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Evaluation of Gunshot Wounds to the Extremities: Correlation of Red Cross Wound Score and Initial Response to Management

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Abstract

Purpose: Gunshot wounds to the extremities are a major cause of death and disability. The Red Cross Wound Score (RCWS) is a simple classification system that is thought to fairly assess severity of injury, influence surgical management and a good predictor of outcome in gunshot wounds. This study aims to evaluate the correlation between the Red Cross Wound Score RCWS and initial response to management.

Methodology: This was a prospective study recruiting all consenting patients who suffered gunshot wounds to any extremity and presented at the University of Port Harcourt Teaching Hospital (UPTH). The study was conducted over a 12-month period between October 2018 and September 2019. Data on demographics, anatomical region of the body involved, type of gun time between injury and hospital presentation were obtained using a proforma. Analysis of extracted data was done by the aid of SPSS for Windows version 20.

Findings: A total of 106 wounds from 82 patients were analyzed; seventy males (85.4%) and 12 females. AK 47 rifles and locally fabricated pistols were the wounding weapons in 32.9% and the left leg (28.3%) was the most injured extremity. Fifty-two wounds (49%) were grade 3, 44 (41.5%) wounds grade 2 and 10 wounds (9.4%) grade 1. There was a positive association between RCWS grade 3 wounds and limb length discrepancy and joint stiffness. Vascular injuries were seen in 6 patients (0.07%). Wound infection (46.2%), joint stiffness (41.5%) and shortening (34%) were the common complications in the study. The study showed that young adult males suffered more gunshot wounds than females. Most of the wounds were RCWS grade 3 and there was a positive association between RCWS grade 3 wounds and limb length discrepancy and joint stiffness. Patients with longer mean presentation time had a higher infection rate.

Recommendations: The Red Cross wound classification should be adopted as a useful scoring system. Also, patients with gunshot injuries should present earlier to the hospital to reduce complications

Keywords: *Red Cross Wound Score, gunshot wounds, extremities*

Introduction

There is an increasing incidence of gunshot injuries in most countries around the world. Performing adequate wound assessment is crucial to patient management in cases of severe trauma.[1] Several wound classification systems exist to describe wounds and guide its management. These classifications include: Gustilo-Anderson (GA) classification,[2] Tscherne classification,[3] and the Arbeitsgemeinschaft Osteosynthesefragen (AO) soft tissue grading system.[4] These classifications correlate with patient outcomes including healing and infection rates, need for secondary surgeries and amputation, length of hospitalization, and lifestyle changes.[5,6] However, they may be inappropriate in conflict settings.

The International Committee of the Red Cross (ICRC) implemented the Red Cross wound classification (RCWC) to quickly assess the severity of a wound in times of conflict.[1] This scoring system was developed to allow the classification of gunshot wounds based on their physical appearance rather than the characteristics of the wounding weapon.[7] It is a useful tool that helps communicate information amongst hospital staff and colleagues without having to remove the dressings. This wound scoring system requires no sophisticated equipment and can be done in a few seconds. It is also useful for the purpose of triage. It is proposed as a means of understanding, communicating and gathering information about war wounds and their treatment. The RCWS is based on the skin wounds, the presence of a cavity, fracture, injury to vital structures and the presence or absence of metallic bodies in the wound. Scores can then be translated into a classification system: graded according to severity and typed according to tissue structures injured.[7]

The RCWS has been advocated to be used as part of the secondary survey of a casualty as taught in the ATLS course.[8] The primary survey identifies life threatening injuries and manages them. The RCWS helps the attending care giver focus on the wound and is useful for those with limited experience of ballistic trauma. The scoring process helps in making clinical decision. The work done on gulf war wounds involved victims from the war field,[8] while this study focused on victims of gunshot wounds in a civilian setting. Presently, no scoring system used in patients with gunshot wounds to the extremities at the University of Port Harcourt Teaching Hospital focuses on the wound characteristics as much as the RCWS. All patients who have suffered high velocity gunshot wounds to the extremities are just classified as a Gustillo et al. grade 3. This study aims to evaluate with clinical, laboratory and radiological parameters, gunshot induced injuries to the extremities and to ascertain if there is a correlation between the RCWS and initial response to management.

Materials and Methods

This was a prospective non-randomised hospital-based study conducted over a 12-month period between October 2018 and September 2019. This study was carried out on all patients who presented with gunshot injuries to the extremities at the University of Port Harcourt Teaching Hospital during the period of the study. This study was carried out at the orthopaedic outpatient clinic, Accident & Emergency unit, male and female orthopaedic wards of the University of Port Harcourt Teaching Hospital.

The sample size was calculated using the formula for determination of sample size for estimating proportions[9]:

$$n = \frac{Z\alpha^2\, p\,(1-p)}{d^2}$$

n = the desired total sample size

Zα = the assumed standard deviation set at 1.96 which corresponds to 95% confidence level

p = the proportion in the target population estimated to have a particular characteristic. 50% is used since there is no reasonable estimate.

d = degree of accuracy set at 10%

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.1)^2}$$

$$n = \frac{3.84 \times 0.25}{0.01}$$

$$n = \frac{0.96}{0.01}$$

n = 96

Adding a 10% attrition rate of 9.6

n = 96 + 9.6 = 106 wounds

All patients admitted to University of Port Harcourt Teaching Hospital who suffered gunshot wounds to the extremities were included in the study. Patients who did not give consent to the study, patients who left the hospital against medical advice, indigent patients who could not afford to do plain radiographs, patients with psychiatric illness who would have posed a follow up difficulty were excluded from the study. All patients who met the inclusion criteria had written consent obtained from them and recruited into the study. Detailed history was then obtained with emphasis on age, gender, anatomical region of the body involved in the injury, nature of the gun used, time between injury and presentation at the hospital. A detailed clinical examination was then carried out with focus on the musculoskeletal system.

Preoperative investigations included haemoglobin concentration, blood grouping, urinalysis, serum urea & electrolytes and plain radiographs of the affected limb(s). Radiographs were taken in two views – anteroposterior (AP) and lateral views (LAT) to determine the pattern of injuries and the presence of shrapnel, bullets or pellets. Computed tomography (CT) scan of the involved limbs were ordered where necessary to properly characterize the fracture. The fracture(s) were classified using the RCWS system. The time interval between the injury and hospital presentation was recorded. Tetanus prophylaxis was given to all patients and where necessary, blood transfused.

Complications such as wound infection, chronic unhealed ulcer, and joint stiffness were documented when they occurred. Wound swab culture with bacteriologic counts of 105 – 106 per gram of tissue or per millilitre of fluid was considered an infection. Although not part of the Red Cross Wound Score protocol, nerve damage was looked out for and recorded. Data was obtained using a prepared proforma (Appendix IV) and then entered into Microsoft Excel and then exported to the Statistical Package for Social Sciences (SPSS) Version 20 for statistical analysis. Data was

presented appropriately using tables and charts. Normality of data was assessed using Kolmogorov-Smirnov Statistics prior to analysis. Normally distributed data was summarized using means and standard deviation while medians and ranges were used for variables that are not normally distributed. Categorical variables were expressed as absolute frequencies and percentages. Independent t test was used to compare the differences in means across two categories while Mann-Whitney U test was used to compare the differences in medians across categories. The relationship between categorical variables was compared using Chi square test or a Fisher's exact test when the expected cell count was less than five in at least twenty percent of the cells. Statistical significance was set at a level of 0.05. Ethical approval was obtained from the Research Ethics Committee of University of Port-Harcourt teaching hospital, Rivers State in line with Helsinki Declaration. The hospital number of the patient was used instead of the name for data collection.

Results

This study had a total of 106 gunshot wounds to the extremities from 82 patients who were hospitalized during the period of the study.

Characterization of wound using Red Cross wound score

A total of 106 wounds were seen. The entry wounds ranged from 1centimetre to 4 centimetres in diameter. Forty-nine of the gunshot wounds had no exit wound component. The exit wounds ranged from 1cm to 9cm. The mean diameter of the entry wound was 1.38±0.73cm, while that of exit wound was 4.82±1.84cm.

Table 1: Distribution of entry and exit wound components (in centimetres) of the RCWS

Variables (N = 106 wounds)	Frequency	Percentage (%)
Entry wound		
1cm	43	41.0
2cm	12	11.4
3cm	20	19.0
4cm	30	28.6
Mean ± S.D = 1.38±0.73cm; Median (range) = 1 (1 – 4) cm		
Exit wound		
None	49	46.7
1cm	5	4.8
2cm	0	0
3cm	6	5.7
4cm	13	12.4
5cm	8	7.6
6cm	19	18.1
7cm	0	0
8cm	4	3.8
9cm	1	1.0
Mean ± S.D = 4.82±1.84cm		
Median (range) = 5 (1 – 9) cm		

S.D – Standard deviation

Among the 106 wounds, 89 of them had cavities (84%) and 17 had no cavities (16%). Twenty-three had no associated fractures (21.7%), 18 sustained simple fractures (17.0%), and sixty-five of them had clinically significant comminution (61.3%). Most of the wounds seen (100) had no associated vascular injury, while six (5.7%) of these wounds had an associated vascular injury. Sixty-two wounds had no metallic body seen on the plain radiographs, six of them had one metallic body and 38wounds had multiple metallic bodies.

Table 2: Distribution of cavity, fracture, vital structure and metallic body components of RCWS

Variables (N = 106 wounds)	N	%
Cavity		
No (C0)	17	16.0
Yes (C1)	89	84.0
Fracture		
None (F0)	22	20.8
Simple fracture, hole or insignificant comminution (F1)	18	17.0
Clinically significant comminution (F2)	66	62.2
Vital structure		
No vital structure injured (V0)	100	94.3
Injury to a major blood vessel (VH)	6	5.7
Metallic body		
None (M0)	62	58.5
One metallic body (M1)	6	5.7
Multiple metallic bodies (M2)	38	35.8

Typing the wound according to the RCWS revealed that 22 had soft tissue wounds only (ST), 78 wounds were type F, and 6 wounds were type VF. No patient had an isolated vascular injury.

Table 3: Wound typing according to the structures involved

Type of gunshot wound	Frequency	Percentage (%)
Type ST	22	20.8
Type F	78	73.6
Type V	0	0.0
Type VF	6	5.7
Total	**106**	**100.0**

The RCWS considers 3 different grades of the gunshot wounds. Fifty-two (49.1%) of the wounds seen were grade 3, 44 (41.5%) were grade 2 and 10 (9.4%) were grade 1.

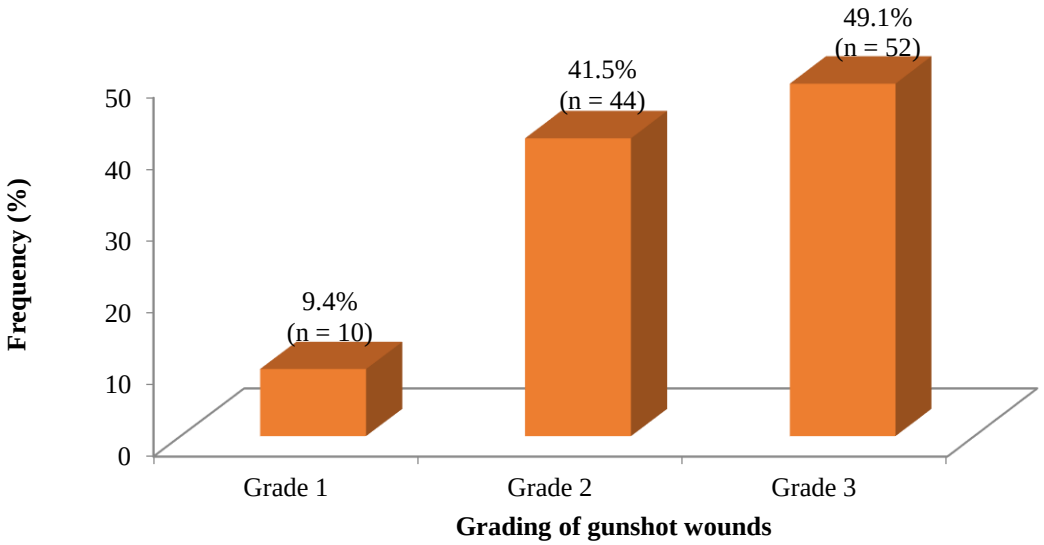

Figure 1: Grading the wound according to the amount of tissue damage

Treatment of Gunshot Wound

The initial treatment given included wound debridement and wash out, external fixation, fasciotomy, splinting with a plaster cast, primary amputation, intramedullary nailing, open reduction, internal fixation with plate and screws. Most of the wounds were debrided – 95 of them (89.6%), 54 of them had external skeletal fixation of the associated fractures, 1 patient had fasciotomy for an impending compartment syndrome following gunshot wound to the left thigh, 21 of them had the limbs splinted with plaster casts, 5 of them had amputation, 2 had intramedullary nails inserted and 1 had ORIF with a buttress plate and screws.

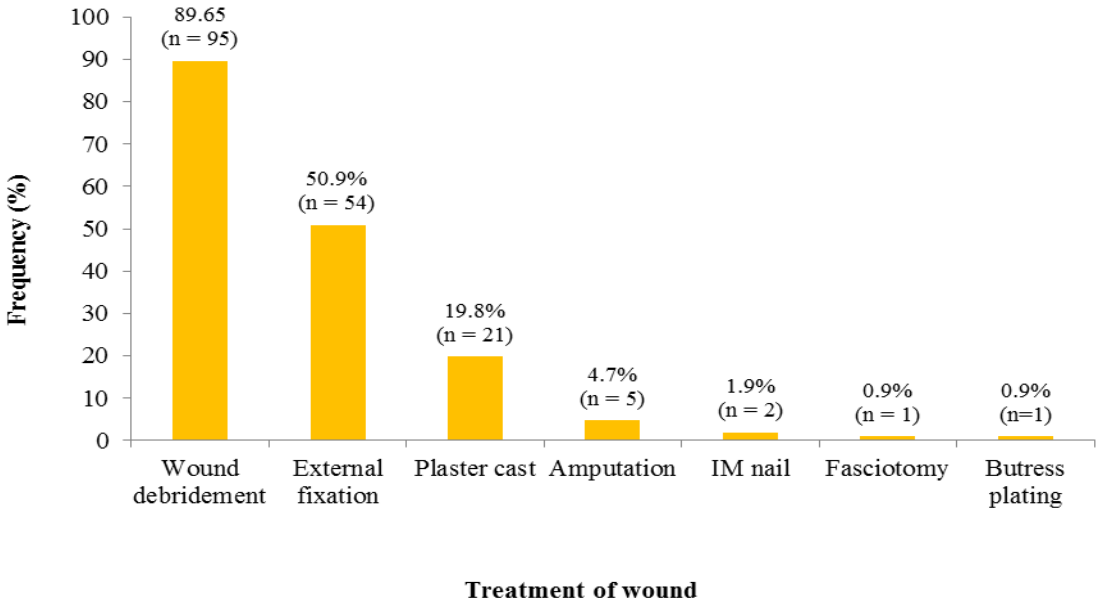

Figure 2: Initial treatment of wound

Outcome/complications of gunshot wound

Complications identified in the course of treating these gunshot wounds included wound infection (46.2%), joint stiffness (41.5%), limb length discrepancy (34%), muscle atrophy (16%), amputation (4.7%), gangrene (2.8%), vascular injury (5.7%), nerve palsy (0.9%), angular deformity (0.9%) and death (1.9%). Forty-nine wounds were complicated by wound infection, joint stiffness was seen in forty-four limbs, associated comminuted fractures with bone loss caused limb length discrepancy in thirty-six limbs, seventeen had muscle wasting from disuse, five had amputation, three had gangrene, six had vascular injury, two patients with femoral artery injuries died despite attempt at repair by the vascular team (one had associated chest injuries and another died from disseminated intravascular coagulation following massive blood transfusion), one patient had a common peroneal nerve palsy with left foot drop and one patient developed an angular deformity following gunshot wound to the tibial plateau.

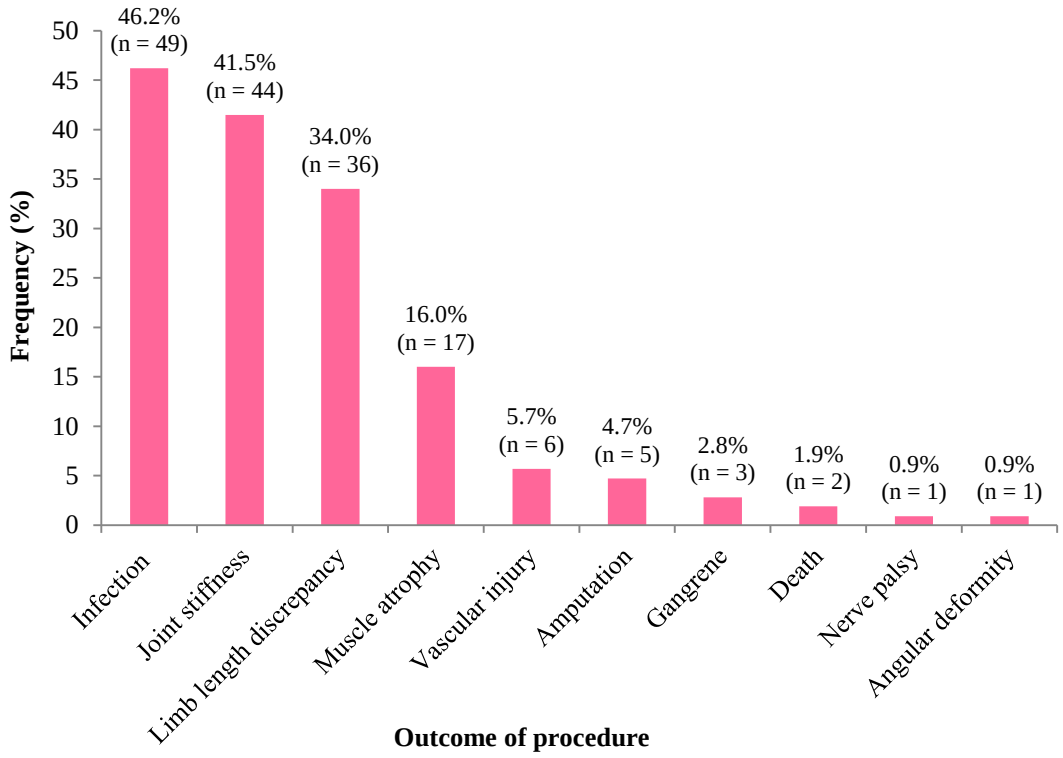

Figure 3: Outcome/complications

Relationship between RCWS Grading and Wound Infection

Wound infection was identified in wounds belonging to all grades. Five out of 10 grade 1 wounds (50.0%), 21 out of 41 grade 2 wounds (51.2%) and 23 out of 49 grade 3 wounds (46.9%) were complicated by wound infection. These differences in proportions of wound infection across RCWS grading were not significant (p=0.919) as shown in table 6.

Table 4: Relationship between RCWS grading and wound infection

	Infection (N=100)*		
RCWS Grading	**Yes n (%)**	**No n (%)**	**Total n (%)**
Grade 1	5 (50.0)	5 (50.0)	10 (100.0)
Grade 2	21 (51.2)	20 (48.8)	41 (100.0)
Grade 3	23 (46.9)	26 (53.1)	49 (100.0)
Total	**49 (49.0)**	**51 (51.0)**	**100 (100.0)**

Chi square = 0.168; p-value = 0.919

*Four of the patients having a total of 6 wounds discharged against medical advice (DAMA)

Relationship between RCWS Grading and Limb Length Discrepancy

Wounds belonging to the RCWS Grade 3 had the highest number of associated shortening (limb length discrepancy). Thirty five out of forty-nine grade 3 wounds had shortening. One grade 2 wound developed shortening and no patient with a grade 1 wound developed shortening. These differences in proportions were statistically significant (p-value = 0.0001).

Table 5: Relationship between RCWS grading and limb length discrepancy

	Limb length discrepancy (N=100)**		
RCWS Grading	**Yes n (%)**	**No n (%)**	**Total n (%)**
Grade 1	0 (0.0)	10 (10.0)	10 (100.0)
Grade 2	1 (2.4)	40 (97.6)	41 (100.0)
Grade 3	35 (71.4)	14 (28.6)	49 (100.0)
Total	**36 (36.0)**	**64 (64.0)**	**100 (100.0)**

*Chi square = 52.363; p-value = 0.0001**

**Statistically significant*

***Four of the patients having a total of 6 wounds discharged against medical advice (DAMA)*

Relationship between RCWS Grading and Vascular Injury

None of the grade 1 wounds had associated vascular injuries. Only 1 out of 41 grade 2 wounds (2.3%) had associated vascular injury, 5 out of 49 grade 3 wounds (9.6%) had vascular injuries.

Table 6: RCWS grading across vascular injury among patients

	Vascular injury		
RCWS Grading	**Yes n (%)**	**No n (%)**	**Total n (%)**
Grade 1	0 (0.0)	10 (100.0)	10 (100.0)
Grade 2	1 (2.3)	43 (97.7)	44 (100.0)
Grade 3	5 (9.6)	47 (90.4)	52 (100.0)
Total	**6 (5.7)**	**100 (94.3)**	**106 (100.0)**

Fisher's exact test = 2.215; p-value = 0.277

Relationship between RCWS Grading and Amputation

Five of the 49 patients with grade 3 wounds (10.2%) had amputation as shown in Table 9. These 5 patients had associated vascular injuries.

Table 7: Relationship between RCWS grading and amputation

	Amputation(N=100)*		
	Yes	No	Total
RCWS grading	**n (%)**	**n (%)**	**n (%)**
Grade 1	0 (0.0)	10 (100.0)	10 (100.0)
Grade 2	0 (0.0)	41 (100.0)	41 (100.0)
Grade 3	5 (10.2)	44 (89.8)	49 (100.0)
Total	**5 (5.0)**	**95 (95.0)**	**100 (100.0)**

Fisher's exact test = 4.467; p-value = 0.097
**Four of the patients having a total of 6 wounds discharged against medical advice (DAMA)*

Joint stiffness was a common complication noticed in these patients. Eleven out of 41 patients with grade 2 wounds developed joint stiffness (26.8%) and 33 out of 49 patients with grade 3 wounds developed joint stiffness (67.3%). These differences in proportions were statistically significant (p-value = 0.0001).

Table 8: Relationship between RCWS Grading and Joint Stiffness

	Joint stiffness (N=100)*		
	Yes	No	Total
RCWS grading	**n (%)**	**n (%)**	**n (%)**
Grade 1	0 (0.0)	10 (100.0)	10 (100.0)
Grade 2	11 (26.8)	30 (73.2)	41 (100.0)
Grade 3	33 (67.3)	16 (32.7)	49 (100.0)
Total	**44 (44.0)**	**56 (56.0)**	**100 (100.0)**

*Chi square = 23.603; p-value = 0.0001**
**Statistically significant*
**Four of the patients having a total of 6 wounds discharged against medical advice (DAMA)*

Disuse atrophy was seen in 6 out of 41 grade 2 wounds (14.6%) and 11 out of 49 grade 3 wounds (22.4%). These differences in proportions were not statistically significant (p-value = 0.198).

Table 9: Relationship between RCWS grading and muscle atrophy

	Muscle atrophy (N=100)*		
	Yes	No	Total
RCWS grading	**n (%)**	**n (%)**	**n (%)**
Grade 1	0 (0.0)	10 (100.0)	10 (100.0)
Grade 2	6 (14.6)	35 (85.4)	41 (100.0)
Grade 3	11 (22.4)	38 (77.6)	49 (100.0)
Total	**17 (17.0)**	**83 (83.0)**	**100 (100.0)**

Chi square = 3.242; p-value = 0.198
**Four of the patients having a total of 6 wounds discharged against medical advice (DAMA)*

Figure 4 shows the mean time to hospital presentation by wound infection. The mean time to hospital presentation was longer among patients with wound infection (14.68 hours) in comparison to those without wound infection (2.35 hours). This difference in means was statistically significant (p=0.032).

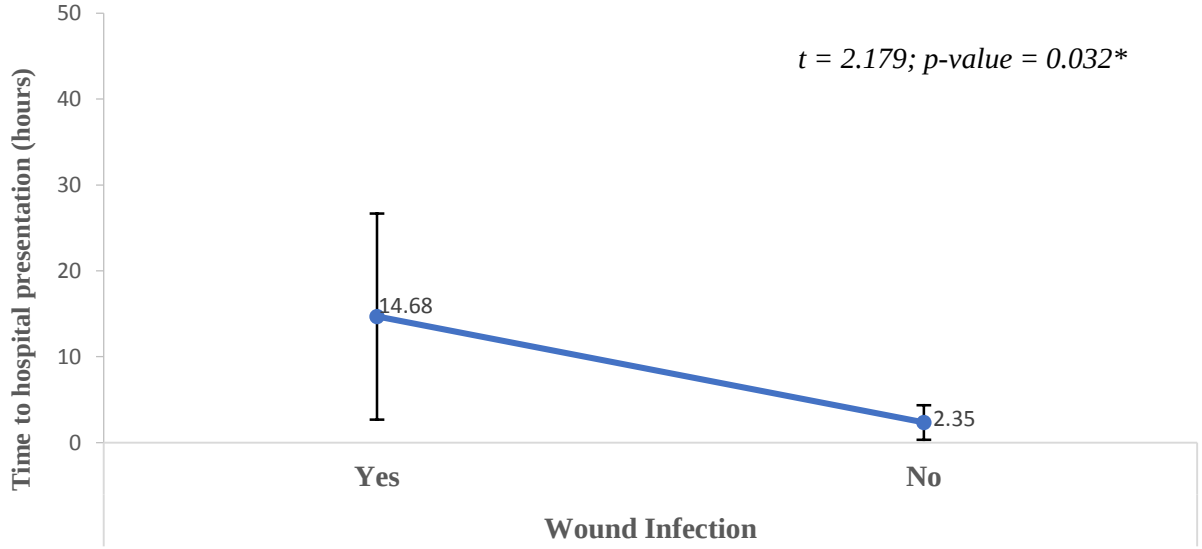

Figure 4: Mean time to hospital presentation across presence of wound infection.

The median (range) time to hospital presentation across the gunshot wound outcome is shown in Table 10. The difference in median time was significant between patients with and without wound infection (p=0.013). The other gunshot wound outcomes showed no significant differences in the median time (p>0.05) as shown in Table 10.

Table 10: Comparison of median time to hospital presentation by presence/absence of gunshot wound outcome

	Time to hospital presentation (hours)			
Gunshot wound outcome	**Median (Range) Outcome present**	**Median (Range) Outcome absent**	**Mann-Whitney U**	**P-value**
Infection	2 (1 – 160)	2 (1 – 10)	2.494	0.013*
Limb length discrepancy	2 (1 – 96)	2 (1 – 160)	0.310	0.757
Gangrene	2 (1 – 5)	2 (1 – 160)	0.082	0.935
Amputation	2 (1 – 5)	2 (1 – 160)	0.708	0.479
Joint stiffness	2 (1 – 96)	2 (1 – 160)	0.048	0.962
Muscle atrophy	2 (1 – 8)	2 (1 – 160)	0.360	0.719

**Statistically significant*

Discussion

The initial treatment offered included resuscitation, thorough wound debridement and saline irrigation, plaster cast immobilisation, external fixation, unreamed intramedullary nailing, amputation, fasciotomy, and delayed wound closure where necessary. This study revealed that wound grade 3 was the most abundant with a percentage of 49.1%, followed by grade 2 (41.5%) and then grade 1(9.4%) as shown in Figure 1. This was at variance with a study conducted by van Gennip et al.[1] who had grade 1 injuries as the highest with a percentage of 79.4%, followed by grade 2 (13.9%) and lastly grade 3(6.7%). Van Gennip's study was on children while ours were on adults. In this study, the most common treatment received was wound debridement (89.65%), followed closely by external fixation, and fasciotomy and buttress plating were the least treatment received as shown in Figure 2. Most gunshot wounds would have to be carefully debrided to prevent infection irrespective of the grade of injury.

Complication rates were particularly high for wound infection, joint stiffness, limb length discrepancy and muscle atrophy. This may be as a result of the number of grade 3 wounds (n=52, 49.1%) inflicted by high velocity weapons like the AK 47. The level of osseous damage /comminution may be the reason for the high number of patients with shortening. The mean time to hospital presentation was longer among patients with wound infection (14.68 hours) in comparison to those without wound infection (2.35 hours) and this was found to be statistically significant (P=0.032). This finding is similar to that obtained in a study analysing the risk factors for gunshot wound infection in a civilian setting.[10] Factors identified to increase wound infection rates were time to hospital presentation greater than six hours, high velocity injury, presence of fracture, anatomical location of the wound with the lower extremity having the highest infection rate (40.6%). All RCWS grades in this study had wound infection. 50% of grade 1 wounds, 51.2% of grade 2 and 46.9% of grade 3 wounds.

These differences in proportions of wound infection across RCWS grading were not statistically significant (p=0.919). Eleven out of 41 patients with grade 2 wounds developed joint stiffness (26.8%) and 33 out of 49 patients with grade 3 wounds developed joint stiffness (67.3%). These differences in proportions were statistically significant (p-value = 0.0001) showing a correlation between joint stiffness and higher RCWS wound grades. Thirty five out of 49 grade 3 wounds developed limb shortening. One grade 2 wound developed shortening and no patient with a grade 1 wound developed shortening. These differences in proportions were statistically significant (p-value = 0.0001) showing a correlation between joint stiffness and higher RCWS wound grades. Muscle atrophy was seen in 6 out of 41 grade 2 wounds (14.6%) and 11 out of 49 grade 3 wounds (22.4%). One patient (0.9%) developed a common peroneal nerve injury and six patients (5.7%) sustained vascular injury in this study. These findings are similar to results from a study[11] done on low-energy civilian gunshot wound trauma to the lower extremities with 1.4% and 6.1% for nerve and vascular injury respectively.

The finding of nerve palsy in this study exposes the limitation of the original Red Cross Wound classification system, which is the absence of nerve injury component in its scoring system hence exposing the need for a revision of this tool. The study by Bowyer et al. also recommended a modification of the RCWS to accommodate significant nerve injury.[12] Out of the six patients who sustained vascular injuries, attempts at vascular repair were made by the vascular team. Only the patient with a RCWS grade 2 wound had successful revascularization following repair. The others

developed gangrene and had lower extremity amputations. All amputations were for RCWS grade 3 wounds (category 3VF). No amputations were performed for RCWS grade 1 and 2 wounds. This shows a correlation between higher RCWS scores and amputation.

The Red Cross wound classification system is useful as a tool for wound evaluation. However, it is not a good tool for triage. The Red Cross wound classification system has no scoring of physiological parameters like blood pressure, pulse or respiratory rate. Furthermore, the preoperative radiograph, which may not be readily available is necessary to do a full scoring of the wound.

Conclusion

Grade 3 wound injury were more common, the most common treatment received was a debridement, complication rates were more for grade 3 injuries. Delay in receiving expert care resulted in more wound infection. The red cross wound classification system is useful for wound evaluation.

Recommendations

The Red Cross wound classification should be adopted as a useful scoring system

Patients with gunshot injuries should present earlier to the hospital to reduce complications

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Conflict of interest

The authors declare no conflict of interest.

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