline x 6 wk)
10	T: 36.6 HR: 87 BP: 150/72 RR: 20	WBC: 9 Hb: 13 Glucose: 783 HbA _{1c} : 14% Na: 128 Cr: 0.7 CRP: 13	Suspected IVDA	Right antecubital fossa	12 h, 1 min	<i>Streptococcus viridans</i>	OR x 2 (antecubital debridement and STSG); piperacillin/tazobactam, vancomycin x 3 d, cefdinir po x 5 d

Abbreviations: BP, blood pressure; Cr, creatinine; CRP, C-reactive protein; HR, heart rate; Hb, hemoglobin; HbA_{1c}, glycosylated hemoglobin; ID, infectious disease; IVDA, intravenous drug user; MICU, medical intensive care unit; MSSA, methicillin-susceptible *Staphylococcus aureus*; Na, sodium; OR, operating room; RR, respiratory rate; STSG, split thickness skin graft; T, temperature; tl abx, total antibiotics; TOS, time to surgery; WBC, white blood cells.

aggressive and well-coordinated, multisystem approach involving emergency, surgical, anesthesia, intensive care, and infectious disease services.

The hand trauma triage system in place at MRVAMC was started in 2008 and presented at the 38th Annual VA Surgeons Meeting in New Haven, Connecticut. The process starts at the level of the ED, urgent care or primary care provider and facilitates rapid access to subspecialty care by reducing unnecessary phone calls and appointment wait times.

All hand emergencies are covered by the plastic surgery service rather than the traditional split coverage between orthopedics and plastic surgery. This provides consistency and continuity for the patients and staff. The electronic health record consult template gives specific instructions to contact the on-call plastic surgeon. The resident/fellow gets called if patient is in-house, and faculty is called if the patient is outside the main hospital. The requesting provider gets instructions on treatment and follow-up. Clinic profiles have appointments reserved for urgent consults during the first hour so that patients can be sent to pre-anesthesia clinic or hand therapy, depending on the diagnosis. This triage system increased our hand trauma volume by a multiple of 6 between 2008 and 2012 but cut the appointment wait time > 1 week by half, as a percentage of consults, and did not significantly increase after-hour use of the operating room. The number of faculty and trainees stayed the same.

We did find that speed to diagnosis for necrotizing infection is an area that can be improved on with a higher clinical suspicion. There is a learning curve to the diagnosis and treatment, which can be prolonged when the index cases do not present themselves often and the patients do not appear in distress. This argues for consistency in hand-specific trauma coverage. The patients were most often initially seen by the resident and examined by a faculty member within hours. There were 4 different plastic surgery faculty involved in these cases, and they all included resident participation before, during, and after surgery. Debridement consists of wide local excision to bleeding tissue. Author review of the operative notes found the numbers of trips to the operating room for debride-

FIGURE 4 Patient 4 Upper Arm and Forearm Debridement and Skin Graft Reconstruction



ment can be reduced as the surgeon becomes more confident in the diagnosis and management, resulting in less “whittling” and a more definitive debridement, resulting in a faster recovery.

The LRINEC (Laboratory Risk Indicator for Necrotizing Fasciitis) is a tool that helps to distinguish necrotizing infection from other forms of soft tissue infection by using a point system for laboratory values that include C-reactive protein (CRP), white blood count, hemoglobin, sodium, creatinine, and glucose values.⁸ We do not routinely request CRP results, but 1 of the 2 patients (patient 9) who had the full complement of laboratory tests would have met high-risk criteria. The diagnostic accuracy of this tool has been questioned⁹; however, the authors welcome any method that can rapidly and noninvasively assist in getting the patient proper attention.

The patients were not seen for long-term follow-up, but some did return to the main hospital or clinic for other pathology and were pleased to show off their grip strength after a 3-ray amputation (patient 1) and

aesthetics after upper arm and forearm debridement and skin graft reconstruction (patient 4, Figure 4).

A single-ray amputation can be expected to result in a loss of grip and pinch strength, about 43.3% and 33.6%, respectively; however, given the alternative of further loss of life or limb, this was considered a reasonable trade-off.¹⁰ One wrist disarticulation and the forearm amputation were seen by amputee clinic for prosthetic fitting many months after the amputations once the wounds were healed and edema had subsided.

CONCLUSION

A well-coordinated multidisciplinary effort was the key to successful identification and treatment of this serious life- and limb-threatening infection at our institution. We did identify room for improvement in making an earlier diagnosis and performing a more aggressive first debridement.

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References

1. Angoules AG, Kontakis G, Drakoulakis E, Vrentzos G, Granick MS, Giannoudis PV. Necrotizing fasciitis of upper and lower limb: a systemic review. *Injury*. 2007;38(suppl 5):S19-S26.
2. Chauhan A, Wigton MD, Palmer BA. Necrotizing fasciitis. *J Hand Surg Am*. 2014;39(8):1598-1601.
3. Cheng NC, SU YM, Kuo YS, Tai HC, Tang YB. Factors affecting the mortality of necrotizing fasciitis involving the upper extremities. *Surg Today*. 2008;38(12):1108-1113.
4. Sunderland IR, Friedrich JB. Predictors of mortality and limb loss in necrotizing soft tissue infections of the upper extremity. *J Hand Surg Am*. 2009;34(10):1900-1901.
5. Coady-Fariborzian L, McGreane A. Comparison of hand emergency triage before and after specialty templates (2007 vs 2012). *Hand (N Y)*. 2015;10(2):215-220.
6. Stevens D, Bryant A. Necrotizing soft-tissue infections. *N Engl J Med*. 2017;377(23):2253-2265.
7. Sharma K, Pan D, Friedman J, Yu JL, Mull A, Moore AM. Quantifying the effect of diabetes on surgical hand and forearm infections. *J Hand Surg Am*. 2018;43(2):105-114.
8. Wong CH, Khin LW, Heng KS, Tan KC, Low CO. The LRINEC (Laboratory Risk Indicator for Necrotizing Fasciitis) score: a tool for distinguishing necrotizing fasciitis from other soft tissue infections. *Crit Care Med*. 2004;32(7):1535-1541.
9. Fernando SM, Tran A, Cheng W, et al. Necrotizing soft tissue infection: diagnostic accuracy of physical examination, imaging, and LRINEC score: a systematic review and meta-analysis. *Ann Surg*. 2019;269(1):58-65.
10. Bhat AK, Acharya AM, Narayanakurup JK, Kumar B, Nagpal PS, Kamath A. Functional and cosmetic outcome of single-digit ray amputation in hand. *Musculoskelet Surg*. 2017;101(3):275-281.