Letter to the Editor

Clinical Outcomes of Ray Amputation in Diabetic Foot Patients

Dear Editor,

Diabetes mellitus is a growing problem in Singapore, with a reported incidence of 11.3% of the Singapore population, a significant increase from 8.2% in 2004.[1] With the implementation of a multidisciplinary approach combined with a clinical pathway, our major amputation rate (below- and above-knee amputation) has been reduced from 31.15% in 2002 to 11.01% in 2007.[2] Nather et al in 2008 identified predictive factors leading to limb loss in diabetic patients to be peripheral vascular disease and infection.[3]

Minor amputations in diabetic feet surgery include toe disarticulation, ray amputation, transmetatarsal amputation, Chopart's, Lisfranc's, Syme and Pirogoff amputation.[4] The ray amputation is the commonest minor amputation performed in Singapore, and is preferred to the disarticulation of the toe.[3] Several papers have studied the outcome of minor amputation in diabetic foot patients without further classifying which type of minor amputation was performed.[5,6,7] Others have studied ray amputations in patients with and without diabetes.[8]

There are few studies in the literature on the clinical outcome of ray amputation in diabetic foot patients.[9,10,11] These studies reported mainly selective aspects of clinical outcome such as mortality and recurrence of ulcers.[9,10,11] The aim of this paper is to evaluate the factors that would predict a poor outcome following a ray amputation.

Materials and Methods

This is a prospective cohort study of 150 consecutive patients with diabetic foot problems undergoing ray amputation by the National University Hospital (NUH) Diabetes Foot Team from January 2007 to October 2010. Ethics approval from the hospital's ethics board was granted. Informed consent was taken. These patients were followed up for a minimum of 12 months.

Demographic data and patient profile such as age, sex, premorbid status, duration and type of diabetes, comorbidities, presence of risk factors such as smoking, alcoholism, and hyperlipidaemia were recorded. Clinical examination included the vascular status (lower limb pulses, ankle and toe-brachial indexes) and the neuropathy status (5.07 Semmes-Weinstein Monofilament testing, Neurothesiometer reading). The presence and severity of renal failure along with cardiac status (history of acute myocardial infarction and latest ejection fraction) and the American Society of Anesthesiologists (ASA) score of the patients were documented. Preoperative blood investigations recorded included glycated haemoglobin (HbA1c), full blood count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Other investigations include wound/tissue and blood cultures. All laboratory/radiological and clinical findings were performed within 1 week of surgery by an independent observer not involved in the surgery. The indications for a ray amputation included 3 broad groups: wet gangrene of the toe, osteomyelitis of the proximal or distal phalanx, and soft tissue infection of the whole toe.

All patients were followed up for any postoperative complications. The need for any repeat operation and type of revision operation (revision of ray amputation, additional ray amputation in the affected foot, transmetatarsal amputation, syme amputation, below-knee amputation or above-knee amputation) were documented. Any mortality was also recorded.

A good clinical outcome is defined as one whose amputation healed and does not develop any complication within a year. A poor clinical outcome is defined as one who underwent proximal level reamputation within a year, and/or underwent additional ray amputation on the same foot within a year, and/or suffered mortality within a year after operation.

Statistical Analysis

All statistical analyses were performed using SPSS 18.0 with statistical significance set at $P<0.050$. Predictive factors for clinical outcome were determined using univariate and stepwise logistic regression analysis. Mann-Whitney U test was used for numerical prognostic factors, and chi-square test was used for categorical factors.

Results

Table 1 shows the patient profile of our study population. The ages of our patients ranged between 24 to 81 years with

a median age of 56 years. Racial distribution in our study cohort was 39.3% Chinese, 38.7% Malays, 20% Indian and 2% other races, and this was compared to the national racial composition of Singapore.[12] The mean follow-up duration was 36 months (range, 13 to 62 months). No patients were lost to follow-up during the minimum follow-up period of 12 months.

Table 2 summarises the results of ray amputation. A total of 106 patients (70.7%) of ray amputations gave a good outcome. Univariate analysis showed that smoking, chronic renal failure, wet gangrene, absence of pulses, delayed capillary filling, low ankle-brachial index (ABI) and toe-brachial index (TBI), high total white blood cell count (TWC) and neutrophil count, high ESR, high urea, high creatinine (Cr) and low haemoglobin (Hb) were associated with a poor clinical outcome. Multivariate analysis showed that smoking, absence of pulses, delayed capillary filling, high ESR, high Cr and neutrophil counts were associated with a poor clinical outcome.

A total of 44 patients (29.3%) had a poor outcome. Of these patients, 22 patients (14.7%) underwent proximal level amputations, 12 patients (8.0%) underwent additional ray amputation, 7 patients (4.6%) underwent forefoot amputation, and 3 (2.0%) patients died within 1 year. Two of the patients died of pneumonia resulting from systemic septicaemia, and 1 patient who had poor preoperative cardiac function died from postoperative acute myocardial infarction.

Table 1. Patient Profile

Factors	Value (%)
Gender distribution	
Male	100 (66.7%)
Female	50 (33.3%)
Age	
≤60 years	103 (68.7%)
>60 years	47 (31.3%)
Race	
Chinese	59 (39.3%)
Malay	58 (38.7%)
Indian	30 (20.0%)
Others	3 (2.0%)
Premorbid activities of daily living	
Independent	132 (88.0%)
Walking with aid	9 (6.0%)
Wheelchair bound	8 (5.3%)
Bed bound	1 (0.7%)
Comorbidities	
Hypertension	111 (74.0%)
Ischaemic heart disease (IHD)	50 (33.3%)
Cerebrovascular accident (CVA)	12 (8.0%)
Hyperlipidaemia	90 (60.0%)
Diabetes type	
Type I	11 (7.3%)
Type II	139 (92.7%)

Discussion

The high incidence of minor amputations performed in diabetic foot patients has been well documented in existing literature.[3,13,14] However, the significantly high rate of reamputations and significant mortality of these patients suggest that these patients should be better managed perioperatively.[6,9,10,11,15]

Izumi et al found the cumulative rates of upper level reamputation post ray amputation to be as high as 50% after 5 years.[9] Ohsawa et al reported a reamputation rate of 40% after 2 years.[11] Murdoch et al reported 60% reamputation rate, with the mean time from first to second amputation being approximately 10 months.[16]

Minor foot amputations have also been associated with poor outcome in terms of mortality.[6] Jones et al have investigated the cumulative mortality rate of toe amputations and reported it to be 31.8% after 3 years and 41.4% after 5 years.[6] A total of 70.7% of our patients had a good outcome. This is similar to results of Izumi et al in 2006, who found 73.3% good outcome after 1 year in a cohort of 277 diabetic foot patients.[9]

In our study, other significant risk factors for a poor outcome included markers of sepsis such as high ESR and high neutrophil counts. Hambleton et al have reported a similar finding in their prospective case controlled study of 205 diabetic foot patients, where sepsis was identified as one of the risk factors for poor outcome.[15]

Chronic renal failure and high Cr levels were associated with a poor outcome. This is similar to results published by Sheahan et al, who looked into a mixed cohort of 607 patients with 91.9% of the cohort having diabetes, and reported endstage renal failure and high Cr levels as poor prognostic indicators.[8]

Limitations of this study include a small sample size and a short follow-up period of less than 5 years. The authors aim to further follow-up the patients to report a 5-year outcome, and to generate a predictive model with an analysis of its prognostic accuracy to better guide management of ray amputations in diabetic foot infections.

Conclusion

The success rate of ray amputation was 70.7%. Smoking, absence of pulses, delayed capillary filling, high ESR, high Cr and neutrophil counts were found to be predictive factors for a poor clinical outcome.

Table 2. Results of Evaluation of Factors as Predictives of Outcome

		Outcome		Unadjusted	Adjusted	
Risk Factors*		**Good**	**Poor**	***P* Value**	**OR (95% CI)**	***P* Value**
Age						
≤60 years		71 (68.9)	32 (31.1)	0.956		
>60 years		35 (74.5)	12 (25.5)			
Gender						
Male		71 (71.0)	29 (29.0)	0.522		
Female		35 (70.0)	15 (30.0)			
Race						
Chinese		37 (62.7)	22 (37.3)	0.222		
Malay		42 (72.4)	16 (27.6)			
Indian		24 (80.0)	6 (20.0)			
Others		3 (100.0)	0 (0.0)			
Premorbid ADL						
Independent		94 (71.2)	38 (28.8)	0.683		
Walking with aid		5 (55.6)	4 (44.4)			
Wheelchair		6 (75.0)	2 (25.0)			
Bedbound		1 (100.0)	0 (0.0)			
Smoking						
	Yes	20 (32.8)	41 (67.2)	0.022	32.1 (8.924 – 91.401)	0.040
	No	64 (71.9)	25 (28.1)		1.0	
Comorbidities						
Hypertension	Yes	76 (68.5)	35 (31.5)	0.216		
	No	30 (76.9)	9 (23.1)			
Hyperlipidaemia	Yes	61 (67.8)	29 (32.2)	0.222		
	No	45 (75.0)	15 (25.0)			
CVA	Yes	9 (75.0)	3 (25.0)	0.511		
	No	97 (70.3)	41 (29.7)			
IHD	Yes	35 (70.0)	15 (30.0)	0.522		
	No	71 (71.0)	29 (29.0)			
Previous AMI	Yes	24 (64.9)	13 (35.1)	0.221		
	No	82 (73.2)	30 (26.8)			
Renal function						
End stage renal failure	ESRF	8 (42.1)	11 (57.9)	0.006		
Chronic renal failure	CRF	7 (58.3)	5 (41.7)			
Normal renal function	Normal	91 (76.5)	28 (23.5)			
Sensory neuropathy	Yes	88 (69.3)	39 (30.7)	0.273		
	No	18 (78.3)	5 (21.7)			
Diabetes mellitus type						
Type 1		9 (81.8)	2 (18.2)	0.322		
Type 2		97 (69.8)	42 (30.2)			
Duration of diabetes						
1 – 5 years		16 (80.0)	4 (20.0)	0.485		
5 – 10 years		24 (64.9)	13 (35.1)			
>10 years		66 (71.0)	27 (29.0)			

ABI: Ankle-brachial index; ADL: Activities of daily living; AMI: Acute myocardial infarction; ASA: American Society of Anaesthesiologists; CRF: Chronic renal failure; CRP: C-reactive protein; CVA: Cerebrovascular accident/stroke; ESR: Erythrocyte sedimentation rate; ESRF: End stage renal failure; Hb: Haemoglobin; HbA1c: Glycated haemoglobin; IHD: Ischaemic heart disease; NF: Normal foot; OR: Odds ratio; PF: Pathological foot; TBI: Toe-brachial index; TWC: Total white blood cell count

*Mann-Whitney U test used for numerical prognostic factors; chi-square test used for categorical factors.

Table 2. Results of Evaluation of Factors as Predictives of Outcome (Con't)

		Outcome		Unadjusted	Adjusted	
Risk Factors*		**Good**	**Poor**	***P* Value**	**OR (95% CI)**	***P* Value**
ASA score						
1		1 (50.0)	1 (50.0)	0.363		
2		58 (73.4)	21 (26.6)			
3		47 (69.1)	21 (30.9)			
4		0 (0.0)	1 (100.0)			
Vasculopathy						
Pulses	Both pulses not palpable	26 (53.1)	23 (46.9)	0.004	1.0	0.050
	1 pulse palpable	15 (83.3)	3 (16.7)		6.337 (1.231 – 32.610)	0.027
	2 pulses palpable	65 (78.3)	18 (21.7)		2.176 (0.870 – 5.440)	0.096
Delayed capillary filling	Yes	18 (50.0)	18 (50.0)	0.002	1.0	0.031
	No	88 (77.2)	26 (22.8)		2.832 (1.102 – 7.281)	
ABI: median (range)		1.1 (0.2 – 2)	0.9 (0.2 – 3.6)	0.001		
TBI: median (range)		0.8 (0.1 – 2.9)	0.5 (0.1 – 3)	0.013		
Neuropathy						
Monofilament test (PF)	≤7/10	93 (70.5)	39 (29.5)	0.560		
	>7/10	13 (72.2)	5 (27.8)			
Monofilament test (NF)	≤7/10	87 (71.3)	35 (28.7)	0.440		
	>7/10	19 (67.9)	9 (32.1)			
Neurothesiometer (PF)	0 – 25 V	11 (61.1)	7 (38.9)	0.820		
	26 – 50 V	55 (72.4)	21 (27.6)			
	>50 V	18 (72.0)	7 (28.0)			
	Not tested	22 (71.0)	9 (29.0)			
Neurothesiometer (NF)	0 – 25 V	17 (89.5)	2 (10.5)	0.102		
	26 – 50 V	41 (69.5)	18 (30.5)			
	>50 V	16 (80.0)	4 (20.0)			
	Not tested	32 (61.5)	20 (38.5)			
Preop parameters: median (range)						
Hb (g/dL)		11.5 (6.4 – 15.7)	10 (7.4 – 15)	0.005		
TWC (x10^9/L)		13.0 (6.5 – 33)	15.6 (6.2 – 28)	0.042		
Neutrophils (x10^9/L)		10.4 (3.2 – 28.4)	14 (4.8 – 23.6)	0.000	0.880 (0.810 – 0.956)	0.002
CRP (mg/L)		120.4 (9.6)	145.4 (15.2)	0.209		
ESR (mm/hr)		94.5 (13 – 150)	157.5 (2 – 356)	0.005	0.982 (0.968 – 0.997)	0.021
Urea (mmol/L)		5.6 (1 – 76)	8.3 (1.4 – 25.9)	0.011		
Creatinine (umol/L)		82.5 (3 – 985)	139 (44 – 939)	0.000	0.997 (0.995 – 0.999)	0.004
HbA1c (%)		10.0 (5.5 – 16)	9.5 (5.9 – 73)	0.474		
Indication for surgery						
Wet gangrene		57 (62.0)	35 (38.0)	0.013		
Osteomyelitis		28 (84.8)	5 (15.2)			
Soft tissue infection of whole toe		21 (84.0)	4 (16.0)			

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*Mann-Whitney U test used for numerical prognostic factors; chi-square test used for categorical factors

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