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An analysis of risk factors associated with traumatic extremity amputation stump wound infection in a Nigerian setting

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Abstract
Purpose We aimed to determine the risk factors associated with traumatic extremity amputation stump wound infection in our environment.
Method This was a retrospective analysis of databases that included the entire patient population with traumatic extremity amputation seen in Ebonyi State University Teaching Hospital and Federal Medical Centre Abakaliki from January 2001 to December 2011.
Result There were 63 patients studied and stump wound infection was a complication in 38 (60 %) of them. Stump wound infection rate significantly correlated with the form of amputation, i.e., a higher rate in crushing than guillotine (sharp clear-cut) amputation (80.5 vs. 22.7 % $p<0.000$); severity, i.e., a higher rate in major than minor amputation (80.6 vs. 33.3 % $p<0.000$); and limb involvement, i.e., a higher rate in lower than upper extremity amputation (71.1 vs. 60.7 % $p<0.002$). Haematocrit level on admission ($p<0.002$), injury to hospital admission interval ($p<0.012$) and injury to first surgical debridement / amputation interval ($p<0.02$) were all significantly related to incidence of wound infection. Multivariate analysis identified crushing amputation as an independent risk factor ($p<0.009$) for traumatic amputation stump wound infection.
Conclusion The only independent predictor of traumatic extremity amputation stump wound infection is a crushing form of amputation; it should be accorded a high priority in interventions aimed at reducing infection rate

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Introduction

Stump wound infection is a common complication following extremity amputation surgery. Wound infection increases the morbidity and mortality associated with amputation [4]. Severe stump wound infection is a common cause of failure of amputation and results in need for stump revision or re-amputation. This further surgical procedure exposes susceptible patients to the risk of operative surgical intervention and other serious complications [4, 9]. Extremity amputation is a common life-saving procedure in the management of victims of natural disasters and mass casualties with severely injured limbs [5, 6, 14, 19]. In natural disasters and mass casualties, a limited human and material resource is one of the challenges in providing medical care to the injured victims. This situation is compounded by the burden of morbidity associated with traumatic extremity amputation stump wound infection.

Wound infection rates ranging from 13 % to 48 % have been reported following amputation surgery necessitated by varying types of indication [1, 3, 11, 17]. Stump wound infection as high as 57 % has also been reported following traumatic extremity amputation [12]. Traumatic extremity amputation often occurs outside the hospital surgical theatre setting, thus the wound is prone to varying degrees of contamination and wound infection is an expected complication.

However, there is evidence in a previous study that wound infection is not a complication of all traumatic extremity amputation stumps [12]. This implies that besides wound contamination other factors contributing to wound sepsis come into play with traumatic extremity amputation stumps.

The aim of this study was to determine the risk factors in traumatic extremity amputation stump wound infection in our environment.

Materials and methods

This was an analysis of the retrospective databases of all the patients who presented in Ebonyi State University Teaching Hospital and Federal Medical Centre Abakaliki with traumatic extremity amputations from January 2001 to December 2011. With the approval of the hospital ethics and research committee, relevant information on population and injury characteristics, in addition to treatment related factors and outcome was extracted from case notes.

The patients were classified into five age groups (0–17, 18–39, 40–65 and >65 years) for data analysis. The relative humidity is high during the wet / rainy season (months of May to October) and low in the dry season (months of November to April) in Southeast Nigeria, which was the setting for this study. The patients were categorised into two groups (dry and wet) based on the season traumatic extremity amputation occurred. The patients were classified into two groups (PCV <30 % and≥30 %) based on their haematocrit measured within 24 hours of admission into the hospital. Smoking and non-smoking, in addition to presence or absence of co-morbid factors such as HIV infection, diabetes mellitus and immunosuppressive therapy were the other form of grouping of the population used in data analysis.

Traumatic extremity amputation was classified into three forms (sharp clear-cut / guillotine, crushing and avulsion) based on specific mechanism of injury. The aetiological factors involved in these mechanisms of injury were also included in the data on injury characteristics. Amputation injury was classified based on severity into major and minor amputation. Major amputation was defined as extremity severance at any level above the ankle in lower limb and the wrist in upper limb. Minor amputation was defined as preservation of at least part of the foot or hand. The limb involved in amputation injury was categorised into upper and lower extremity.

The interval between amputation injury and hospital admission was grouped into three categories (one to six, seven to 24 and over 24 hours) for analysis. An empirical antibiotic was administered to all the patients within the first hour of hospital admission. One of the following combinations of drugs was used at random: A [Ampiclox + Gentamycin + Metronidazole], B [Ciprofloxacin + Metronidazole] and C [Ceftriaxone + Metronidazole]. Antibiotics were adjusted as necessary based on the result of routine wound culture and antibiogram. The interval between amputation injury and first surgical debridement or formal amputation was also divided into three groups (<24, 25–48 and >48 hours) for analysis. The traumatic amputation was completed in the hospital surgical theatre setting during the first surgical debridment or formal amputation elected as close to the zone of injury which will leave the patient with a functional stump. Contaminants in the stump wound were removed as much as possible by thorough washing with copious quantity of normal saline. The provisional amputation stump wound at the end of the procedure was dressed daily in the surgical ward until it was good enough for delayed primary closure, skin grafting or refashioning of the stump.

The relevant outcome in this analysis was amputation stump wound infection. Stump wound infection was defined as documented evidence of purulent discharge, cellulitis or positive wound culture within three months of traumatic severance of the extremity. Patients were categorised into two groups (presence / absence of wound infection) based on this outcome.

Cases of trauma-related amputation without partial or complete severance of the extremity at the scene of injury, and cases of gangrene complicating poorly managed simple and open injuries of the extremity by orthodox medical practitioners or traditional bonesetters (bonesetters gangrene) were excluded from this study. Data analysis was carried out using Statistical Package for Social Sciences (SPSS) version 16 and Quantitative skills software (SISA tables) from SISA. A univariate analysis was carried out using SPSS and SISA tables. The significant variables ($p<0.05$) in the univariate analysis were entered into a stepwise logistic regression model for multivariate analysis using SPSS.

Results

There were 63 patients with traumatic extremity amputation and 38 (60 %) of them had stump wound infection.

Univariate analysis identified risk factors for stump wound infection (Tables 1, 2 and 3). Stump wound infection was significantly related to the severity of amputation; major amputations were associated with increased rate of infection compared to minor amputations (80.6 vs. 33.3 %, $p<0.000$). Wound infection rate was significantly higher in lower extremity amputations than upper extremity ones (71.1 vs. 60.7 % $p<0.002$). The form of amputation significantly correlated with incidence of wound infection; there was a higher rate of infection in crushing than guillotine (sharp clear-cut) amputations (80.5 vs. 22.7 % $p<0.000$). Wound infection rate was significantly related to the aetiology of amputation ($p<0.002$); 73.5 % of amputation stumps arising from road traffic accidents were infected. All of the amputation stump wounds from gunshot and collapse structures were infected whereas none of the machete injury related amputations were infected. There was significantly higher incidence of wound infection in patients who presented to the hospital after 24 hours of injury than the ones who presented within the first six hours (80.8 vs. 50.0 % $p<0.012$). The interval between injury and first surgical debridment significantly correlated with the

Table 1 Univariate analysis of amputation stump wound infection by population characteristics

Characteristic	Wound infection		Total (%)	χ^2	*p* value
	Yes (%)	No (%)			
Age					
0–17	6 (60.0)	4 (40.0)	10 (15.9)	4.234	0.237
18–39	20 (52.6)	18 (47.4)	38 (60.3)		
40–65	11 (84.6)	2 (15.4)	13 (20.6)		
>65	1 (50.0)	1 (50.0)	2 (03.2)		
Gender					
Male	29 (58.0)	21 (42.0)	50 (79.4)	0.544	0.461
Female	9 (69.2)	4 (30.8)	13 (20.6)		
Season					
Dry	14 (51.9)	13 (48.0)	27 (42.9)	1.415	0.234
Wet	24 (66.7)	12 (33.3)	36 (57.1)		
Haematocrit					
<30 %	27 (77.1)	8 (22.9)	35 (55.6)	9.314	0.002
≥30 %	11 (39.3)	17 (60.7)	28 (44.4)		
Smoking					
Yes	3 (100)	0 (00.0)	3 (04.8)	2.072	0.150
No	35 (58.3)	25 (41.7)	60 (95.2)		
HIV infection					
Negative	37 (59.7)	25 (40.3)	62 (98.4)	0.699	0.603
Positive	1 (100)	0 (0.00)	1 (01.6)		

incidence of stump wound infection; infection was more likely in patients who had surgical debridment later than 48 hours after injury than in those who had it within the first 24 hours (73 vs. 66 %; $p<0.02$). This interval was less than 24 hours in 23.8 % of the patients and later than 48 hours in 60.3 % of patients.

There was a significantly higher infection rate in patients whose haematocrit on admission was under

Table 2 Univariate analysis of amputation stump wound infection by injury characteristics

Characteristic	Wound infection		Total (%)	χ^2	*p* value
	Yes (%)	No (%)			
Aetiology					
Road traffic injury	25 (73.5)	9 (26.5)	34 (54.0)	21.054	0.002
Industrial machine injury	4 (44.4)	5 (55.6)	9 (14.3)		[a]0.004
Machete injury	0 (00.0)	7 (100)	7 (11.0)		
Explosives injury	3 (60.0)	2 (40.0)	5 (07.9)		
Gunshot	3 (100)	0 (00.0)	3 (04.8)		
Collapsed structures	3 (100)	0 (00.0)	3 (04.8)		
Door injury	0 (00.0)	2 (100)	2 (03.2)		
Form of amputation					
Crushing	33(80.5)	8 (19.5)	41 (65.1)	19.975	0.000
Guillotine (sharp cut)	5 (22.7)	17 (77.3)	22 (34.9)		
Severity					
Minor amputation	9 (33.3)	18 (66.7)	27 (42.9)	14.37	0.000
Major amputation	29 (80.6)	7 (22.9)	36 (57.1)		
Limb involvement					
Upper extremity	17 (60.7)	11 (39.3)	28 (44.4)	9.314	0.002
Lower extremity	27 (71.1)	8 (22.9)	35 (55.6)		

[a]Fisher's exact test *p* value

Table 3 Univariate analysis of amputation stump wound infection by intervention related factors

Characteristic	Wound infection		Total (%)	χ^2	*p* value
	Yes (%)	No (%)			
Injury to hospital interval					
1–6 h	15 (50.0)	15 (50.0)	30 (47.6)	8.825	0.012
7–24 h	2 (28.8)	5 (71.4)	7 (11.1)		
>48 h	21 (80.3)	5 (19.2)	26 (41.3)		
Injury–debridement interval					
<24 h	10 (66.7)	5 (33.3)	15 (23.8)	9.314	0.002
25–24 h	5 (50.0)	5 (50.0)	10 (15.9)		
>48 h	28 (73.7)	10 (26.3)	38 (60.3)		
Antibiotics					
A [ampiclox, gentamycin, metronidazole]	25 (58.1)	18 (41.9)	43 (68.3)	0.669	0.414
B [ciprofloxacin and metronidazole]	3 (50.0)	3 (50.0)	6 (9.5)		
C [ceftriaxone and metronidazole]	10 (71.4)	4 (28.6)	14 (22.2)		

30 % than in those with a haematocrit over 30 % (77.1 vs. 39.3 % $p<0.002$).

Wound infection rate was higher in females than males (69.2 vs. 58.0 %), in the wet than dry season (66.7vs. 51.9 %), in cigarette smokers than non-smokers (100 vs. 58.3 %) and in HIV infected patients (100 vs. 59.7 %), but the differences were not statistically significant. The highest rate of infection (84.6 %) occurred in patients between 40 and 65 years but the difference when compared to infection rate in other age groups was not significant ($p>0.237$) as shown in Table 1.

The significant variables identified in the univariate analysis were entered into a stepwise logistic equation to evaluate the risk of each factor when adjusted for other factors. The results are summarised in Table 4. The form of amputation (crushing amputation) was identified as the only independent risk factor ($p<0.009$) in traumatic extremity amputation stump wound infection.

Discussions

This study showed that risk factors other than expected wound contamination were involved in traumatic extremity amputation stump wound infection. In this study, the form of amputation based on specific mechanism of injury (crushing amputation) is the only independent risk factor in stump wound infection (Table 4). In crushing amputation, the zone of injury is wide with extensive soft tissue devitalisation whereas guillotine (sharp clear-cut) amputation is characterised by zone of injury limited to the site of traumatic severance and minimal tissue destruction [18]. The crushing mechanism of injury is also more likely to crush contaminants with the tissues, and wound infection is almost inevitable once necrosis of damaged muscles and other soft tissues in the zone of injury set in. Wound infection secondary to myonecrosis from inadequate first surgical debridment has been documented in a previous study as a common cause of failure following replantation in crushing amputation [15]. Therefore, a high priority should be given to crushing amputation in wound exploration to assess the extent of injury, thorough surgical debridment / lavage within the zone of injury and other interventions aimed at reducing the incidence of stump wound infection.

Although the crushing form of amputation was the only independent risk factor identified in this study, the other significantly associated factors especially the ones that are

Table 4 Multivariate analysis of risk factors in amputation stump wound infection: summary of logistic regression model

Factor	B	S.E.	Wald statistics	df	Sig (*p* value)	Exp B (estimated odds ratio)
Haematocrit	0.3604	0.8506	0.1795	1	0.6718	1.4339
Aetiology	−0.0182	0.2054	0.0078	1	0.9295	0.9820
Form of amputation	−2.0035	0.7679	6.8067	1	0.0091	0.1349
Severity of amputation	0.8450	1.0199	0.6865	1	0.4074	2.3280
Limb involvement	0.1289	0.9126	0.0199	1	0.8877	1.1375
I-H admission interval	0.0090	0.4805	0.0003	1	0.9851	0.9911
I-D interval	−0.7053	0.5672	1.5460	1	0.2137	0.4940
Constant	−0.5919	2.0245	0.0855	1	0.7700	

I-H injury to hospital, *I-D* injury to first surgical debridement/ amputation modifiable need to be highlighted. The time between injury and hospital admission was an identified risk factor ($p<$ 0.012) in univariate analysis. Twenty-six patients (41.3 %) presented more than 24 hours after injury (Table 1). Open fractures and traumatic amputation are in the clinical spectrum of open injuries of the extremity. In open fracture, reduction in wound infection rate by early initial antibiotics administration and wound debridment has been documented [2, 8, 13]. The prolonged interval between injury and presentation to hospital is potentially related to a delay in appropriate emergency trauma care (such as antibiotics administration and early wound care) especially in our setting where it has been documented in a previous study that there was no pre-hospital care given to over 80 % of patients with traumatic amputation [12]. The interval between injury and hospital admission is a modifiable risk factor. The reasons for the relatively late presentation observed in patients with traumatic amputation in our setting will require another study, and it is important for appropriate intervention aimed at shortening the interval between injury and hospital admission.

The injury to first surgical debridment interval is also a risk factor ($p<0.020$) associated with stump wound infection in this study. Infection was more likely when the injury to first surgical debridement/amputation interval was later than 48 hours as seen in 60.3 % of our patients (Table 3). Delay in surgical intervention in open injury of the extremity has been attributed to multiple factors that are patient- and system-related. “Patient factors include the presence of haemodynamic instability, associated injuries or medical complication, whereas system factors are time of arrival to definitive care centre, hospital efficiency and protocols for management, operative room and surgeon availability” [10]. Apart from the time of arrival to the hospital (later than 24 hours in 41.1 % of patients in Table 3), the extent of involvement of these factors in the delay of surgical intervention observed in this study is not evident; another study is required for its identification and appropriate intervention.

The significantly ($p<0.002$) higher incidence of stump wound infection in patients with haematocrit level less than 30 % on admission is expected because a previous study has demonstrated that tissue oxygen tension correlated inversely with the risk of surgical wound infection [7]. Haemoglobin amongst other factors (cardiac output, local perfusion, etc.) is known to influence tissue oxygenation and perfusion [16]. This underlines the need for prompt fluid and blood replacement in resuscitation of these patients to reduce the incidence of stump wound infection and its associated morbidity.

Although the number of patients in this study was relatively small and data analysed derived from a retrospective database, the result from logistic regression analysis is quite strong; crushing form of amputation was significantly and independently associated with stump wound infection. There are limited published studies on traumatic extremity amputation stump wound infection, and this is the first to determine the associated risk factors that can be used as a starting point for further research.

Conclusion

In traumatic extremity amputation, injury characteristics and aetiology, patient’s haematocrit level, timing of presentation and appropriate intervention are factors significantly associated with incidence of stump wound infection. However, crushing form of amputation being the only independent predictor of stump wound infection should be accorded a high priority in interventions aimed at reducing infection rate.

Conflict of interest The authors declare they have no conflicts of interest.

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