Necrotising fasciitis (NF) is a severe and rapidly fulminating septic process, primarily involving subcutaneous and fascial tissues. It has the potential to spread precipitously to involve an entire limb resulting in significant soft tissue defects and in some cases amputation and death. The upper extremity is less commonly affected (6–27%) compared with other anatomical sites and the diagnosis is often challenging.1,2 Early surgical debridement is the single most important factor in determining outcome3–7 and delay in treatment adversely impacts mortality.8

Due to the rarity of upper extremity NF, its description in the literature has been limited to case reports, small studies or large studies of mixed anatomical sites which included the upper limb. Mortality rates for the upper extremity have been reported as high as 36%.9 Factors predicting mortality for NF of the upper extremity include altered level of consciousness and respiratory distress on presentation1 as well as more proximal involvement of a limb.9 NF has been shown to be twice as prevalent in the South Auckland population compared with the rest of the developed world.10 Investigation into these factors of the upper extremity is yet to be done on an Australasian population.

This study aimed to comment on the incidence and outcomes of NF of the upper limb in Auckland, New Zealand. It looked at the characteristics of patients with upper limb NF to assess whether any characteristics could be correlated with outcomes. The hypothesis was that an older age, history of immunosuppression and delay until first debridement would result in higher rates of morbidity and mortality.

**Methods**

A retrospective review of all patients treated with necrotising fasciitis of the upper limb at the Auckland Regional Centre for Plastic, Reconstructive and Hand Surgery between 1 January 2006 and 1 December 2015 was performed. Diagnosis was made intraoperatively by the surgical team with the presence of necrotic fascia removed easily with blunt dissection in conjunction with purulence resembling a ‘dishwater’ appearance (Figure 2, 3). Patient demographics, clinical features, laboratory and radiological investigations, surgical parameters, reconstruction methods and immediate and long-term outcomes were investigated. QuickDASH (Disabilities of Arm, Shoulder and Hand) and Patient Evaluation Measure (PEM) questionnaires (Figure 1) were used to evaluate subjective outcomes. Tests of association was carried out between each of the clinical characteristics and mortality, using Fisher exact test for the categorical variables and non-parametric test for the continuous variables.

**Results**

Fifteen patients were identified. Mean follow-up time was 24 (standard deviation [SD]21) months. Mean age at admission was 54 (SD:21) years (Table 1). Forty-seven percent were NZ European, 40% Polynesian and 13% Māori. Positive smoking history was recorded in 40% of patients. The most common comorbidity seen was type 2 diabetes (40%). Only one case had a history of intravenous drug usage (IVDU). The most common initial site of symptomatology was the hand (60%) followed by the elbow (20%), forearm (13%) and chest.
wall (7%). Ninety-three percent of cases had positive tissue cultures of which the most frequently isolated organism was *Streptococcus pyogenes* (73%). Polymicrobial cultures were seen in 57%. The majority of patients initially received an antibiotic regime of intravenous Penicillin, Clindamycin and Gentamycin until a specific organism(s) was isolated. Mean time to the operating room from admission was 47 (SD: 84) hours. Patients underwent a mean of 3.4 debridements and 12 cases underwent reconstruction (11 split skin graft, one anterolateral thigh free flap). Reconstruction did not occur in three cases; two due to mortality and one healed satisfactorily by secondary intention. Mean length of hospital admission was 17.6 (SD:12.4) days.

Three patients (20%) died in our study, all due to disease specific causes. Two deceased cases were complicated by multi-organ dysfunction secondary to septicemia. One deceased case was complicated by hospital-acquired pneumonia and septicemia-induced arrhythmia with subsequent cardiac dysfunction. Univariate analysis (Table 1) demonstrated older age (p=0.017), hypertensive disease (p=0.044) and the need for amputation (p=0.029) were significantly associated with mortality. Requirement for amputation in the two cases indicated the difficulty in controlling the infection; correlating with more severe disease course as opposed to a lack of reconstructive options. Ethnicity, diabetes, smoking history, history of IVDU, more proximal involvement of the upper limb, time between presentation and first debridement, pyrexia, dyspnoea and hypotension were not significantly associated with an increased risk of mortality.

Of the survivors, mean QuickDASH score was 21.1. A QuickDASH score of 0 indicates no disability, while a score of 100 indicates complete disability. PEM Hand Health score was 77% and PEM Overall Assessment score was 87%, with a higher percentage demonstrating a higher level of satisfaction (Figure 4).

**Table 1: Univariate analysis.**

<table>
<thead>
<tr>
<th></th>
<th>Survived</th>
<th>Deceased</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean years(SD)</td>
<td>47.7 (17.9)</td>
<td>80.3 (9.5)</td>
<td>0.017</td>
</tr>
<tr>
<td>Type II diabetes (%)</td>
<td>33.3</td>
<td>66.6</td>
<td>0.525</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>25</td>
<td>100</td>
<td>0.044</td>
</tr>
<tr>
<td>Smoking history (%)</td>
<td>50</td>
<td>0</td>
<td>0.229</td>
</tr>
<tr>
<td>IVDU* (%)</td>
<td>1</td>
<td>0</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Time to debridement, hours (SD)</td>
<td>30 (48.9)</td>
<td>110 (163.2)</td>
<td>0.276</td>
</tr>
<tr>
<td>Amputation (%)</td>
<td>0</td>
<td>66.6</td>
<td>0.029</td>
</tr>
<tr>
<td>Length of stay, mean days(SD)</td>
<td>19 (12.5)</td>
<td>12 (12.8)</td>
<td>0.391</td>
</tr>
<tr>
<td>Number of debridements, mean (SD)</td>
<td>3.9 (2.2)</td>
<td>1.7 (1.2)</td>
<td>0.089</td>
</tr>
<tr>
<td>Vital signs on presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever* (%)</td>
<td>66.7</td>
<td>100</td>
<td>0.73</td>
</tr>
<tr>
<td>Dyspnoea* (%)</td>
<td>22.2</td>
<td>33.3</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Hypotension* (%)</td>
<td>22.2</td>
<td>33.3</td>
<td>&gt;0.99</td>
</tr>
</tbody>
</table>

*IVDU—Intravenous drug usage. Fever defined as >38°C. Dyspnoea defined as a respiratory rate ≥20 breaths/minute. Hypotension defined as a systolic blood pressure ≤90mmHg.
Discussion

This study has shown that NF of the upper limb poses a significant mortality risk, particularly in the elderly. The foundation of treatment for NF is early and aggressive surgical debridement, initiation of broad spectrum antibiotics and intensive care support.\textsuperscript{10–14} The results presented here demonstrate of those that survive and obtain aggressive treatment, sound quality of life outcomes can be achieved.

Diagnosis is often delayed resulting in poor outcomes with a mortality rate in the upper limb in the range of 9–36%.\textsuperscript{2,4,15} Distinguishing NF from a simple soft tissue infection can be problematic and relies on a high index of suspicion. Early in the disease process, patients can appear relatively well, without features of systemic toxicity such as high-grade pyrexia and hypotension.

Early findings of low-grade pyrexia, oedema, erythema and pain are present. Crepitus, suggesting gas formation in the deeper tissues as a result of anaerobic metabolism, is a classical but infrequent sign.\textsuperscript{2} Pain out of proportion to the clinical picture in conjunction with clinical acumen is a reliable sign assisting diagnosis.\textsuperscript{2,5}

NF of the upper extremity is uncommon, affecting 10% of cases in a large 11-year retrospective review of all anatomical sites in a New Zealand based study.\textsuperscript{10} Given the paucity of published cases specifically of the upper limb, no convincing prognostic indicators have been identified. Cheng and colleagues demonstrated an altered level of consciousness on arrival to hospital as well as signs of respiratory distress were significant predictors of mortality in their retrospective review.\textsuperscript{2} Schecter and colleagues demonstrated a significant reduction in the length of hospital admission and number of debridements needed in patients undergoing radical debridement within 24 hours.\textsuperscript{15} No significant predictors of mortality were noted.

The results of this study have demonstrated significantly worse outcomes for older patients (48 [SD: 18] years in survivors and 80 [SD: 10] years in deceased) and those with hypertensive disease. Type 2 diabetes, although the most commonly encountered comorbidity in the current study population, was not significantly associated
Figure 2: Prior to first debridement, 43 hours after presentation. ‘Dishwater appearance noted with gentle blunt debridement’.

Figure 3: Dorsal forearm fascia during first debridement.
Figure 4: Seven months post-operatively after split skin graft reconstruction demonstrating satisfactory cosmetic appearance and function.
with mortality in this study. It is possible, however, with a larger sample size this trend would have likely lead to significance. Numerous authors have demonstrated risk factors significantly associated with mortality in studies of NF of all anatomical sites. Type 2 diabetes, heart disease, pre-existing renal impairment and gout have all been demonstrated as predictors of mortality in NF of all anatomical sites. McHenry et al showed that the average time from admission to operation in those who survived was 25 h versus 90 h in the non-survivors (both clinically and statistically significant).

Tang and colleagues found significantly worse mortality with individuals suffering from more proximal involvement of a limb compared with distal sites such as the hand and foot.

Three cases (20%) in the current study underwent radiological investigations (ultrasonography, USS ± computed tomography, CT/magnetic resonance imaging, MRI) ordered prior to first debridement. USS aided in excluding subcutaneous collections, however CT/MRI proved inconclusive. Although time to the operating room from presentation was longer in patients requiring radiology (79 hours) compared with those who did not (38 hours), this trend was not significant. No significant relationship was found between ordering of radiology, number of debridements or length of stay. Foreign bodies, abscesses and fluid collections can be easily demonstrated using sonography, however these features are not always present in NF. CT allows detection of subcutaneous and fascial oedema, gas formation, abscesses and foreign bodies. In cases of massive fluid collections along the fascia seen on CT or USS, NF can be suspected. Compared with MRI, USS and CT do not have as high accuracy for differentiation between cellulitis and NF because of their lower sensitivity in detecting deep fascial fluid. Although the treatment of choice due to its high sensitivity (100%), MRI is costly, not entirely specific (86%) and often unavailable in a timely manner allowing prompt diagnosis.

Clinical acumen must remain to allow timely diagnosis and recognition of the need for surgical debridement.

Despite variation in reconstructive procedures that took place patients who retained their affected limb had generally satisfactory outcomes in terms of QuickDASH and PEM. As there were no survivors who underwent amputation (two cases) the functional outcome of these patients cannot be assessed and plausibly could have reduced the mean score.

The study is by its small sample size and retrospective nature, highlighting the scarcity of NF. Although a high proportion of our study, only three patients died limiting statistical analysis. Risk factors such as type 2 diabetes and a delay in time to first surgical debridement may have had an association with mortality as demonstrated by authors on other populations.

In conclusion, NF of the upper limb is an uncommon condition with significant mortality, especially in the elderly, requiring prompt recognition and early surgical management. Diagnosis remains clinical and an element of diagnostic acumen will allow prompt appropriate treatment to be initiated. This study has demonstrated sound outcomes in survivors of NF of the upper limb and high levels of patient satisfaction with treatment.
Competing interests:
Nil.

Author information:
Depak Patel, Plastics and Hand Surgery, Middlemore Hospital, Auckland;
Annabel Dekker, Plastics and Hand Surgery, Middlemore Hospital, Auckland;
Shirley Collocott, Plastics and Hand Surgery, Middlemore Hospital, Auckland;
Bruce Peat, Plastics and Hand Surgery, Middlemore Hospital, Auckland;
Alessandra Canal, Plastics and Hand Surgery, Middlemore Hospital, Auckland.

Corresponding author:
Dr Depak Patel, Plastics and Hand Surgery Middlemore Hospital, Auckland.
d_patel89@hotmail.com

URL:

REFERENCES:
18. McHenry CR, Piotrowski JJ, Petrinic C. Determinants of


