Predictors and Risk Factors of Wound Complications in Diabetic Patients Post Lower Limb Amputation: A Prospective Study

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Introduction: Despite advances in limb-salvage surgery, lower extremity amputation is still commonly required as an end result of the progression of arterial occlusive disease or failed arterial reconstruction. Furthermore, the increasing prevalence of diabetes has led to the appearance of more patients with foot complications leading to eventual lower extremity amputation.

Aim of work: To investigate the predictors and risk factors associated with wound complications after lower limb amputations in diabetic patients.

Patients and methods: This is a prospective study, in which we follow up diabetic patients who went for lower limb amputation (AKA or BKA) and record the incidence of post operative wound complications. The study included 30 diabetic patients undergoing lower limb amputation in Ain Shams University hospitals, with postoperative follow up for 24 weeks, and the outcome measured is the incidence of post operative complication in relation to preoperative risk factors and predictors.

Results: Regarding the comparison between AKA and BKA it was found that patients who had BKA had higher rates of superficial SSI which were statistically significant (P<0.05). While patients who had AKA had higher rates of pneumonia andmortality but not statistically significant (P>0.05). Wound disruption, pulmonary embolism and MI were higher in patients who had BKA but was not statistically significant (P>0.05). Regarding assessing predictors and risk factors for assessing post operative complications it was found that female gender, smoking and obesity (BMI >30) was statistically significant in assessing the risk factors (P value <0.05). Also regarding other predictors and risk factors of postoperative complication after the end of the study duration it was found that HGb (Anemia), Hct, ESR and CRP are considered predicators (P-value < 0.05). Other factors such as preoperative sepsis, emergency status and presence of infection were strongly related to post operative complication P-value 0.003 each (P-value < 0.05).

Conclusion: Surgical site infections (SSIs) following lower extremity amputations (LEAs) are a major cause of patient morbidity and mortality. The objectives of this study were to investigate the incidence of SSI and risk factors associated with SSI after LEA in diabetic patients. This study found that below-the-knee amputation, smoking, obesity, emergency status, anemia, lower hematocrit and preoperative sepsis to be associated with SSIs. Obesity specifically exacerbates the risk of developing postoperative surgical site infections in patients undergoing above-the-knee but not below-the knee amputation surgery.

Key words: Diabetic patients, lower limb amputation, wound complications.

Introduction

The word amputation derives from the Latin amputare, which means cutting around.[1]

At the beginning of the 20th century, the majority of amputations resulted from the traumas of war. Since the Second World War, the resulting cause of amputation has changed. Today the majority of amputations are due to vascular insufficiency and not trauma.[1]

Lower extremity amputation is one of the oldest and most commonly performed surgical procedures and yet has undergone very few modifications since its inception. Despite advances in limb-salvage surgery, lower extremity amputation is still commonly required as an end result of the progression of arterial occlusive disease or failed arterial reconstruction. Furthermore, the increasing prevalence of diabetes has led to the appearance of more patients with foot complications leading to eventual lower extremity amputation.[2]

Major lower extremity amputations continue to be part of all vascular practices, despite the general approach of aggressively attempting to salvage limbs. Though often viewed as a failure of treatment, major amputation should be considered reconstructive, when possible, and a definitive treatment option. The convergence of several important factors, including the increased life expectancy of the population and the epidemics of diabetes and peripheral arterial disease (PAD), suggests that amputations will remain an important issue facing patients and surgeons. The goal of amputation is to remove all infected, gangrenous, and ischemic tissue and provide the patient with the longest functional limb. Avoidance of repeated

DOI: 10.21608/ASJS.2024.351421

amputations and provision of uncomplicated healing of operative sites are crucial for the patient's optimal recovery and best functional rehabilitation or palliation.[3]

Surgical site infections (SSIs) remain a major cause of patient morbidity and mortality that also impose substantial financial burden on the healthcare system despite improvements in infection control techniques in surgical practice.[4]

Surgical site infections (SSIs) have been reported to be one of the most common causes of nosocomial infections; is accounting 20% to 25% of all nosocomial infections worldwide.[5]

SSIs have been responsible for the increasing cost; morbidity and mortality related to surgical operations and continue to be a major problem worldwide.[6]

Globally, surgical site infection rates have been reported to range from 2.5% to 41.9%.[7]

Patients with DM have 30 times greater lifetime risk of amputation compared to non-diabetics.[8] The 5-year and 10-year survival rates are 60% and 57% for above-knee amputees and 30% and 27% for below-knee amputees. Patients with diabetes had lower survival rates.[9] The majority of the lower extremity amputations are performed due to diabetes and its related complications.[10]

Lower extremity amputation is a surgical procedure entailing high rates of postoperative morbidity, with mortality reaching up to 16% in recent reports. Wound-related complications remain especially prominent following lower extremity amputations.[11] Diabetic patients are a particularly vulnerable population, with a higher incidence of amputations due to several indications including critical limb ischemia, diabetic foot ulcers, and gangrene.[12] In this population, SSIs not only increase the risk for mortality, but also can lead to impaired wound healing and consequently complications in prosthesis fitting.[13] This impairs the functionality of amputees and increases their dependency, which further increases long term mortality.[14] Previous studies have shown an association between different preoperative factors and increased incidence of SSIs in major non-cardiac surgeries.[15] In LEA studies, factors such as level of amputation, disposition, smoking, body mass index (BMI), and age were found to be associated with occurrence of SSI.[16]

Aim of work

The aim of this study is to investigate the predictors and risk factors associated with wound complications after lower limb amputations in diabetic patients.

Patients and methods

This is a prospective study, in which we follow up diabetic patients who went for lower limb amputation (AKA or BKA) and record the incidence of post operative wound complications. The study included 30 diabetic patients undergoing lower limb amputation in Ain Shams University hospitals, with postoperative follow up for 24 weeks, and the outcome measured is the incidence of post operative complication in relation to preoperative risk factors and predictors.

Diabetic patients of both genders aged more than 18years old, with type 1 and 2 diabetes, adequate tissue perfusion defined as ankle/brachial index between 0.7 and 1.2., or palpable distal pedal pulses and resistant diabetic foot ulcer to conservative dressings therapy were included in the study. While patients with ankle-brachial pressure index <0.5, traumatic amputations, tumor induced ulcer and patients refused to participate in the study were excluded from the study.

All patients who met those criteria accepted to sign consent for this study and proceeded to following measures.

Full detailed clinical history was taken from all patients: Personal history including habits of medical importance eg: smoking. Clinical history including the evaluation of cardiovascular risk factors and comorbidities. Different comorbidities: diabetes mellitus, hypertension, dyslipidaemia, renal impairment, cerebrovascular disease and any other medical illnesses. Detailed drug history: all daily medications in details. Surgical history: all previous surgeries, especially previous debridement or minor amputations.

Clinical examination was performed to all patients: General examination including patients' decubitus i.e. orthopnoea, chest condition i.e. dyspnea, presence of any disability or previous lost or amputated limb, presence of pallor or tachycardia Proper examination and assessment of affected foot to confirm non-salvageability and need for lower limb amputation and then level of amputation decided by pulse examination and ABI.

Routine preoperative laboratories were ordered for all patients: Kidney function tests, liver function tests, full blood count to exclude anemia, coagulation profile (INR and aPTT), and serum albumin.

Preoperative general investigation was ordered for all patients: ECG and ECHO for cardiac patients to assess the cardiac condition, pulmonary function test for COPD patients and thyroid profile for hypothyroid patients.

Operative technique: All amputations were performed by general and vascular surgery consultants and specialists in Ain Shams university

hospitals. All amputations were done either if BKA using the long posterior myocutaneous flap technique or AKA using anterior and posterior skin flaps for a fishmouth type closure the a Redivac suction drain was placed in all stumps and was removed 48 hours after operation if there was minimal output. Wound closure was performed in layers with a vertical mattress technique using non-absorbable sutures, which were routinely removed on postoperative day 14 if there was no surgical site infection.

Postoperative care: all patients were informed to do wound dressing with betadine every other day, and adequate broad spectrum antibiotics were prescribed for all patients. Instructions for follow up were given.

Follow up: Patients were followed up for 24 weeks, and the outcomes were healing or presence of post operative complication (Superficial SSI, deep SSI or wound deheince) or deterioration of general health due to incidence of new insults postoperative (MI, pneumonia, pulmonary embolism). Amputations complicated by wound necrosis or severe infection, leading to subsequent above knee amputation; will be classified as "failed healing".[17]

Results

The study plan was accepted by the Ethical Committee of Ain Shams University Hospitals, and it was held at Ain Shams University Hospitals. All patients included in the study signed an informed consent form. The study was conducted on 30 patients, 20 females (66.7) and 10 males (33.3%), the age ranged between 41 years and 75 years with mean age of 59.57 years ± 9.89 SD. The amputation was below the knee in 20 patients (66.7%) and above the knee in 10 patients (33.3%). Out of the 10 AKA 2 patients needed debridment (20%) and out of the 20 BKA 7 patients needed debridment (35%). Out of the 20 patient of BKA 3 patients needed to raise the level of amputation (15%). Of this sample (n=30) we had 24 smokers (80%) and 6 non-smokers (20%). Regarding obesity we had 21 were obese (70%) (BMI >30) and 6 not obese (30%). Their recoded preoperative labs were as follows: Hb mean of 10.66 ± 1.44, Hct range 35.18 ± 3.78, TLC mean of 12.23 ± 3.71, ESR median of 60 (20 – 84) and CRP median of 8 (2 – 15).

The overall 6 months postoperative mortality was 10% (n= 3). The incidence of postoperative myocardial infarction were 13.3% (n= 4), while the postoperative renal failure rate was 10% (n = 3). Superficial, deep, and organ space SSI rates were 60% (n= 18), 26.7% (n= 8), and 6.7% (n= 2) respectively. The incidence of wound disruption was 10% (n= 3), Pneumonia 16.7% (n= 5) and pulmonary embolism 3.3% (n= 1). The incidence of renal failure was 10% (n= 3).

Regarding the comparison between AKA and BKA it was found that patients who had BKA had higher rates of superficial SSI which were statistically significant (P<0.05). While patients who had AKA had higher rates of pneumonia andmortality but not statistically significant (P>0.05). Wound disruption, pulmonary embolism and MI were higher in patients who had BKA but was not statistically significant (P>0.05).

Regarding assessing predictors and risk factors for assessing post operative complications it was found that female gender, smoking and obesity (BMI >30) was statistically significant in assessing the risk factors. (P value <0.05).

Also regarding other predictors and risk factors of postoperative complication after the end of the study duration it was found that HGb (Anemia), Hct, ESR and CRP are considered predicators (P-value < 0.05),. Other factors such as preoperative sepsis, emergency status and presence of infection were strongly related to post operative complication P-value 0.003 each (P-value < 0.05).

At the end of the study it was found that risk factors for assessing post operative wound complications include level of amputation BKA as opposed to AKA (P value 0.036) {OR 12.667, CI 1.177 to 136.283}, female gender (P value 0.036) {OR 12.667, CI 1.177 to 136.283}, obesity (BMI>30) (P value 0.024) { OR 16, CI 1.451 to 176.451}, smoking (P value 0.029) {OR 11, CI 1.271 to 95.178}, emergency status (P value 0.014) {OR 21, CI 1.834 to 240.515}, presence of infection (P value 0.014) {OR 21, CI 1.834 to 240.515} and preoperative sepsis (P value 0.014) {OR 21, CI 1.834 to 240.515}. Also some laboratory markers were considered risk factors and were statistically significant such as HB level (P value 0.004) {OR 46, CI 3.33 to 634.883), hematocrit level (P value 0.003) {OR 96, CI 4.94 to 1865.699), ESR (P value 0.004) {OR 46, CI 3.333 to 634.883) and CRP (P value 0.014) {OR 21, CI 1.834 to 240.515).

Table 1: Demographic data and characteristics of the studied patients

		No. = 30
AKA/BKA	AKA	10 (33.3%)
	BKA	20 (66.7%)
Demographics		
Sex	Male	10 (33.3%)
	Female	20 (66.7%)
Age	Mean ± SD	59.57 ± 9.89
	Range	41 – 75
Obesity	No	9 (30.0%)
	Yes	21 (70.0%)
Smoking	No	6 (20.0%)
	Yes	24 (80.0%)
Cigarettes/d	Median (IQR)	30 (20 – 40)
	Range	10 – 60
COPD	No	19 (63.3%)
	Yes	11 (36.7%)
DM	No	0 (0.0%)
	Yes	30 (100.0%)
HTN	No	10 (33.3%)
	Yes	20 (66.7%)
IHD	No	14 (46.7%)
	Yes	16 (53.3%)
History of stroke	No	25 (83.3%)
	Yes	5 (16.7%)
CKD	No	27 (90.0%)
	Yes	3 (10.0%)
Osteomyelitis	No	25 (83.3%)
	Yes	5 (16.7%)

Table 2: Initial labs among the studied patients

Initial labs		No. = 30
HGB	Mean ± SD	10.66 ± 1.44
	Range	9 – 13.5
Hematocrit	Mean ± SD	35.18 ± 3.78
	Range	30 – 43
TLC	Mean ± SD	12.23 ± 3.71
	Range	6 – 20
PLT	Median (IQR)	338 (248 – 405)
	Range	169 – 599
CRP	Median (IQR)	8 (2 – 15)
	Range	0.5 – 96
ESR	Median (IQR)	60 (20 – 84)
	Range	12 – 140
HbA1c	Mean ± SD	8.50 ± 1.82
	Range	5.6 – 13.1
Creat	Mean ± SD	1.03 ± 0.35
	Range	0.6 – 1.9
Alb	Mean ± SD	3.35 ± 0.47
	Range	2.6 – 4.4
INR	Mean ± SD	1.13 ± 0.11
	Range	0.9 – 1.33

Table 3: Follow-up of postoperative complications among the studied patients

		1 week	2 weeks	3 weeks	4 weeks	8 weeks	12 weeks	24 weeks
Superficical SSI	No	19 (63.3%)	16 (53.3%)	14 (46.7%)	12 (40.0%)	12 (40.0%)	12 (40.0%)	12 (40.0%)
	Yes	11 (36.7%)	14 (46.7%)	16 (53.3%)	18 (60.0%)	18 (60.0%)	18 (60.0%)	18 (60.0%)
Deep SSI	No	27 (90.0%)	25 (83.3%)	24 (80.0%)	22 (73.3%)	22 (73.3%)	22 (73.3%)	22 (73.3%)
	Yes	3 (10.0%)	5 (16.7%)	6 (20.0%)	8 (26.7%)	8 (26.7%)	8 (26.7%)	8 (26.7%)
Organ spaced SSI	No	29 (96.7%)	29 (96.7%)	28 (93.3%)	28 (93.3%)	28 (93.3%)	28 (93.3%)	28 (93.3%)
	Yes	1 (3.3%)	1 (3.3%)	2 (6.7%)	2 (6.7%)	2 (6.7%)	2 (6.7%)	2 (6.7%)
Wound disruption	No	29 (96.7%)	29 (96.7%)	29 (96.7%)	28 (93.3%)	27 (90.0%)	28 (93.3%)	28 (93.3%)
	Yes	1 (3.3%)	1 (3.3%)	1 (3.3%)	2 (6.7%)	3 (10.0%)	2 (6.7%)	2 (6.7%)
Pneumonia	No	29 (96.7%)	29 (96.7%)	29 (96.7%)	28 (93.3%)	27 (90.0%)	26 (86.7%)	25 (83.3%)
	Yes	1 (3.3%)	1 (3.3%)	1 (3.3%)	2 (6.7%)	3 (10.0%)	4 (13.3%)	5 (16.7%)
Pulmonary embolism	No	30 (100.0%)	30 (100.0%)	30 (100.0%)	29 (96.7%)	29 (96.7%)	29 (96.7%)	29 (96.7%)
	Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (3.3%)	1 (3.3%)	1 (3.3%)	1 (3.3%)
Myocardial infarction	No	30 (100.0%)	30 (100.0%)	29 (96.7%)	28 (93.3%)	28 (93.3%)	27 (90.0%)	26 (86.7%)
	Yes	0 (0.0%)	0 (0.0%)	1 (3.3%)	2 (6.7%)	2 (6.7%)	3 (10.0%)	4 (13.3%)
Debridment needed	No	27 (90.0%)	25 (83.3%)	23 (76.7%)	21 (70.0%)	21 (70.0%)	21 (70.0%)	21 (70.0%)
	Yes	3 (10.0%)	5 (16.7%)	7 (23.3%)	9 (30.0%)	9 (30.0%)	9 (30.0%)	9 (30.0%)
Higher level of amputation needed	No	29 (96.7%)	28 (93.3%)	28 (93.3%)	27 (90.0%)	27 (90.0%)	27 (90.0%)	27 (90.0%)
	Yes	1 (3.3%)	2 (6.7%)	2 (6.7%)	3 (10.0%)	3 (10.0%)	3 (10.0%)	3 (10.0%)
Death	No	29 (96.7%)	29 (96.7%)	29 (96.7%)	28 (93.3%)	28 (93.3%)	28 (93.3%)	27 (90.0%)
	Yes	1 (3.3%)	1 (3.3%)	1 (3.3%)	2 (6.7%)	2 (6.7%)	2 (6.7%)	3 (10.0%)

Table 4: Comparison between AKA and BKA groups regarding follow up at the end of the study (After 24 weeks)

	AKA		BKA		Test value	P-value	Sig.
	No. = 10		No. = 20				
SuperficicalSSI	3	30.0%	15	75.0%	5.625	0.017	S
Deep SSI	4	40.0%	4	20.0%	1.364	0.243	NS
Organ spaced SSI	2	20.0%	0	0.0%	4.286	0.038	S
Wound disruption	0	0.0%	2	10.0%	1.071	0.301	NS
Pneumonia	3	30.0%	2	10.0%	0.120	0.729	NS
Pulmonary embolism	0	0.0%	1	5.0%	0.517	0.472	NS
Myocardial infarction	0	0.0%	4	20.0%	2.308	0.129	NS
Debridment needed	2	20.0%	7	35.0%	0.714	0.398	NS
Higher level of amputation needed	0	0.0%	3	15.0%	1.667	0.197	NS
Death	2	10.0%	1	10.0%	0.000	1.000	NS

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.

*: Chi-square test.

Table 5: Relation of occurrence of complications with demographic data and risk factors of the studied patients

		Non-complicated	Complicated	Test value	P-value	Sig.
		No. = 5	No. = 25			
AKA/BKA	AKA	4 (80.0%)	6 (24.0%)	5.880*	0.015	S
	BKA	1 (20.0%)	19 (76.0%)			
Demographics						
Age	Mean ± SD	59.20 ± 10.99	59.64 ± 9.91	-0.089•	0.930	NS
	Range	48 – 72	41 – 75			
Sex	Male	4 (80.0%)	7 (28.0%)	4.852*	0.028	S
	Female	1 (20.0%)	18 (72.0%)			
Obesity	No	4 (80.0%)	8 (32.0%)	4.000*	0.046	S
	Yes	1 (20.0%)	17 (68.0%)			
Smoking	No	3 (60.0%)	4 (16.0%)	4.509*	0.034	S
	Yes	2 (40.0%)	21 (84.0%)			
Cigarettes/d	Median (IQR)	30 (10 – 40)	25 (20 – 40)	-0.363≠	0.717	NS
	Range	10 – 40	10 – 60			
COPD	No	3 (60.0%)	16 (64.0%)	0.029*	0.865	NS
	Yes	2 (40.0%)	9 (36.0%)			
DM	No	0 (0.0%)	0 (0.0%)	–	–	–
	Yes	5 (100.0%)	25 (100.0%)			
HTN	No	2 (40.0%)	8 (32.0%)	0.120*	0.729	NS
	Yes	3 (60.0%)	17 (68.0%)			
IHD	No	3 (60.0%)	11 (44.0%)	0.429*	0.513	NS
	Yes	2 (40.0%)	14 (56.0%)			
History of stroke	No	4 (80.0%)	21 (84.0%)	0.048*	0.827	NS
	Yes	1 (20.0%)	4 (16.0%)			
CKD	No	4 (80.0%)	23 (92.0%)	0.667*	0.414	NS
	Yes	1 (20.0%)	2 (8.0%)			
Osteomyelitis	No	4 (80.0%)	21 (84.0%)	0.048*	0.827	NS
	Yes	1 (20.0%)	4 (16.0%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.

*: Chi-square test; •: Independent t-test; ≠: Mann-Whitney test.

Table 6: Relation of occurrence of complications with initial laboratory parameters of the studied patients

Initial labs		Non-complicated	Complicated	Test value	P-value	Sig.
		No. = 5	No. = 25			
HGB	Mean ± SD	12.26 ± 1.43	10.34 ± 1.23	3.100•	0.004	HS
	Range	9.8 – 13.5	9 – 13.5			
Hematocrit	Mean ± SD	39.8 ± 4.49	34.26 ± 2.93	3.536•	0.001	HS
	Range	32 – 43	30 – 41			
TLC	Mean ± SD	9.30 ± 1.53	12.82 ± 3.75	-2.041•	0.051	NS
	Range	6.9 – 11	6 – 20			
PLT	Median (IQR)	248 (227 – 360)	341 (300 – 405)	-0.891≠	0.373	NS
	Range	190 – 420	169 – 599			
CRP	Median (IQR)	1.2 (1 – 2)	8 (6 – 18)	-2.180≠	0.029	S
	Range	0.9 – 8	0.5 – 96			
ESR	Median (IQR)	17 (15 – 19)	60 (50 – 85)	-2.796≠	0.005	HS
	Range	13 – 50	12 – 140			
HbA1c	Mean ± SD	7.52 ± 1.29	8.69 ± 1.87	-1.334•	0.193	NS
	Range	5.6 – 9	6.5 – 13.1			
Creat	Mean ± SD	1.22 ± 0.44	0.99 ± 0.33	1.346•	0.189	NS
	Range	0.8 – 1.9	0.6 – 1.8			
Alb	Mean ± SD	3.48 ± 0.53	3.33 ± 0.47	0.654•	0.518	NS
	Range	2.9 – 4	2.6 – 4.4			
INR	Mean ± SD	1.19 ± 0.09	1.11 ± 0.11	1.340•	0.191	NS
	Range	1.1 – 1.33	0.9 – 1.3			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.

•: Independent t-test; ≠: Mann-Whitney test.

Table 7: Relation of occurrence of complications with clinical data of the studied patients

Clinical data		Non-complicated	Complicated	Test value	P-value	Sig.
		No. = 5	No. = 25			
Preoperative sepsis	No	4 (80.0%)	4 (16.0%)	8.727*	0.003	HS
	Yes	1 (20.0%)	21 (84.0%)			
Emergency status	No	4 (80.0%)	4 (16.0%)	8.727*	0.003	HS
	Yes	1 (20.0%)	21 (84.0%)			
Presence of infection	No	4 (80.0%)	4 (16.0%)	8.727*	0.003	HS
	Yes	1 (20.0%)	21 (84.0%)			
Presence of Ischemia	No	5 (100.0%)	23 (92.0%)	0.429*	0.513	NS
	Yes	0 (0.0%)	2 (8.0%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.

*: Chi-square test.

Table 8: Logistic regression analysis for factors associated with occurrence of complication after 24 weeks

	Univariate				Multivariate			
	P-value	Odds ratio (OR)	95% C.I. for OR		P-value	Odds ratio (OR)	95% C.I. for OR	
			Lower	Upper			Lower	Upper
CRP >2	0.014	21.000	1.834	240.515				
BKA	0.036	12.667	1.177	136.283				
Female gender	0.036	12.667	1.177	136.283				
Obesity	0.024	16.000	1.451	176.451				
Smoking	0.029	11.000	1.271	95.178				
HGB <= 12.2	0.004	46.000	3.333	634.883				
Hematocrit <= 39	0.003	96.000	4.940	1865.699				
ESR >19	0.004	46.000	3.333	634.883				
Preoperative sepsis	0.014	21.000	1.834	240.515				
Emergency status	0.014	21.000	1.834	240.515				
Presence of infection	0.014	21.000	1.834	240.515				

Discussion

Postoperative SSIs remain a substantial burden on everyday surgical care.[4]

Significant predictors of SSI following LEA included level of amputation, female sex, smoking, preoperative sepsis, emergency status, and obesity. The increased odds of SSI following BKA, as compared to AKA, could be explained by decreased blood perfusion to the more distal parts of the extremity. In addition, as suggested by Hasanadka et al., BKA is in close proximity to the infected foot in cases of gangrene, which tend to occur distally.[14] Moreover, the higher rates of hematoma in BKA makes it more susceptible to infection.[18]

Smoking was also found to be an independent predictor of SSI, consistent with previous studies.[19,20] Substances such as nicotine, nitric oxide, and carbon monoxide inhaled from smoking disrupt the endothelial lining of blood vessels and impair immune response, leading to delayed wound healing and increased susceptibility to infection.[21]

Emergency status and preoperative sepsis were also independently associated with the occurrence of SSI in LEA. Both conditions place the incision under high risk of infection due to suboptimal preoperative preparation and the increased presence of the infecting organism in the body.

Consistent with previous studies, we found that the risk of developing a SSI increases in a stepwise manner with obesity.[22,23]

The etiology of wound complications in obese individuals is multifactorial, involving both local and systemic factors. Locally, factors contributing to poor wound healing include the relative hypo-vascularity of subcutaneous adipose tissue, which may also reduce antibiotic delivery and increase wound tension. Poor skin perfusion also makes obese individuals susceptible to pressure-induced injuries, which can be aggravated by difficulties in repositioning and increased shearing during movement.[24]

We also found that preoperative hematocrit level was directly proportional to the risk of developing an SSI: as the severity of anemia increased, the odds of developing SSI increased. This proves the hypothesis that lower hematocrit levels would cause decreased tissue oxygenation and hence impede wound healing leading to a higher infection rate. In fact, a study that investigated the relationship between hematocrit and gangrene in BKAs found that higher hematocrit was in fact associated with increased risk for insipidus gangrene.[23] Another small study that assessed the predictors of healing after lower limb amputation surgery found that patients with hemoglobin >120 g/L (Normal) had a higher risk of wound healing failure compared to patients with hemoglobin <120 g/l.[26] These findings were attributed to one main theory, higher hematocrit is associated with an increase in blood viscosity which impedes oxygen delivery and inflammatory factors washout in the microvasculature, while lower hematocrit is a product of hemodilution which increases tissue perfusion and oxygen tension. In fact, a relatively high hematocrit is a known risk factor for tissue ischemia.[27]

Also, hemodilution has been shown to increase blood flow and decrease claudication in patients with peripheral arterial disease.[28] This effect was evident in the BKA group after sensitivity analysis. Perhaps this effect is mitigated in the more proximal AKAs with larger caliber vessels that are less

susceptible to occlusion, while accentuated in more distal amputations where much narrower vessels predominate.

Conclusion

Surgical site infections (SSIs) following lower extremity amputations (LEAs) are a major cause of patient morbidity and mortality. The objectives of this study were to investigate the incidence of SSI and risk factors associated with SSI after LEA in diabetic patients. This study found that below-the-knee amputation, smoking, obesity, emergency status, anemia, lower hematocrit and preoperative sepsis to be associated with SSIs. Obesity specifically exacerbates the risk of developing postoperative surgical site infections in patients undergoing above-the-knee but not below-the knee amputation surgery.

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