The surgical management of diabetic foot infections at a regional Australian hospital

Steven Craig, John Cherry

Citation: Craig S, Cherry J (2016) The surgical management of diabetic foot infections at a regional Australian hospital. *The Diabetic Foot Journal* **19**: 20–5

Article points

1. Data relating to patients requiring inpatient antibiotics and surgical intervention for diabetic foot infection on first presentation at Wollongong Hospital over 3 years were audited.
2. Overall and major amputation rates were comparable with previous studies; white cell count and male gender increased the likelihood of amputation.
3. Based on the results, a region-specific protocol has been developed.

Key words

- Amputation
- Diabetes
- Diabetic foot
- Regional
- Surgery

Authors

Steven Craig is surgical registrar at Wollongong Hospital, New South Wales, Australia; John Cherry is junior medical officer at Orange Health Service, New South Wales, Australia

Data on the surgical management of diabetic foot infections (DFIs) in Australia are limited. The authors performed a retrospective clinical audit to determine the operative management and amputation rate for surgically treated DFIs to determine which factors may predict amputation, and to help guide future management protocols. Ninety-one adult patients with diabetes and inframalleolar infection requiring inpatient antibiotics and surgical intervention between 2007 and 2009 were included. Only the first presentation was recorded. The observed overall amputation rate in this population was 74.7%, with 20 major and 48 minor amputations. Of the patients who re-presented, 21% underwent amputation. The amputation rate increased significantly with male sex (*P*=0.014) and white cell count (*P*=0.004). The authors' study had a comparable rate of overall amputation and major amputation compared with previous Australian studies and provides a valuable benchmark for improving the surgical management of DFI in Australia. Based on the results of this clinical audit, a region-specific DFI protocol has been developed.

Foot infections are a significant source of morbidity in persons with diabetes mellitus, and they are a growing burden on the Australian healthcare system (Australian Institute of Health and Welfare, 2008; Diabetes Australia, 2007). In 2004–5, there were 9,900 hospital admissions for the management of diabetic foot ulcers and infections, resulting in approximately 3,400 lower extremity amputations (Australian Institute of Health and Welfare, 2008). With the prevalence of diabetes reaching near epidemic levels in Australia, the incidence of diabetic foot infections (DFIs) is likely to remain a significant problem.

Despite the medical and financial burdens associated with DFIs in Australia, little is known about their surgical management. To date, there have been only three published studies on this topic (Steffen and O'Rourke, 1998; O'Rourke et al, 2002; Ismail et al, 2015). To better understand the topic, we performed a retrospective clinical audit of surgically managed DFIs over a 3-year period at a large regional Australian hospital. Specifically, we aimed to determine the operative management and amputation rate for DFIs, and improve their management by developing treatment protocols specific to local demographics and available regional resources.

Methods

Population

All adult patients with diabetes and an inframalleolar infection that required both inpatient antibiotic therapy and surgical intervention at Wollongong Hospital between January 1, 2007 and December 31, 2009 were considered eligible for the study. The presence or absence of DFI was defined and classified according to the Infectious Diseases Society of America guidelines for the diagnosis and treatment of DFIs (Lipsky et al, 2004).

Patients were defined as having diabetes if they had a diagnosis of either type 1 or type 2 diabetes

mellitus and were taking insulin and/or an oral hypoglycaemic agent on presentation; or had a laboratory-confirmed blood sugar level that met the current World Health Organization diagnostic criteria for diabetes mellitus.

For patients with multiple presentations for DFIs, we only recorded the first presentation for a DFI that required both inpatient antibiotics and surgical intervention. We recorded initial presentation and re-presentations separately to reduce the effect of 'double counting' a patient re-presenting multiple times with the same infection.

Case ascertainment

The International Classification of Diseases codes (E10.73 and E11.73) and diagnosis-related groups (K01Z, J60A, J60B, I64A, I64B, I12A, I12B, I12C, K60A and K60B) relevant to DFIs were used to search Wollongong Hospital's medical records for possible patient encounters during the study period. The medical records were reviewed to determine whether patients met the study criteria. This resulted in a final study population of 91 patients.

Case review and data collection

For each patient who met the study inclusion criteria, data were recorded regarding basic demographics, clinical presentation, relevant investigations, antibiotic therapy, formal surgical procedures, length of stay (LOS), and prior or subsequent admissions. Procedures performed out of theatres (i.e. simple debridement on the ward) were not considered surgical procedures. The term 'minor amputation' refers to an amputation distal to the tarsometatarsal joint, whereas 'major amputation' refers to amputation through or proximal to the tarsometatarsal joint. Re-presentations were recorded if the full re-presentation was available in the patient's medical record and the patient represented with an infection in the same foot between January 1, 2007 and July 1, 2011. Re-presentations to other facilities were not recorded.

Statistical analysis

Each patient was classified according to the Infectious Diseases Society of America clinical classification of DFI as either mild, moderate or severe. The primary outcome measured was the rate of major and minor amputation. Patient groups were further collapsed into non-severe (by combining the mild and moderate groups) and severe groups to allow for comparison using Wilcoxon rank-sum (Mann–Whitney U) tests. Factors potentially influencing the amputation rate were analysed using univariate logistic regression; statistically significant variables were then used to construct a multivariate logistic regression model. Variables were removed from the multivariate model in a backward, step-wise progression if found to no longer be significant. Results were considered statistically significant if $P<0.05$.

Results and outcomes

The overall median age of the 91 patients included in the study was 63 years (interquartile range 55–77). The majority of patients in all groups were male (mild 10/12, moderate 26/40, severe 29/40, total 65/91). The numbers of patients with mild, moderate and severe infections and the median patient ages are given in *Table 1*.

Surgical procedures

A total of 143 surgical procedures were performed on the 91 patients studied (*Table 2*). Of these, 68

Table 1. Infection severity demographics (*n*=91).

Severity of infection	Number of patients (%)	Median age
Mild	12 (13%)	75.5
Moderate	40 (44%)	64.5
Severe	39 (43%)	62

Table 2. Number of procedures per patient (*n*=91).

Number of procedures	Number of patients
1	57
2	20
3	10
4	4

Table 3. Method of revascularisation (*n*=17).

Method of revascularisation	Number of patients
Angioplasty	11
Angioplasty with stenting	4
Grafting procedure	2

Table 4. Depth of debridement (*n*=52).

Depth of debridement	Number of patients
To bone	39
To subcutaneous tissue	6
To tendon or muscle	3
No depth recorded	4

patients (75%) had one or more amputations, 51 patients (56%) had one or more debridements, and 17 patients (18.7%) had one or more revascularisation procedures (*Table 3*). Fifty-two patients underwent debridement. The depth of debridement varied, and is shown in *Table 4*.

For all surgical procedures, the median time to surgery was 2 days (interquartile range 1–4, range 0–32 days). Of the 68 patients who underwent amputation, *Table 5* shows the final amputation level.

Length of stay

LOSs for different levels of infection are given in *Table 6*. For all presentations, the median LOS was 14 days (interquartile range 8–23). There was no significant difference in LOS when the patient groups were collapsed into non-severe and severe for comparison using a Wilcoxon rank-sum test (*P*=0.82).

Amputation rate

Univariate and multivariate analyses were utilised to determine predictors for amputation. The amputation rate was not found to be unidirectional with age (tertiles) or severity, so these were analysed as discrete categorical variables. The variables tested using logistic regression were surgeon, age (tertiles), sex, severity, HbA_{1c}, C-reactive protein, white cell count (WCC), and insulin use.

The multivariate analysis selected variables of the univariate tests with a *P* value <0.2 (age, sex, C-reactive protein and WCC). Variables were removed in a backward, step-wise progression if they were no longer significant. Male gender (odds ratio 4.2, 95% confidence interval 1.3–13.4, *P*=0.014) and increased WCC (odds ratio 1.42 for each increase of 1.0×10^9/L WCC, 95% confidence interval 1.1–1.8, *P*=0.004) significantly influenced amputation rate.

Re-presentation

Thirty-eight patients re-presented to the same facility with an infection in the same foot during the study period. There was no significant difference in the number of re-presentations between non-severe and severe groups when a comparison was made using the Wilcoxon rank-sum test (*P*=0.198). The median LOS for re-presentation was 14.5 days (3.5–29.5).

Of those patients who re-presented, 21% underwent an amputation. There was no significant difference in amputation rate on re-presentation between severe and non-severe groups when compared to Wilcoxon rank-sum test (*p*=0.19).

Discussion

Previously published studies on the surgical management of DFIs in Australia are limited. Steffen (1998) first reported an audit of 51 patients admitted to Cairns Base Hospital between 1992 and 1994 for DFIs requiring surgical intervention. An overall amputation rate of 84%, a major amputation rate of 31%, and a mean LOS of 48 days was reported. This was followed by O'Rourke et al (2002), who reported the results of 126 patients presenting to the High Risk Foot Service at Royal Darwin Hospital between 1997 and 2000. An overall amputation rate of 63%, a major amputation rate of 23%, and a mean LOS of 46 days was recorded by the High Risk Foot Service.

More recently, Ismail et al (2015) reported the results of a small audit of 24 patients admitted to a secondary health centre in Queensland between 2012 and 2013 for the management of DFIs. They reported operative management in 63% of patients, with a minor amputation rate of 25% and no major amputations. The lower amputation rate in this study is likely a reflection of the secondary hospital setting, with a number of patients being transferred to tertiary hospitals for further management.

Our study reviewed the outcomes of surgically-managed DFIs from 2007 to 2009 at Wollongong Hospital. The observed overall amputation rate in this population was 74.7%, and there was a major amputation rate of 22%. There are inherent

Table 5. Final amputation level of patients (*n*=68) undergoing lower extremity amputation.

Final amputation level	Mild	Moderate	Severe	Total
Minor amputation	6	19	23	**48**
Single other toe	5	10	6	**21**
Great toe	1	4	11	**16**
Combined great and other toe	0	3	2	**5**
Multiple other toes	0	2	4	**6**
Major amputation	4	8	8	**20**
Tarsometatarsal	1	4	4	**9**
Below knee amputation	3	1	3	**7**
Above knee amputation	0	3	1	**4**
Grand total	10	27	31	**68**

limitations in comparing study populations from different locations, ethnicities and study periods, but the current study had comparable rates of overall amputation and major amputation with those previously reported Australian studies, all of which have been from regional centres.

Although the incidence of amputation is often a principal marker of the quality of care for DFIs, the interpretation of results requires caution. The comparison of amputation rates is confounded by significant variations in reporting methods, including the definition of amputation, the choice of numerator and denominator, and population selection. For example, Steffen and O'Rourke (1998) recorded the most recent admission, Ismail et al (2015) and O'Rourke et al (2002) examined all admissions, while our study recorded first presentation only. Nevertheless, amputation rate is useful in monitoring outcomes for DFIs in a defined cohort. A sustained reduction in the incidence of amputation, as well as a low overall incidence of amputation, should be the aim of centres trying to improve their care of DFIs.

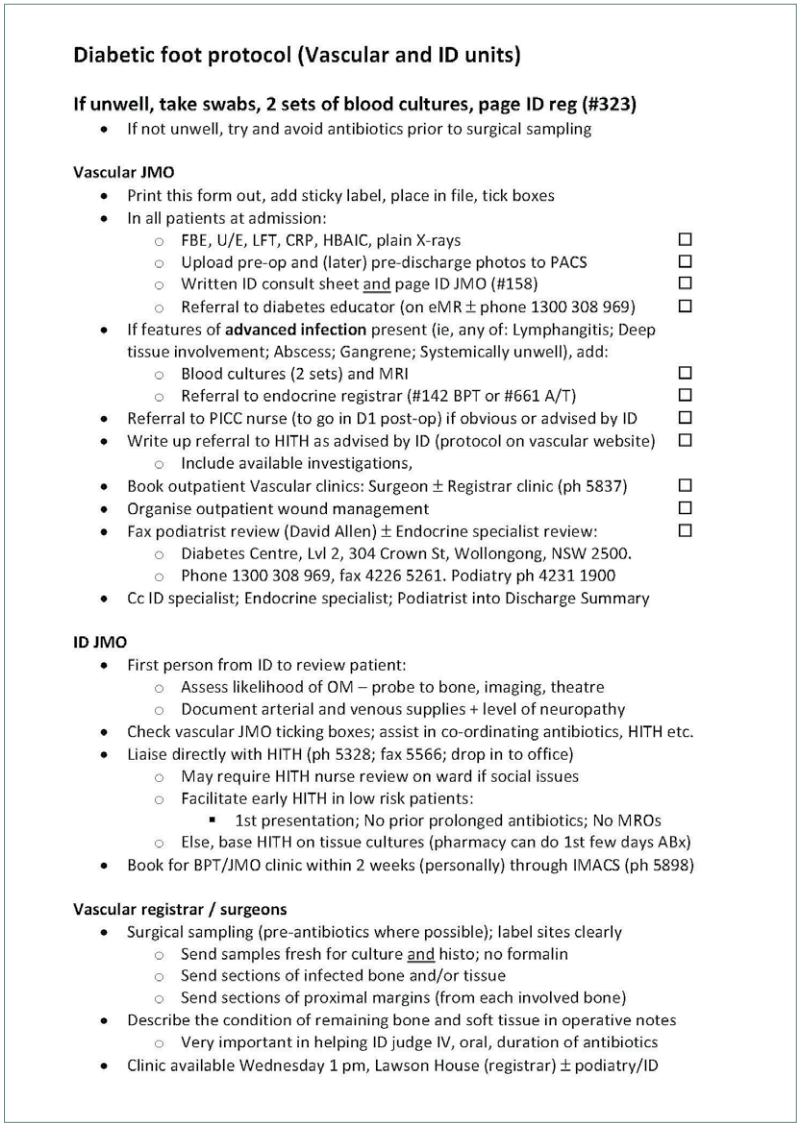
The ratio of major to minor amputations is also an important measure of the success of DFI management. For example, a slightly reduced overall amputation rate with a dramatic increase in the proportion of major amputations could not be viewed as a management success. Larsson et al (2008) reported the success of a multidisciplinary treatment programme for DFIs over a 20-year period. They reported that while the overall amputation rate had only slightly reduced during the study period, there was a sustained reduction of more than 50% in the incidence of major amputation. In our cohort, approximately 30% of amputations performed (20/68) were major amputations.

While the frequency of amputation and debridement were similar to that described by Steffen and O'Rourke (1998) and O'Rourke et al (2002), revascularisation rates in the current study were much higher (18.7% versus 5.9% and 5.9%, respectively). This is likely explained by a growing awareness that diabetic ischaemia is typically a result of macrovascular arterial occlusive disease without microvascular occlusion (LoGerfo and Coffman, 1984). Reductions in amputation rates in people with diabetes have been attributed to the introduction of successful revascularisation techniques, particularly peripheral angioplasty (Faglia et al, 2005).

The median time to first surgical intervention was 2 days across all severity groups in the present

Table 6. Length of hospital stay for different severities of diabetic foot infection (*n*=91).

Severity of infection	Number of patients	Average length of stay (days)
Mild	12	12
Moderate	40	16.5
Severe	39	17



Diabetic foot protocol (Vascular and ID units)

If unwell, take swabs, 2 sets of blood cultures, page ID reg (#323)

- If not unwell, try and avoid antibiotics prior to surgical sampling

Vascular JMO

- Print this form out, add sticky label, place in file, tick boxes
- In all patients at admission:
  - FBE, U/E, LFT, CRP, HBAIC, plain X-rays ☐
  - Upload pre-op and (later) pre-discharge photos to PACS ☐
  - Written ID consult sheet and page ID JMO (#158) ☐
  - Referral to diabetes educator (on eMR ± phone 1300 308 969) ☐
- If features of **advanced infection** present (ie, any of: Lymphangitis; Deep tissue involvement; Abscess; Gangrene; Systemically unwell), add:
  - Blood cultures (2 sets) and MRI ☐
  - Referral to endocrine registrar (#142 BPT or #661 A/T) ☐
- Referral to PICC nurse (to go in D1 post-op) if obvious or advised by ID ☐
- Write up referral to HITH as advised by ID (protocol on vascular website) ☐
  - Include available investigations,
- Book outpatient Vascular clinics: Surgeon ± Registrar clinic (ph 5837) ☐
- Organise outpatient wound management ☐
- Fax podiatrist review (David Allen) ± Endocrine specialist review: ☐
  - Diabetes Centre, Lvl 2, 304 Crown St, Wollongong, NSW 2500.
  - Phone 1300 308 969, fax 4226 5261. Podiatry ph 4231 1900
- Cc ID specialist; Endocrine specialist; Podiatrist into Discharge Summary

ID JMO

- First person from ID to review patient:
  - Assess likelihood of OM – probe to bone, imaging, theatre
  - Document arterial and venous supplies + level of neuropathy
- Check vascular JMO ticking boxes; assist in co-ordinating antibiotics, HITH etc.
- Liaise directly with HITH (ph 5328; fax 5566; drop in to office)
  - May require HITH nurse review on ward if social issues
  - Facilitate early HITH in low risk patients:
    - 1st presentation; No prior prolonged antibiotics; No MROs
  - Else, base HITH on tissue cultures (pharmacy can do 1st few days ABx)
- Book for BPT/JMO clinic within 2 weeks (personally) through IMACS (ph 5898)

Vascular registrar / surgeons

- Surgical sampling (pre-antibiotics where possible); label sites clearly
  - Send samples fresh for culture and histo; no formalin
  - Send sections of infected bone and/or tissue
  - Send sections of proximal margins (from each involved bone)
- Describe the condition of remaining bone and soft tissue in operative notes
  - Very important in helping ID judge IV, oral, duration of antibiotics
- Clinic available Wednesday 1 pm, Lawson House (registrar) ± podiatry/ID

Figure 1. Wollongong Hospital diabetic foot protocol.

study, suggesting that surgical intervention was generally performed promptly. Aggressive surgical intervention has been reported to reduce the need for major amputation and reduce the LOS in DFI (Faglia et al, 2006).

The median LOS for all patients in the current study was 14 days, with no significant difference in median LOS between non-severe and severe patients. The LOSs in the studies by Steffen and O'Rourke (1998) and O'Rourke et al (2002) were substantially longer (48 days and 46 days, respectively), possibly due to reporting mean LOS rather than median LOS. In contrast, the shorter LOS reported in the study by Ismail et al (2015) was likely due to the lack of major amputations conducted. Similar to amputation rate, LOS is an imperfect measure of the success of DFI management, especially in small cohorts. The time to complete resolution of infection and wound healing, with reference to re-infection and re-amputation, would be a more informative time-based measure of DFI care.

Multivariate analysis in the present study showed that the amputation rate increased significantly with male sex (P=0.014). Studies from Australia (Payne, 2000) and abroad (Armstrong et al, 1997; van Houtum et al, 2004; Trautner et al, 2007; Schofield et al, 2009) have also reported a higher amputation rate in men. Although the present study and others have found that the amputation rate increases with male gender, other multivariate studies have not demonstrated a sex influence on the probability of amputation in DFI (Gershater et al, 2009; Lipsky et al, 2011). Further systematic evaluation is required to determine whether sex differences in amputation rates in DFI exist and, if so, why.

Developing a management protocol

Based on the results of the retrospective audit, a clinical protocol for the management of DFI was drafted, incorporating applicable, evidence-based recommendations (*Figure 1*). This clinical protocol is thought likely to improve clinical outcomes for patients with DFI managed in this hospital, and to reduce the incidence of lower extremity amputation in individuals with diabetes. The authors aim to prospectively audit and publish the outcomes of this protocol in the near future.

Study limitations

This single-centre retrospective audit is subject to several inherent limitations. First, the relatively small population from a single facility limits statistical power and increases the likelihood of random error. Second, cases that were miscoded may have been missed in our search protocol. Third, there was dependence on hospital inpatient record-keeping, which was at times incomplete or illegible. Finally, the follow-up period was limited to the study period and was, therefore, not uniform for all patients.

Conclusion

Given the prevalence and ubiquity of DFIs in Australia, there is a pressing need to determine appropriate benchmarks for the surgical management of DFIs. This study will act as a contemporary baseline for other healthcare facilities to assess their process of care. ■

Armstrong DG, Lavery LA, van Houtum WH, Harkless LB (1997) The impact of gender on amputation. *J Foot Ankle Surg* **36**: 66-9; discussion 81

Australian Institute of Health and Welfare (2008) *Diabetes: Australian Facts 2008*. Australian Institute of Health and Welfare, Canberra. Available at: http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=6442454991 (accessed 09.03.2016)

Diabetes Australia (2007) *National Priorities for Turning Around the Diabetes Epidemic, 2007–2008*. Diabetes Australia, Canberra

Faglia E, Dalla Paola L, Clerici G, et al (2005) Peripheral angioplasty as the first-choice revascularization procedure in diabetic patients with critical limb ischemia: prospective study of 993 consecutive patients hospitalized and followed between 1999 and 2003. *Eur J Vasc Endovasc Surg* **29**: 620–7

Faglia E, Clerici G, Caminiti M, et al (2006) The role of early surgical debridement and revascularization in patients with diabetes and deep foot space abscess: retrospective review of 106 patients with diabetes. *J Foot Ankle Surg* **45**: 220–6

Gershater MA, Löndahl M, Nyberg P et al (2009) Complexity of factors related to outcome of neuropathic and neuroischaemic/ischaemic diabetic foot ulcers: a cohort study. *Diabetologia* **52**: 398–407

Ismail I, Dhanapathy A, Gandhi A, Kannan S (2015) Diabetic foot complications in a secondary foot hospital: a clinical audit. *Australas Med J* **8**: 106–12

Larsson J, Eneroth M, Apelqvist J, Stenström A (2008) Sustained reduction in major amputations in diabetic patients: 628 amputations in 461 patients in a defined population over a 20-year period. *Acta Orthop* **79**: 665–73

Lipsky BA, Berendt AR, Deery HG et al; Infectious Diseases Society of America (2004) Diagnosis and treatment of diabetic foot infections. *Clin Infect Dis* **39**: 885–910

Lipsky BA, Weigelt JA, Sun X et al (2011) Developing and validating a risk score for lower-extremity amputation in patients hospitalized for a diabetic foot infection. *Diabetes Care* **34**: 1695–700

LoGerfo FW, Coffman JD (1984) Current concepts. Vascular and microvascular disease of the foot in diabetes. Implications for foot care. *N Engl J Med* **311**: 1615–9

O'Rourke I, Heard S, Treacy J, Gruen R, Whitbread C (2002) Risks to feet in the top end: outcomes of diabetic foot complications. *ANZ J Surg* **72**: 282–6

Payne CB (2000) Diabetes-related lower-limb amputations in Australia. *Med J Aust* **173**: 352–4

Schofield CJ, Yu N, Jain AS, Leese GP (2009) Decreasing amputation rates in patients with diabetes – a population-based study. *Diabet Med* **26**: 773–7

Steffen C, O'Rourke S (1998) Surgical management of diabetic foot complications: the Far North Queensland profile. *Aust N Z J Surg* **68**: 258–60

Trautner C, Haastert B, Mauckner P, Gätcke LM, Giani G (2007) Reduced incidence of lower-limb amputations in the diabetic population of a German city, 1990–2005: results of the Leverkusen Amputation Reduction Study (LARS). *Diabetes Care* **30**: 2633–7

van Houtum WH, Rauwerda JA, Ruwaard D, Schaper NC, Bakker K (2004) Reduction in diabetes-related lower-extremity amputations in The Netherlands: 1991–2000. *Diabetes Care* **27**: 1042–6