Prevalence and risk factors of gunshot wound infection in the Eastern Democratic Republic of the Congo: a hospital-based cross-sectional study

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Abstract

Background

Survivors of gunshot injury have a major risk of wound infection. The prevalence of gunshot wound infection rates in low-income countries various to a country from another. Overall, there are limited data on civilian gunshot wound infection and its predisposing factors. The aim of this study is to determine the prevalence of gunshot wound infection and associated risk factors in a tertiary hospital of eastern part of the Democratic Republic of the Congo (DRC).

Materials and methods

This was a retrospective analysis of data on the entire patients who presented in Provincial General Reference Hospital of Bukavu in the DRC with gunshot injury from January 1st 2019 to December 31, 2020.

Results

There were 549 patients, and wound infection was a complication in 26.6% of them. Multivariate logistic regression analysis identified fractures (adjusted odds ratio [aOR] = 1.81; 95% CI: 1.12–2.92; p = 0.0146), nerve damage (aOR = 2.65; 95% CI: 1.70–4.14; p < 0.0001), trunk (aOR = 5.64; 95% CI: 2.61–12.16; p < 0.0001), lower extremity (aOR = 2.71; 95% CI: 1.39–5.28; p = 0.0034), and multiple > 2 (aOR = 2.35; 95% CI: 1.05–5.25; p = 0.0378) as independent predictors of gunshot wound infection.

Conclusion

The independent predictors of gunshot wound infection identified in this study implied ajudicious assessment and a high priority accorded to trunk perforating wounds, fractures and vasculo-nervous damage in interventions aimed at reducing gunshot wound infection rate.

Introduction

Firearm violence is becoming more common in Eastern part of the Democratic Republic of the Congo and are associated with substantial morbidity, mortality, and socioeconomic consequences. Gunshot wounds (GSWs) vary depending in their mechanism of production or ballistic properties, the wounds site, the anatomical regions affected, the severity of the wound and the possible evolution of the affected organs. GSWs are subdivided into low velocity (< 1200 ft/sec) or high velocity (> 1200 ft/sec) injuries, depending on the causative firearm [1].

Six conflicts are in the Democratic Republic of Congo, and four of the six are based in the Eastern Democratic Republic of Congo. The two Kivu regions are home to the Kivu conflict. This complex sociopolitical context can be traced back to the colonial era with the tense relations between the indigenous Kivu population and neighboring Rwandans. [2].

The determinant of damage injury depends on energy that is transferred to soft tissues[3].GSWs are now a worldwide public health problem and it prevalence has undergone a major increase [4]. Many factors have influenced this growth, including family disintegration, unemployment, joining criminal groups when young, experiences with drugs and the uncontrolled diffusion of violent acts in the mass media, nation’sconflict as well as the fact that weapons are easier to acquire [5].

During war time, survivors have a high risk of wound infection, a complication that occur in short and long-term morbidity and mortality associated with firearm injuries [6];the risk of infection in firearm injury is high with introduction of contaminants and microorganisms at the time of initial wound contamination and during hospital care [7].

In recent publications, in war trauma setting, incidence of infectious complications of all firearm injuries involved range from 11 to 40% irrespective anatomical body region affected [8–11]. In high-income countries, in civilian trauma setting, the infection rate ranges from 1.5 to 11.6% [12–14], and 6.5 to 63.2% is the incidence founded in recent published report in low-income countries [14–18].

The majority of published paper on descriptions of gunshot wound infections were based on experience of single centers and studies derived from management of patient with gunshot injuries [4, 14, 17]. There’s a significant difference in practice on firearm injury in war trauma setting and civilian trauma in many aspects of management [8].

There are limited data on firearm wound infection and its associated risk factors trauma setting; theknowledge about the risk factors of infection in gunshot wound will allow interventions aimed at prevention and reach a safe care of patients.

The purpose of this study was to determine the prevalence of gunshot wound infection and to identify its associated risk factors in a single center of eastern part of the Democratic Republic of the Congo.

Materials and methods

This was a cross-sectional study conducted on all the patients who presented in Provincial General Reference Hospital in Bukavu (in the South Kivu Province, in the eastern part of the Democratic Republic of the Congo [Figure 1])with firearm injuries from January 1st 2019 to December 31 2020.Bukavu, the capital of South Kivu province in the Eastern Democratic Republic of the Congo, serves as a vital healthcare hub for the region, notably housing the Provincial General Reference Hospital. This hospital stands as the primary facility equipped and staffed to handle firearm-related injuries, drawing patients from across the province and surrounding areas. Situated in a region plagued by armed conflict and violence, this hospital plays a critical role in providing emergency medical care to individuals affected by gunshot wounds. Given its status as the sole institution capable of managing such injuries effectively, it serves as a lifeline for countless individuals in need of urgent medical attention, highlighting its indispensable role in the local healthcare infrastructure.

With the approval of the hospital ethics and research committee, relevant information on population, firearm weapon and injury characteristics, in addition to intervention-related factors and outcome, was retrieved retrospectively from patients' hospital records.

For statistical analysis, the patients were classified into five age groups (0–20 years, 20–29 years, 30–39 years, 40–49 years, and ≥ 50 years), and gender (male or female). The clinical, radiological, and intra operative findings were documented in the case notes. Pre-hospital care in this study was defined as care (at the scene, during transport, primary health facility, home, patent medicine store) given to the patient prior to presentation to trauma center. For data analysis, the anatomical region was categorized into head and neck, trunk (chest, abdomen, pelvis, and perineum), upper extremity, lower extremity, and multiple (injury involving two or more regions).

We define some variables:

Injury-hospital care: time interval between injury and admission to the referral hospital.

Pre-hospital care: Yes, if the patient was treated in another peripheral structure before transfer to the reference hospital.

Shock index: the heart rate divided by systolic blood pressure.

Injury severity score (ISS): a medical score to assess trauma severity.

Wound infection, the relevant outcome in this analysis, was defined as documented evidence of purulent discharge, cellulitis or positive wound culture within 3 months of injury. Based on this outcome, patients were classified into two categories (absence and presence of wound infection).

Patients presenting to the hospital with firearm injuries were received in the emergency room for resuscitation (ATLS protocol), initial wound care, empirical administration of antibiotics, and tetanus toxoid. Antibiotics were adjusted as necessary based on result of routine wound culture and antibiogram when done. All the patients had clinical assessment, management through irrigation of wound with normal saline, and dressing with sterile gauze and bandage. All patients with simple wounds, complex contaminated perforating and penetrating wound underwent wound exploration, judicious surgical debridement, and wound irrigation with adequate amount of normal saline.

The open woundwas inspected after 24 hours; thereafter, it was closed or dressed daily in the surgical ward with normal saline solution until it was clean and good enough for secondary closure or split skin grafting. The protocol in management of open fracture was applied in the treatment of associated fractures. The fractures were basically immobilized using external fixators. The protocol in the management of abdominal injury was selective conservative treatment in hemodynamically stable patients with minimal abdominal signs and no violation of peritoneal cavity while laparotomy was undertaken in those presenting with acute abdomen, peritonitis, visceral perforation, evisceration, andhemodynamic instability. The exit and entrance wounds were closed by delayed primary or secondary closure or by skin graft.

All gunshot casualties who were treated, discharged and followed up for 3 months or had wound infection prior to self-discharge against medical advice or death were included in this analysis. The casualties brought in dead- or dead-on arrival, and those without wound infection prior to self-discharge against medical advice were excluded.

Data analysis was carried out using STATA version 16. Significant variables derived from bivariate analysis were entered into multivariate analysis in a stepwise logistic regression to evaluate the risk of each factor when adjusted for other factors. In all the analysis, p value < 0.05 was considered statistically significant.

Results

During the period under study, a total of 549 patients with gunshot injuries were enrolled giving a mean of 275 gunshot injuries annually.

The gunshot wound infection rate was 26.6%.

There were 463 (84.34%) males and females were 86 (15.66%) with a male to female ratio of 5.38:1. The age ranged from 1 to 77 years, with a mean of 32.36 ± 13.74 years (Table 1).

The highest number of cases (*n* = 417; 75.96%) comes from rural areas near Bukavu city.

The injury profile shown that lower extremity was most commonly affected (*n* = 230) and mostly treated surgically. The next most commonly affected regions were the trunk (chest/abdomen)(*n* = 98). There was none with HIV infection, diabetes mellitus or immunosuppressive therapy as co-morbidity.The incidence of wound infection was related to the anatomical site of injury (p = 0.001), the highest rate of infection (38,78%) in the trunk and the lower (13,54%) in upper extremity (Table 1).

The injury characteristics in correlation with wound infectionin univariate analysis are the injury severity score (p = 0.0125), presence of fracture (p = 0.002), vascular and nerve damage (p < 0.0001)(Table 2).

Furthermore, intervention-related factors are associated with the wound infection in univariate analysis: pre-hospital care (p = 0.0158), injury hospital interval > 15 days (p = 0.0126), and length of hospital stay > 15 days (p = 0.0013)(Table 3).

The result of multivariate analysis is summarized in logistic regression model in Fig. 1.

Multivariate logistic regression analysis identified anatomical region, presence of fracture and nerve damage as independent predictors of gunshot wound infection.

Indeed, in multivariate analysis, we found that fractures (adjusted odds ratio [aOR] = 1.81; 95% CI: 1.12–2.92; $p = 0.0146$), nerve damage (aOR = 2.65; 95% CI: 1.70–4.14; $p < 0.0001$), trunk (aOR = 5.64; 95% CI: 2.61–12.16; $p < 0.0001$), lower extremity (aOR = 2.71; 95% CI: 1.39–5.28; $p = 0.0034$), and multiple > 2 (aOR = 2.35; 95% CI: 1.05–5.25; $p = 0.0378$) were predictors of gunshot wound infection (Fig. 2).

Table 1

Wound infection by population characteristics and anatomic locationof injury

Variable	Total (%) (N = 549)	Infection Yes (%) (n = 147)	Infection No (%) (n = 402)	X^2	p-value
Age (years)				4.84	0.3034
< 20	75 (13.66)	16 (21.33)	59 (78.67)		
20–29	190 (34.61)	46 (24.21)	144 (75.79)		
30–39	145 (26.41)	45 (31.03)	100 (68.97)		
40–49	69 (12.57)	23 (33.33)	46 (66.67)		
≥ 50	70 (12.75)	17 (24.29)	53 (75.71)		
Mean ± SD (years)	32.36 ± 13.74	33.20 ± 12.63	32.06 ± 14.13	0.91	0.3653*
Sex				0.87	0.3496
Male	463 (84.34)	128 (27.65)	335 (72.35)		
Female	86 (15.66)	19 (22.09)	67 (77.91)		
Residence				4.42	0.1095
Bukavu (urban)	87 (15.85)	18 (20.69)	69 (79.31)		
South-Kivu rural	417 (75.96)	112 (26.86)	305 (73.14)		
Out-of-province	45 (8.20)	17 (37.78)	28 (62.22)		
Anatomic region				16.70	**0.0022**
Head and Neck	46 (8.38)	11 (23.91)	35 (76.09)		
Trunk (chest/abdomen)	98 (17.85)	38 (38.78)	60 (61.22)		
Upperextremity	96 (17.49)	13 (13.54)	83 (86.46)		
Lowerextremity	230 (41.89)	66 (28.70)	164 (71.30)		
Multiple > 2	79 (14.39)	19 (24.05)	60 (75.95)		

***p-value from Student t test**

Table 2

Wound infection by clinic characteristics and complications

Variable	**Total (%)**	**Infection**		X^2	**p-value**
	(N = 549)	**Yes (%)**	**No (%)**		
		(n = 147)	**(n = 402)**		
Injuryseverityscore				8.77	**0.0125**
Moderate (9–15)	10 (1.82)	0 (0.00)	10 (100.00)		
Severe (16–24)	52 (9.47)	21 (40.38)	31 (59.62)		
Verysevere (≥ 25)	487 (88.71)	126 (25.87)	361 (74.13)		
Fracture				9.29	**0.0023**
No	232 (42.26)	46 (19.83)	186 (80.17)		
Yes	317 (57.74)	101 (31.86)	216 (68.14)		
Vascular damage				14.20	**< 0.0001**
No	195 (35.52)	33 (16.92)	162 (83.08)		
Yes	354 (64.48)	114 (32.20)	240 (67.80)		
Nerve damage				29.36	**< 0.0001**
No	256 (46.63)	40 (15.63)	216 (84.38)		
Yes	293 (53.37)	107 (36.52)	186 (63.48)		
Shock index				0.19	0.6605
< 0.9	140 (25.50)	35 (25.00)	105 (75.00)		
≥ 0.9	409 (74.50)	112 (27.38)	297 (72.62)		
Anemia				2.22	0.1367
No	408 (74.32)	102 (25.00)	306 (75.00)		
Yes	141 (25.68)	45 (31.91)	96 (68.09)		

Table 3
Wound infection by intervention-related factors and hospital stays

Variable	Total (%) (N = 549)	Infection Yes (%) (n = 147)	Infection No (%) (n = 402)	X^2	p-value
Pre-hospital care				5.83	**0.0158**
Yes	349 (63.57)	106 (30.37)	243 (69.63)		
No	200 (36.43)	41 (20.50)	159 (79.50)		
Injury-hospital interval				8.74	**0.0126**
≤ 1day	200 (36.43)	41 (20.50)	159 (79.50)		
2–15 days	321 (58.47)	94 (29.28)	227 (70.72)		
> 15 days	28 (5.10)	12 (42.86)	16 (57.14)		
Length of hospital stay				13.25	**0.0013**
≤ 1day	20 (3.64)	4 (20.00)	16 (80.00)		
2–15 days	101 (18.40)	13 (12.87)	88 (87.13)		
> 15 days	428 (77.96)	130 (30.37)	298 (69.63)		

Discussion

Gunshot injuries represent a global public health problem and pose therapeutic challenges to trauma and general surgeons all over the world [18, 19].

The gunshot wound infection rate (26.6%) in this study though within the range reported in low-income nations was higher than the rate reported in civilian trauma setting in developed countries. However, it was less than the infection rate found in Tanzania (49.1%) [26] and in Nigeria (29.6%) [31].

Result of this study indicates that the casualties were predominantly young active male and this correlated with the findings in previous published reports [20–24].

In this study, assault injury was the major cause of firearm injury. This is similar to the findings in other published studies from Nigeria and Tanzania [14, 25, 26], but is at variance with the preponderance of assault-related injury reported in Cameroon[27]. However, in a recent study, about the emerging trend in the epidemiology of gunshot injuries in the emergency department of a Nigeria [28], reported preponderance of assault related injury as an emerging trend in civilian firearm injury in Nigeria. The preponderance of gunshot injury in the sub-region has been attributed to poverty and high level of unemployment [29].

In (Table 1), the higher incidence of gunshot in middle-aged population compared with the youth suggests that the former is in better economic and financial standing than the latter. On the other view, the higher incidence of gunshot injury among young people is in keeping with youthful aggressiveness and adventurous nature. In our environment, land, politic and community conflict as well as street banditry often occur in rural setting and may be an explanation of higher incidence of assault-related injury in rural areas observed in (Table 1). And this is explained by the high concentration of minerals on rural setting in East of the Democratic Republic of the Congo.

A gunshot fracture being an open fracture is prone to wound infection. The rate of wound infection in open fracture increases with the increasing grade of fracture and could be as high as 50% for Gustilo Type III fractures [3], especially the type IIIc.

This also corroborates the results of our study according to which vascular and nerve damage are associated with infections.

The preponderance of extremity injury correlates with the finding in previous published reports[18, 26].This because the casualties that are likely to make it to the emergency room alive are those with extremity injury, while those with injury to the head, neck and trunk are always died on the spot of shot or on road to the hospital.

In this study, there was more gunshot fracture involving the long bone of the lower extremity than those involving the upper extremity (as shown in Table 1), and this is similar to the finding in other studies[3, 18, 26].

Anemia due to hemorrhage of varying degrees of severity is the principal complication of firearm injuries [14].

Studies reported that the tissue oxygen tension correlated inversely with the risk of surgical wound infection [30]. Authors reported that severe blood loss was a significant factor for gunshot wounds infection[12].

However, in our study anemia was not significantly associated with wound infection.

We still insist on control of blood loss and correction of anemia. However, when there is indication for urgent blood transfusion, judicious blood transfusion is more appropriate because of the risk of sepsis associated with aggressive transfusion in trauma patients [27].

In Table 2, wound infection was the most common complication of gunshot, an observation that is similar to the finding reported by other authors[26].

The duration of hospital admission is directly related to the morbidity in firearm injury. In this study, the duration of hospital admission correlated directly with the incidence of wound infection complicating injury as shown in Table 2. In a recent report from civilian setting, other factors significantly associated with prolonged duration of hospital admission in Table 2 were all significantly high-risk factors for gunshot wound infection [31].

This retrospective study on the prevalence and risk factors of gunshot wound infection in the Eastern Democratic Republic of the Congo provides valuable insights, yet it is not without limitations. Firstly, the reliance on retrospective data from a single tertiary hospital in Bukavu may introduce selection bias, as it excludes patients treated elsewhere or those with less severe injuries. Consequently, the findings may not be fully representative of the broader population affected by gunshot wounds in the region. Additionally, the study's focus on anatomical location and injury type, while informative, overlooks potential confounders such as wound management practices, antibiotic use, and patient comorbidities, which could influence infection rates but were not examined. Moreover, the lack of longitudinal follow-up restricts the assessment of long-term outcomes and the comprehensive understanding of the clinical course of gunshot wound infections in this context.

Despite these limitations, the study's identification of independent predictors of gunshot wound infection, such as fractures and nerve damage, underscores the importance of targeted interventions for high-risk patients. The findings emphasize the need for judicious assessment and prioritization of certain wound characteristics in clinical practice to mitigate infection rates effectively. However, to enhance the applicability and robustness of these findings, future research should adopt prospective designs, encompassing multiple healthcare settings and a broader range of variables, while also incorporating longitudinal follow-up to assess long-term outcomes and further elucidate the complexities surrounding gunshot wound infections in low-resource settings like the Eastern Democratic Republic of the Congo.

Conclusion

In our environment, the distribution of firearm injury varies in location and etiology of gunshot. There are many risk factors for gunshot wound infection, independent predictors shown in this study calls for preventive strategies based on the observed pattern.

The independent predictors of gunshot wound infection identified in this study implied a judicious assessment and a high priority accorded to trunk perforating wounds, fractures and vasculo-nervous damagein interventions aimed at reducing gunshot wound infection rate.

The relatively high morbidity and preventable death rate also call for improvement in pre-hospital and emergency room care as well as measures aimed at reducing and preventing wound infection rate that has a principal role in the factors associated with morbidity.

Abbreviations

D.R.C: Democratic Republic of the Congo

GSWs: Gunshot wounds

Declarations

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No one.

Authorship Contributions

PBM and JTM have designed, conceptualized the study, and written the first draft under the supervision of SOW , and GMB contributed to the drafting of the paper. All authors have reviewed and approved the final manuscript.

Compliance with ethical standards

This study received ethical clearance from the Ethical Committee of the Catholic University of Bukavu.

Conflicts of interest

No conflict of interest was declared by the authors.

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