

Prediction of wound complications after major amputation for patients with critical limb ischemia

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Background/aim

Management of patients with critical limb ischemia from peripheral vascular disease is still a big issue for vascular and endovascular surgeons. For patients who are not candidates for revascularization, 20–40% will undergo major amputation within 6–12 months. Mortality following major amputation of the lower extremity in these patients has been high. This study aims at identifying important factors that lead to wound complications following major amputation in patients with end-stage critical ischemia.

Patients and methods

This study enrolled 120 in patients who underwent major lower extremity amputations affected by critical limb ischemia, since January 2017 and till March 2020, in the Vascular Surgery Departments at Al-Azhar University Hospitals, Cairo, Egypt. A total of 67 patients underwent transfemoral above-knee amputations (AKA) and 53 underwent transtibial below-knee amputations (BKA). The follow-up was done at first week and first, third, and sixth months postoperatively, and 1-year mortality was assessed as well. The various risk factors were analyzed in this study, including age, coronary artery disease, chronic heart failure, cerebrovascular disease, hypertension, diabetes mellitus, hemodialysis, white blood cell (WBC) count, C-reactive protein-quantitative (CRP), lactate dehydrogenase, and serum albumin level.

Results

The present study exhibited that most cases were men (75%) and former smokers (64.2%). A total of 91 patients (75.8%) had a history of hypertension. Univariate analysis exhibited that there were defiantly more wound occurrences ($P < 0.05$) for those patients who underwent BKA in the greater than or equal to 55-year-old age group, smokers, patients with high WBCs, patients with low serum albumin level and with positive CRP, and dialysis-dependent patients. However, the patients who underwent an AKA, the multivariate analysis determined positive CRP and dialysis dependent as significant predictors ($P < 0.05$) of a wound occurrence.

Conclusion

Predictors that significantly increased the risks of delayed recovery for those who underwent BKAs are greater than or equal to 55-year-old group, smokers, patients with elevated WBCs, and patients on dialysis proved to be predictive, and for AKA the predictive factors were low serum albumin level, patients with high WBCs, and patients with dialysis dependence.

Keywords:

critical limb ischemia, major amputation, wound healing

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Introduction

Management of patients with critical limb ischemia (CLI) from peripheral vascular disease is still a big issue for vascular and endovascular surgeons. For patients who are not candidates for revascularization, 20–40% undergo major amputation within 6–12 months. Mortality following major amputation of the lower extremity in these patients has been high [1].

Recent studies have shown 30-day mortality rates from 6 to 17%, with a higher risk among patients with CLI who are typically elderly and have a high prevalence of multiple risk factors including diabetes, hypertension,

cardiovascular and cerebrovascular diseases, and renal insufficiency [2].

Endovascular management of patients with CLI has changed a lot over the past 25 years, with new techniques replacing surgical procedures. Major amputations have also decreased, though it continues to come first in 60–70% of those patients. Major

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amputation is associated with high mortality, morbidity, and revision rates. These complications increase the length of hospital stay and add to the overall treatment costs. Overall, 5–10% of below-knee amputees and 15–20% of above-knee amputees pass away in hospitals. On the contrary, perioperative mortality for infrainguinal open and endovascular revascularization is 2–8% and 1–3%, respectively [3].

Previously it was found that 20–37% complication rate associated with amputation is considerably greater than the 16–17% for open vascular surgery and 5–9% for endovascular intervention. Wound infection comes as a frequent complication with 10–30%, and if not healed, reamputation will be the end result; however, deep vein thrombosis (13–26%), cardiac complications (9–10%), bleeding (8%), and renal failure (2–3%) are also important so far [4].

The aim of the present work was to identify important factors that lead to wound complications following major amputation in patients with end-stage critical ischemia.

Patients and methods

Patients and study design

The study included 120 in patients who underwent major lower extremity amputations affected by CLI from January 2017 to March 2020. They were recruited from Vascular Surgery Departments at Al-Azhar University Hospitals, Cairo, Egypt.

All patients underwent transfemoral above-knee amputations (AKA) ($n=67$) and transtibial below-knee amputations (BKA) ($n=53$) for vascular disease CLI. The assessment was further restricted to only those with the age of 50 years or greater and a history of ischemic rest pain or gangrene, or prior revascularization for peripheral vascular disease.

Patients with major amputations resulting from trauma, bone/skin malignancy, infection patients having guillotine amputations, reamputations, and diabetic gangrene without ischemia were excluded from the study.

Ethical considerations

The present study was conducted with the code of ethics of the world medical association according to the principles expressed in the declaration of Helsinki. This study has been approved by the local Ethics Committee of the Faculty of Medicine for Girls, Al-Azhar University, with approval number 1293-3-2022.

Methods

Preoperative risk factors, postoperative variables, and mortality data were collected. Wound complications were defined as surgical site infection or wound dehiscence. Various risk factors were analyzed in this study, including age; comorbidities, including coronary artery disease, chronic heart failure, cerebrovascular disease, hypertension, and diabetes mellitus; and hemodialysis. Follow-up was done at first week and first, third, and sixth months postoperatively, and 1-year mortality rate was assessed as well.

All patients in our study were subjected to serum albumin and lactate dehydrogenase (LDH) determinations and quantitative C-reactive protein (CRP), using kits purchased from Spectrum Diagnostics, Cairo, Egypt, and white blood cell (WBC) count using an automated blood cell counter of Mendry Co (Nanshan, China).

Statistical analysis

Data were fed to the computer and analyzed with IBM SPSS software package version 20.0 (IBM Corp., Armonk, New York, USA). The Kolmogorov–Smirnov test was used to verify the normality of distribution of variables. Comparisons between groups for categorical variables were assessed using the χ^2 -test (Fisher). McNemar analyzes the significance between the different stages, Student's t -test was used to compare two groups for normally distributed quantitative variables. Mann–Whitney test was used to compare between two groups for not normally distributed quantitative variables. Odds ratio was used to calculate the ratio of the odds and 95% confidence interval of an event occurring in one risk group to the odds of it occurring in the nonrisk group. P values less than 0.05 were considered as statistically significant.

Results

A total of 100 lower extremity amputations were executed in patients affected by CLI during the study period. The target age was 58.8 ± 9 years. The majority of cases were men (75%) and former smokers (64.2%). A total of 91 patients (75.8%) had a history of hypertension and 116 patients (96.7%) had diabetes (65.7%). Moreover, 26 patients (21.7%) underwent hemodialysis and 77 patients (64.2%) had previously undergone lower extremity procedure revascularization. Of the 120 amputations performed, 67 (55.8%) were AKA and 53 (44.2%) were BKA, as observed in Table 1.

Table 1. General outcome for all patients

	Total (n=120) [n (%)]	Outcome [n (%)]		Test of significance	P value
		Clean (n=80)	Infection (n=40)		
Sex					
Male	30 (25)	22 (27.5)	8 (20)	$\chi^2=0.800$	0.371
Female	90 (75)	58 (72.5)	32 (80)		
Age (years)					
Mean±SD	58.8±9	58.3±8.7	59.8±9.7	$t=0.857$	0.393
Median (Minimum–maximum)	58 (40–84)	57 (40–84)	60.5 (40–82)		
Diabetes	116 (96.7)	76 (95)	40 (100)	$\chi^2=2.069$	0.300
Hypertension	91 (75.8)	60 (75)	31 (77.5)	$\chi^2=0.091$	0.763
Ischemic heart diseases (IHD)	69 (57.5)	41 (51.3)	28 (70)	$\chi^2=3.836$	0.050
WBC ($\times 10^3$)					
Mean±SD	15.1±12.2	11.5±9.1	22.4±14.2	$U=863.50$	<0.001*
Median (Minimum–maximum)	10.5 (1–56)	9 (1–43)	21 (3–56)		
ALB					
Mean±SD	3±0.6	3.2±0.5	2.6±0.5	$t=5.176$	<0.001*
Median (minimum–maximum)	2.6 (1.6–3.6)	3.6 (1.6–3.6)	2.6 (1.6–3.6)		
CRP					
Negative	84 (70)	73 (91.3)	11 (27.5)	$\chi^2=51.61$	<0.001*
Positive	36 (30)	7 (8.8)	29 (72.5)		
LDH					
Mean±SD	195.5±64.4	181.4±40.2	223.9±90.3	$U=1091.5$	0.005*
Median (minimum–maximum)	174.5 (133–499)	170 (133–310)	186 (140–499)		
Smoking	77 (64.2)	46 (57.5)	31 (77.5)	$\chi^2=4.639$	0.031*
Type					
AKA	67 (55.8)	47 (58.8)	20 (50)	$\chi^2=0.828$	0.363
BKA	53 (44.2)	33 (41.3)	20 (50)		
Cerebrovascular disease					
No	86 (71.7)	59 (73.8)	27 (67.5)	$\chi^2=0.513$	0.474
Yes	34 (28.3)	21 (26.3)	13 (32.5)		
Dialysis dependent					
No	94 (78.3)	65 (81.3)	29 (72.5)	$\chi^2=1.203$	0.273
Yes	26 (21.7)	15 (18.8)	11 (27.5)		
Prior revascularization					
No	43 (35.8)	27 (33.8)	16 (40)	$\chi^2=0.453$	0.501
Yes	77 (64.2)	53 (66.3)	24 (60)		
Death					
No	85 (70.8)	59 (73.8)	26 (65)	$\chi^2=0.988$	0.320
Yes	35 (29.2)	21 (26.3)	14 (35)		

AKA, above-knee amputations; ALB, albumin; BKA, below-knee amputations; CRP, C-reactive protein; LDH, lactate dehydrogenase; t , Student's t -test; U , Mann–Whitney test; WBC, white blood cells.

*Statistically significant between clean and infection outcome at $P \leq 0.05$.

Table 2. Distribution of the studied cases according to re-intervention in the infection group (n=40)

Re-intervention	N (%)
No	7 (17.5)
Revision	20 (50)
High level	13 (32.5)

The present results showed that 13 (32.5%) of 40 infection cases of wound dehiscence required conversion to a higher-level amputation and 20 (50%) required revision. These data are reported in Table 2.

The comparison between AKA and BKA according to death is summarized in Table 3, where 1-year mortality after AKA (32.8%) was insignificantly increased ($P=0.320$) than BKA (24.5%).

The univariate analysis exhibited that there were defiantly more wound occurrences ($P < 0.05$) for those patients who underwent BKA in the greater than or equal to 55-age group, for smokers, for patients with high WBCs, patients with low albumin level and with positive CRP, and dialysis-dependent patients. The multivariate analysis determined that the low albumin and positive CRP

and dialysis dependent were predictors of a wound occurrence following BKA significantly (Table 4).

For patients who underwent an AKA, the univariate analysis showed that females, patients with lower

Table 3. One-year mortality after above-knee amputation (AKA) and below-knee amputation (BKA)

Type				
Death	AKA (n=67)	BKA (n=53)	χ^2	P value
No	45 (67.2)	40 (75.5)	0.989	0.320*
Yes	22 (32.8)	13 (24.5)		

*Insignificant difference between AKA and BKA, using χ^2 -test.

preoperative albumin, those with positive CRP, those who underwent prior revascularization, those with high LDH, patients with an elevated WBC count, and patients with dialysis dependence had more significant ($P<0.05$) wound occurrences. The multivariate analysis determined positive CRP and dialysis dependent as significant predictors ($P<0.05$) of a wound occurrence (Table 5).

The results of risk factors for 1-year mortality after major amputations are shown in Table 6. In the univariate analysis, a low serum albumin

Table 4. Univariate and multivariate logistic regression analyses for the parameters affecting wound infection in BKA (n=20 infected vs 33 clean)

	Univariate P	OR (95% CI) (LL-UL)	Multivariate [#] P	OR (95%CI) (LL-UL)
Sex (female)	0.174	0.413 (0.115–1.478)		
Age (years) (≥ 55)	0.030*	4.722 (1.158–19.259)	0.127	4.052 (0.671–24.482)
Smoking	0.028*	4.250 (1.169–15.454)	0.394	2.124 (0.375–12.020)
HTN	0.721	1.280 (0.330–4.959)		
IHD	0.206	2.053 (0.673–6.261)		
WBC ($\times 10^3$)	0.015*	1.070 (1.013–1.130)	0.836	1.008 (0.934–1.089)
ALB	0.017*	0.278 (0.097–0.796)	0.028*	0.107 (0.015–0.785)
CRP	$<0.001^*$	13.464 (3.348–54.154)	0.023*	10.327 (1.375–77.570)
LDH	0.315	1.005 (0.996–1.014)		
Cerebrovascular disease	0.473	1.592 (0.447–5.664)		
Dialysis dependent	0.039*	0.105 (0.012–0.892)	0.018*	0.028 (0.001–0.543)
Prior revascularization	0.204	0.452 (0.133–1.540)		
Death	0.174	2.423 (0.677–8.675)		

ALB, albumin; BKA, below-knee amputations; CI, confidence interval; CRP, C-reactive protein; HTN, hypertension; IHD, Ischemic heart disease; LDH, lactate dehydrogenase; LL, lower limit; OR, odds ratio; UL, upper limit; WBC, white blood cell.

[#]All variables with $P<0.05$ was included in the multivariate

*Statistically significant at $P\leq 0.05$

Table 5. Univariate and multivariate logistic regression analyses for the parameters affecting wound infection in AKA (n=20 infected vs 47 clean)

	Univariate P	OR (95% CI) (LL-UL)	Multivariate [#] P	OR (95% CI) (LL-UL)
Sex (female)	0.033*	9.806 (1.202–80.036)	0.063	445.377 (0.710–279402)
Age (years) (≥ 55)	0.240	0.514 (0.170–1.559)		
Smoking	0.376	1.700 (0.525–5.500)		
HTN	0.963	1.029 (0.308–3.435)		
IHD	0.130	2.479 (0.766–8.028)		
WBC ($\times 10^3$)	0.001*	1.092 (1.038–1.150)	0.832	0.987 (0.873–1.116)
ALB	0.001*	0.082 (0.019–0.364)	0.068	0.070 (0.004–1.220)
CRP	$<0.001^*$	58.67 (11.814–291.327)	0.009*	625.303 (4.837–80834)
LDH	0.004*	1.019 (1.006–1.033)	0.747	0.996 (0.975–1.018)
Cerebrovascular disease	0.674	1.269 (0.418–3.856)		
Dialysis dependent	0.001*	10.750 (2.791–41.398)	0.032*	68.094 (1.438–3223.5)
Prior revascularization	0.036*	3.197 (1.077–9.492)	0.660	2.251 (0.061–83.300)
Death	0.806	1.149 (0.381–3.467)		

AKA, above-knee amputations; ALB, albumin; CI, confidence interval; CRP, C-reactive protein; HTN, hypertension; IHD, Ischemic heart disease; LDH, lactate dehydrogenase; LL, lower limit; OR, odds ratio; UL, upper limit; WBC, white blood cell.

[#]All variables with $P<0.05$ was included in the multivariate.

*Statistically significant at $P\leq 0.05$.

Table 6. Univariate and multivariate logistic regression analyses for the results of risk factors for 1-year mortality after major amputations (n=35 died vs 85 alive)

	<i>P</i>	Univariate OR (95% CI) (LL-UL)	<i>P</i>	Multivariate [#] OR (95%CI) (LL-UL)
Sex (female)	0.728	1.179 (0.467–2.976)		
Age (years) (≥55)	0.370	1.496 (0.620–3.609)		
Smoking	0.519	1.317 (0.570–3.045)		
D	0.852	1.244 (0.125–12.385)		
HTN	0.112	2.361 (0.819–6.800)		
IHD	0.019 [*]	2.822 (1.183–6.729)	0.546	1.488 (0.410–5.402)
WBC (×10 ³)	0.002 [*]	1.054 (1.020–1.089)	0.711	0.989 (0.933–1.048)
ALB	0.001 [*]	0.285 (0.136–0.599)	0.029 [*]	0.232 (0.062–0.862)
CRP	0.128	1.909 (0.830–4.389)		
LDH	0.064	1.006 (1.000–1.012)		
Type	0.321	1.504 (0.671–3.372)		
Cerebrovascular disease	<0.001 [*]	52.667 (16.305–170.12)	<0.001 [*]	55.280 (13.516–226.10)
Dialysis dependent	0.035 [*]	2.646 (1.072–6.528)	0.740	1.270 (0.310–5.202)
Prior revascularization	0.064	2.143 (0.956–4.806)		

ALB, albumin; CI, confidence interval; CRP, C-reactive protein; HTN, hypertension; IHD, Ischemic heart disease; LDH, lactate dehydrogenase; LL, lower limit; OR, odds ratio; UL, upper limit; WBC, white blood cell.

[#]All variables with $P < 0.05$ was included in the multivariate.

^{*}Statistically significant at $P \leq 0.05$.

Table 7. Baseline to 6-month follow-up rate of infection (n=120)

	Baseline	1 week	1 month	Follow-up 3 months	6 months
Clean					
Yes	80 (66.7)	88 (73.3)	83 (69.2)	106 (88.3)	120 (100)
No	40 (33.3)	32 (26.7)	37 (30.8)	14 (11.7)	0 (0)
<i>P</i>		0.256	0.760	<0.001 [*]	<0.001 [*]

P, *P* value for McNemar test for comparing between baseline and each other periods.

^{*}Statistically significant at $P \leq 0.05$.

concentration, elevated WBC count, dialysis dependence, cerebrovascular disease, and congestive heart failure were significant predictors for 30-day mortality. In the multivariate analysis, elevated WBC count and cerebrovascular disease were significant predictors ($P < 0.05$) for 30-day mortality.

The rate of infection postoperative in both groups was insignificantly decreased at the first week from 33.3 to 26.7% and then it was also insignificantly increased at first month to reach 30.8%. With long-term follow-up, the rate of infection had decreased significantly at third and sixth months to reach 11.7 and 0%, respectively, as shown in Table 7.

Discussion

Several previous studies have cited the outcomes after amputation of lower limbs; however, reports on outcomes after major amputation, only in patients

with peripheral arterial diseases, are little [5]. We focused on outcomes after major amputation, such as AKA and BKA in patients with ischemia.

A total of 120 patients underwent a major amputation for CLI. Significant predictors of a wound occurrence following BKA were greater than or equal to 55 years old group, smokers, patients with elevated WBCs, and patients on dialysis. Significant predictors of a wound occurrence following an AKA were female sex, patients with low albumin, patients with an elevated WBCs, and patients on dialysis.

Kolossváry *et al.* [6] have illustrated that sepsis, end-stage renal disease, tobacco use, and age of 65 years in BKA are risk factors for wound complications.

Although Conte *et al.* [7] have cited that female sex is a risk factor for wound complications after lower extremity revascularization, we have mentioned that female sex is a predictor for wound complications after AKA. The relationship between females and wound complication is still researchable.

Greenblatt *et al.* [8] had a high rate of perioperative complications after major amputation in their study, whereas according to our study, 66.7% of the stumps recovered without complications.

Wound occurrence was defined as wound dehiscence. Superficial and deep surgical site infections were defined as the primary endpoints. Yamotoo *et al.* [9]

determined in a prospective cohort (234 amputations for peripheral arterial disease or diabetes mellitus) a stump infection rate of 42% for AKAs and 23% for BKAs. In this study, 77 patients had a previous bypass procedure, 53 (66.3%) patients had clean wounds, and 24 patients had stump infections.

In this study, the wound complication rate was 33.3% overall ($n=40$), with 50% in AKA ($n=20$), and 50% in BKA ($n=20$). Of 40 cases of wound dehiscence, 13 (32.5%) required conversion to a higher-level amputation and 20 (50%) required revision.

In a review of Persiani *et al.* [10], 20% of transtibial amputation, 22% of disarticulation of the knee, and 8% of the transfemoral amputations had revisioned or underwent a reamputation. Other studies suggest that the primary healing of BKAs varies between 30 and 92% and that the number of reamputations varies between 4 and 30% [11]. In a review of Van Niekreck *et al.* [12], the postoperative complications rate was 20% with a reamputation rate of 6.4%.

In this study, diabetes mellitus had no significant risk factors for wound complication after major amputation. In a review of Karam *et al.* [13], diabetes mellitus was associated with a high risk of major amputation.

The 30-day mortality rates after major amputation range from 4 to 22%. Factors such as age, cardiac disease, and cerebrovascular disease were reliable to be assessed [14].

In this study, a low serum albumin concentration, elevated WBC count, cerebrovascular disease, and congestive heart failure were significant factors for 30-day mortality. No reports have explained the relationship between the serum albumin level and 30-day mortality after major amputation in patients with PAD. However, Morisaki *et al.* [15] found that the low serum albumin level was associated with 30-day mortality in patients who underwent major amputation.

In this study, 30-day mortality was 35 (29.2%) patients (10.83% for patients after BKA and 18.3% following AKA). Significant independent predictors of mortality following BKA and AKA included several severe comorbid conditions.

Meltzer *et al.* [16] have cited that age above 75 years, prior amputation or revascularization, hemodialysis, severe cardiac disease, recent angina within the last 1 month or myocardial infarction within the last 6

months, and history of an emergency operation were risk factors.

Conclusion

Wound complications are considered to be a big problem in patients undergoing major amputations because of peripheral vascular diseases. Some predictors significantly increase the risks of delayed recovery for such patients. For BKA, the predictive factors were greater than or equal to 55-year-old group, smokers, patients with elevated WBCs, and patients on dialysis proved to be predictive, and for AKA, the predictive factors were low serum albumin level, patients with high WBCs, and patients with dialysis dependence. A low serum albumin level, high WBCs, end-stage renal disease, cerebrovascular disease, and congestive heart failure were risk factors for 30-day mortality after major amputation.

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Conflicts of interest

There are no conflict of interest.

References

- Westin GG, Armstrong EJ, Bang H, Khung Kyong YEO, David Anderson, David L, *et al.* Association between statin medications and mortality, major adverse cardiovascular event, and amputation-free survival in patients with critical limb ischemia. *J Am Coll Cardiol* 2014; 63:682–690.
- Mustapha JA., Saab FA, Martinsen BJ., Behrens AN., Montero-Baker MF., Wiechmann BN, *et al.* Orbital atherectomy treatment of peripheral artery disease and critical limb ischemia. *JCLI* 2021; 8.
- Moustafa JA., Katzen BT, Nevelli RF, Lokestein RA, Ziller T, Miller L, Jaff MR. Determinants of long term outcomes and costs in the management of critical limb ischemia: a population-based cohort study. *Journal of American Heart Association* 2018; 7:e009724.
- Kollosvary E, Ferenci T, Kovats T, Kovacs L, Jarai Z, Menehey J, Farkas K. Trends in major lower limb amputation related to peripheral arterial disease in Hungary. A nationwide study (2004-2012). *European Journal of vascular and endovascular surgery* 2015; 50:78–85.
- Belmont PJ, Davey S, Orr JD, Ochoa LM, Bader JO, Schoenfeld AJ. Risk factors for 30-day postoperative complications and mortality after below-knee amputation: a study of 2,911 patients from the national surgical quality improvement program. *J Am Coll Surg* 2011; 213:370–378.
- Kolossváry E, Ferenci T, Kovats T, Kovacs L. Trends in major lower limb amputation related to peripheral arterial disease in Hungary: A Nationwide Study (2004-2012). *Eur J Vasc Endovasc Surg* 2015; 50:78–85.
- Conte MS, Brabbury AW, Kolh P, White JV. Global vascular guidelines in the management of chronic limb threatening ischemia. *European Journal of vascular and endovascular surgery* 2019; 58(S1):S109 e33.
- Greenblatt DY, Rajamanickam V, Mell MW. Predictors of surgical site infection after open lower extremity revascularization. *J Vasc Surg* 2011; 54:433–439.
- Yamamoto JN, Sakashita H, Miyama N, Takai K, Komai H. Evaluation of perfusion index as a screening tool for developing critical limb ischemia. *Annals of Vascular diseases* 2021; 14:328–333.
- Persiani F, Filippi F, D'Andrea A, Dito R, Felcarell R, Panzera C, *et al.* Complications and mortality after major amputation in patients with critical limb ischemia: a single center experience. *Clin Res Foot Ankle* 2019; 7:1.
- Dillingham TR, Pezzin LE, Shore AD. Reamputation, mortality, and health care costs among persons with dysvascular lower-limb amputations. *Arch Phys Med Rehabil* 2005; 86:480–486.

12. Van Niekerk LJ, Stewart CP, Jain AS. Major lower limb amputation following failed infrainguinal vascular bypass surgery: a prospective study on amputation levels and stump complications. *Prosthetics and Orthotics international journal* 2009; 25:29–33.
13. Karam J, Shepard A, Rubinfeld I. Predictors of operative mortality following major lower extremity amputations using the national surgical quality improvement program public-use data. *J Vasc Surg* 2013 58:1276–1282.
14. Van Netten JJ, Fortington LV, Hinchliffe RJ, Hijmans JM, *et al*. Early post-operative mortality after major lower limb amputation: a systematic review of population and regional based studies. *Eur J Vasc Endovasc Surg* 2016; 51:248–258.
15. Morisaki K, Yamaoka T, Iwasa K. Risk factors for wound complications and 30-day mortality after major lower limb amputations in patients with peripheral arterial disease. *SAGE Journals, Vascular* 2017; 26:12–17.
16. Meltzer AJ, Graham A, Connolly PH, Meitzer EC, Karowoski JK, Bush HL, Schnider DB. The Comprehensive Risk Assessment for Bypass (CRAB) facilitates efficient perioperative risk assessment for patients with critical limb ischemia. *J Vasc Surg*, 2013; 57: 1186–1195.