

Hematological Markers as Predictors of Severity and Outcomes in Firearm Injuries

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ABSTRACT

Objective: To compare the hematological parameters of firearm injury patients on presentation with severity of sustained injuries and to determine the relationship of these hematological parameters with hospital stay duration.

Study Design: Prospective Comparative Study.

Place and Duration of Study: Surgery Department of Secondary Care Hospital Bannu, Pakistan, from Jul 23 to Jun 24.

Methodology: Two hundred and fifty patients presenting to emergency department with firearm injuries were included. All patients underwent complete blood picture analysis on presentation. Patients were followed throughout admission, and blood parameters on arrival were compared with injury severity scores (ISS) and duration of hospital admission.

Results: The median (IQR) age of the study population was 30(25-36) years and 152(60.8%) had sustained severe injuries as per ISS. Median (IQR) hospital admission was 5(2-8) days. Statistically significant association was found between ISS and total leukocyte count, red blood cell count, hemoglobin level, hematocrit, neutrophil count, and lymphocyte count on presentation (p -values <0.05). There was also a statistically significant association between hospital admission duration and total leukocyte count, red blood cell counts, hemoglobin level, hematocrit, neutrophil count, lymphocyte count, and red cell distribution width on presentation (p -values <0.05).

Conclusion: Several hematological parameters of firearm injury patients on presentation are associated with severity of sustained injuries and duration of hospital stay. Neutrophil counts, lymphocyte counts, and red cell distribution width on presentation may serve as important markers for determining severity of injuries and hospital stay in firearm injury patients.

Keywords: Hematological tests, Injury severity score, Wounds and injuries.

How to Cite This Article: Malik AH, Amir M, Saleem MR, Ahmed Z, Hamid A. Hematological Markers as Predictors of Severity and Outcomes in Firearm Injuries. *Pak Armed Forces Med J* 2025; 75(5): 945-948. DOI: <https://doi.org/10.51253/pafmj.v75i5.12430>

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INTRODUCTION

Firearm wounds present as a unique surgical challenge, with a wide array of injuries to different organ systems.¹ They are a great public health concern, with over 2.75 million deaths in last decade alone.² Firearm injuries not only cause mortality but also produce significant morbidity, economic burden, and psychological effects.³ Prompt and early effective management of such patients is essential to save valuable lives.

Different scoring systems, both anatomical and physiological, have been developed to quantify injuries sustained. The injury severity score is commonly used for this purpose.⁴ However, the physiological effects and extent of damage caused by such injuries are sometimes not very apparent on arrival, as ballistic trauma produces a cavitation effect.⁵ This makes such injuries more destructive and their management more complicated. This is also the reason why injury scoring systems do not fully depict

the severity of such injuries.⁶ Rapid assessment and prompt management are essential aspects of care of such patients. Hemorrhagic shock is a common cause of death after firearm injuries.⁷ Blood samples are normally drawn on the arrival of the patients in emergency department. Focus is mainly on hemoglobin/hematocrit levels for rapid initiation of transfusion, for survival of the patients. There is a significant association of low hemoglobin levels, shock, and death in firearm injury patients.⁸

Many research studies have been carried out on the role of different hematological parameters as prognostic markers of severity, morbidity, and mortality in different diseases, such as infections, sepsis, COVID-19, pulmonary embolism, and atrial fibrillation.⁹ Some data is available regarding trauma patients in general. However, limited data exist regarding the role of different hematological parameters on arrival in emergency department as prognostic markers of severity, morbidity, and mortality in firearm injury patients.¹⁰

This study aimed to compare the hematological parameters of firearm injury patients on presentation

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Received: 07 Jul 2024; revision received: 25 Sep 2024; accepted: 08 Oct 2024

with the nature/severity of sustained injuries and determine relationship with clinical outcomes, for better surgical care.

METHODOLOGY

This was a prospective comparative study conducted at the Surgery Department of Secondary Care Hospital Bannu, Pakistan, from Jul 23 to Jun 24. Sample size was calculated using the WHO sample size calculator, with a confidence level of 95% and anticipated population proportion of firearm injuries 0.11.¹¹ Two hundred and fifty patients presenting to emergency department with firearm injuries were included using convenience sampling.

Inclusion Criteria: Patients of both genders between 10 and 70 years, presenting in emergency department with firearm injuries, within eight hours after sustaining injuries, and without any prior surgical management were included in the study.

Exclusion Criteria: Patients with co-morbid conditions, ongoing another active disease process, and patients with no signs of life on arrival were excluded from the study.

Permission was taken from hospital ethical review committee (vide letter no. ERC/15 dated 1 Jul 2023) before commencing the study. Informed consent was obtained from the patients before being included in the study. Confidentiality of data obtained was ensured.

All patients underwent complete blood picture analysis on presentation using Sysmex XP100 hematology analyzer. Hematological parameters noted included total leukocyte count, red blood cell count, hemoglobin levels, hematocrit, platelet count, neutrophil counts, lymphocyte counts, and red cell distribution width. Injury severity scores (ISS) of patients were calculated on admission. Injury severity score is a well-known trauma scoring system in which injury is documented in six body regions, including head and neck, face, chest, abdomen, extremities, and external region. Most severe injury in each body region was given a score on an ordinal scale from 1 to 6 as follows: Minor 1, Moderate 2, Serious 3, Severe 4, Critical 5, and Potentially Untreatable 6. The highest scores from the three most severely injured body regions were squared and added together to get a final score. A score of >15 was considered a serious injury.¹² Patients were followed throughout admission, and different blood parameters on arrival were compared

with injury severity scores and duration of hospital admission, as a measure of clinical outcomes.

Data collected was analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Quantitative variables, such as age, ISS, and hospital stay, were depicted as median and interquartile range (IQR). Qualitative data, such as regions involved and ISS severity, were presented as frequency and percentage. An independent sample t-test was utilized to compare ISS and hospital stay with different haematological parameters. Statistically significant association was determined by p -value $\leq$ 0.05.

RESULTS

A total of 250 patients were included in the study. Descriptive parameters of the study population are shown in Table-I.

Table-I: Descriptive Parameters of the Study Population (n=250)

Parameter	Descriptive Statistics
Age median (IQR)	30.0 (25.0-36.0) years
Duration of admission median (IQR)	5 (2.0-8.0) days
ISS median (IQR)	16.0 (9.0-25.0)
ISS Severity n(%)	Moderate (ISS $\leq$ 15) 98(39.2%) Severe (ISS>15) 152(60.8%)
Regions Involved n(%)	Limbs 124(49.6%) Multiple regions 64(25.6%) Head/Face 39(15.6%) Chest 12(4.8%) Abdomen 11(4.4%)

*IQR = Interquartile Range
ISS = Injury severity scores

Statistically significant association was found between ISS severity and hospital admission duration, with duration being 2.63 ± 1.67 days in ISS <15 group as compared to 8.49 ± 5.28 days in ISS >15 group (p -value<0.001). Association of ISS severity with hematological parameters is shown in Table-II.

Table-II: Comparison of Hematological Parameters with ISS (n=250)

Hematological Parameter	ISS $\leq$ 15 (Moderate Injury) Mean $\pm$ SD	ISS >15 (Severe Injury) Mean $\pm$ SD	p -value
TLC (x10 ⁹ /L)	9.98 $\pm$ 3.28	12.80 $\pm$ 5.56	<0.001
RBC (x10 ¹² /L)	5.10 $\pm$ 0.59	4.57 $\pm$ 0.87	<0.001
Hb (g/dL)	14.52 $\pm$ 1.43	13.18 $\pm$ 2.27	<0.001
Hct (%)	42.51 $\pm$ 3.85	38.31 $\pm$ 7.18	<0.001
Platelet count (x10 ⁹ /L)	223.16 $\pm$ 67.56	211.48 $\pm$ 84.50	0.251
Neutrophils count (%)	67.54 $\pm$ 13.57	76.59 $\pm$ 12.33	<0.001
Lymphocytes count (%)	24.46 $\pm$ 11.68	16.34 $\pm$ 11.05	<0.001
RDW (fL)	42.12 $\pm$ 3.69	42.62 $\pm$ 4.09	0.323

*TLC = Total Leucocyte Count

RBC= Red Blood Cells

Hb = Hemoglobin

Hct = Hematocrit

RDW (fL) = Red blood cell Distribution Width (femtoliters)

There was a statistically significant association between ISS severity and total leukocyte count, red blood cell count, hemoglobin levels, hematocrit, neutrophil counts, and lymphocyte counts on presentation.

There was a statistically significant association between hospital admission duration and total leukocyte counts, red blood cell counts, hemoglobin levels, hematocrit, neutrophil counts, lymphocyte counts, and red cell distribution width on presentation (Table-III).

Table-III: Comparison of Hematological Parameters with Hospital Stay Duration (n=250)

Hematological Parameter	Hospital Stay (≤ 7 days) Mean $\pm$ SD	Hospital Stay (> 7 days) Mean $\pm$ SD	p-value
TLC ($\times 10^9/L$)	10.83 $\pm$ 3.92	12.97 $\pm$ 6.03	0.001
RBC ($\times 10^{12}/L$)	4.99 $\pm$ 0.71	4.47 $\pm$ 0.86	<0.001
Hb (g/dL)	14.18 $\pm$ 1.86	13.00 $\pm$ 2.21	<0.001
Hct (%)	41.60 $\pm$ 5.17	37.52 $\pm$ 7.29	<0.001
Platelet count ($\times 10^9/L$)	223.85 $\pm$ 68.34	204.37 $\pm$ 90.46	0.054
Neutrophils count (%)	69.98 $\pm$ 13.99	77.63 $\pm$ 11.45	<0.001
Lymphocytes count (%)	22.25 $\pm$ 12.36	15.44 $\pm$ 10.09	<0.001
RDW (fL)	42.01 $\pm$ 3.59	43.04 $\pm$ 4.36	0.044

*TLC = Total Leucocyte Count

RBC= Red Blood Cells

Hb = Hemoglobin

Hct = Hematocrit

RDW (fL) = Red blood cell Distribution Width (femtoliters)

DISCUSSION

The study conclusively found that several hematological parameters of firearm injury patients on presentation are associated with severity of sustained injuries and duration of hospital stay. Since firearm injuries are associated with greater cavitation, more kinetic energy, and greater depth of penetration, they produce more grave injuries than those visible.⁵ They are associated with significant morbidity and mortality. Biomarkers such as different hematological parameters may guide the severity of sustained injuries and clinical outcomes.

Can *et al.*, have found leukocytosis to be associated with ISS greater than 15, but not with clinical outcomes.¹³ Similar results were found in our study, with a statistically significant increase in total leukocyte count in patients with ISS greater than.¹⁵ It was also associated with the length of hospital stay in our study. Low hemoglobin on arrival has been associated with a grave prognosis. The results of this study were statistically significant and associated with hemoglobin on arrival, ISS, and duration of hospital stay. A study by Kawai *et al.*, concluded that

hemoglobin levels on arrival are influenced by factors such as hemodilution and compensatory fluid shifts; low hemoglobin levels are still associated with the severity of injuries.¹⁴ Additionally, another study by Figueiredo *et al.*, described that low hematocrit level is also a valid indicator of severe hemorrhage in trauma patients.¹⁵ In this study, both hematocrit and total red blood counts were associated with the severity of injuries and hospital stay. Thus, in accordance with the literature.

A study conducted by Vulliamy *et al.*, found that platelets develop significant changes in their behavior after severe trauma/blood loss, irrespective of platelet counts.¹⁶ In this study, no association of platelet counts was found with severity or duration of hospital stay. Another study by Fields *et al.*, concluded that shock weakens platelet aggregation while tissue injury increases it.¹⁷ This may be the reason why platelet counts on arrival are a non-reliable parameter. It was also presented by Janicova *et al.*, that after trauma, neutrophils play an important role in the initiation and upregulation of the inflammatory response.¹⁸ In this study, a statistically significant association of neutrophil counts on arrival with ISS and length of hospital stay was found. Studies like Finlay *et al.*, claimed that they have found neutrophilia in trauma patients, peaking about 3 hours after insult and remaining elevated for days.¹⁹ Therefore, neutrophil count may serve as an important tool for predicting the severity as well as clinical course of the patient. In contrast to neutrophil counts, lymphocyte counts tend to fall after trauma, a fact was studied by Soulaïman *et al.*²⁰ This study also found similar results, with lymphocyte counts also demonstrating a statistically significant association with severity and hospital stay. Manson *et al.*, have found lymphopenia within 24 hours of trauma, which persisted in patients developing multi-organ dysfunction syndrome.²¹ Both neutrophil and lymphocyte counts may serve as important indicators in firearm injury patients.

Red cell distribution width, which reflects the variation in red blood cell size, has been extensively investigated as a prognostic marker of disease severity in infections, sepsis, COVID-19, pulmonary embolism, and atrial fibrillation.²² In the present study, an association was observed between red cell distribution width and length of hospital stay in patients with firearm injuries. Similar findings have been reported in the literature, where red cell distribution width has been identified as a prognostic indicator of mortality

in trauma patients and shown to be significantly elevated among this group. Therefore, red cell distribution width is also important in firearm injury patients.

LIMITATIONS OF STUDY

This was a single-center study done on a limited number of patients. Hematological parameters were studied only on arrival. Further studies on trends of hematological parameters on a larger sample will provide more insight into the topic.

CONCLUSION

Several hematological parameters of firearm injury patients on presentation are associated with severity of sustained injuries and duration of hospital stay. While hemoglobin levels, total leukocyte counts, and hematocrit levels are commonly assessed in firearm injury patients, neutrophil counts, lymphocyte counts, and red cell distribution width on presentation may also serve as important markers for determining severity of sustained injuries and stepping up treatment strategies.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AHM & MA: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

MRS & ZA: Data acquisition, data analysis, approval of the final version to be published.

AH: Critical review, concept, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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