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ORIGINAL ARTICLE

Epidemiology and emergency management of firearm injuries presenting to Tertiary Care Hospital.

Madeeha Gul[1], Tahirullah Khan[2], Fawad Inayat[3], Muhammad Jawad Ullah[4], Khaliq Jan[5], Numan Khan[6]

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ABSTRACT… Objective: To analyze the demographic, clinical, and management characteristics of firearm injuries to formulate prevention strategies and optimize trauma care. **Study Design:** Retrospective Cross-sectional study. **Setting:** Lady Reading Hospital, Peshawar. **Period:** 15/4/2021 to 25/12/2021. **Methods:** including 147 patients with firearm injuries admitted. Data on demographics, injury characteristics, management strategies, and outcomes were collected from medical records. Statistical analysis was performed using SPSS version 25.0, with associations assessed through Chi-square tests. **Results:** The study population had a mean age of 35.2 ± 12.4 years, with 80% being male. Assault was the leading cause of injury, accounting for 62.5% of cases in males and 33.3% in females. Accidental injuries were more common in females (50%) compared to males (25%). Head and neck injuries were most prevalent, observed in 50% of females and 37.5% of males. Surgical intervention was required in 60% of cases, while 40% were managed conservatively. Significant associations were found between gender and anatomical location (p=0.02), as well as between age and cause of injury (p=0.02). **Conclusion:** Firearm injuries predominantly affect young males, with distinct gender- and age-based patterns. Males experienced a higher proportion of assault-related injuries, while females had more accidental injuries, emphasizing the need for gender-specific prevention strategies, including firearm safety education and community-based violence prevention programs. Younger individuals were disproportionately affected by head and neck injuries and assault-related incidents, underscoring the importance of age-specific interventions.

Key words: Firearms, Gunshot, Injury Severity Score, Trauma Centers, Violence, Wounds.

INTRODUCTION

Firearm-related trauma represents a significant global public health burden, with an estimated 251,000 deaths reported annually worldwide, constituting approximately 4% of all injury-related mortalities.[1] The World Health Organization (WHO) data indicates a rising trajectory in firearm-related morbidity and mortality, particularly in developing nations, with substantial socioeconomic implications.[2] Epidemiologic studies reveal that firearm injuries afflict persons in their productive years more frequently, predominantly male and with a mean age distribution of 25-45 years of age, which results in great loss.[3]

The etiology of firearm injuries is a complicated interrelation of societal, behavioral, and environmental factors. Contemporary literature categorizes these injuries into three primary mechanisms: unintentional discharge (accidental), assault (interpersonal violence), and self-inflicted injuries (suicide attempts).[4] The degree and severity of injury for ballistic projectiles is governed by their ballistic properties and their reaction to human tissue. Modern ballistics research indicates that tissue damage occurs through three primary mechanisms: This dependence leads to injury patterns that vary considerably depending on the projectile velocity, mass, and tissue characteristics and involves permanent cavity formation, temporary cavity effects, and secondary missile formation.[5]

Firearm injury pathophysiology involves complex patterns of trauma mechanisms associated with the direct destruction of tissues, shock wave

1. BDS Resident Oral and Maxillofacial Surgery, Lady Reading Hospital Peshawar, Pakistan.
2. BDS, FCPS, CHPE, Associate Professor Oral and Maxillofacial Surgery, Lady Reading Hospital Peshawar, Pakistan.
3. MPhil Scholar Biochemistry, Abdul Wali Khan University, Mardan, Pakistan.
4. PhD Microbiology, Lecturer Allied Health Sciences, Iqra National University, Peshawar, Pakistan.
5. PhD Nursing, Assistant Professor Nursing, Iqra University, Chak Shahzad, Islamabad Pakistan.
6. BDS, Resident Oral and Maxillofacial Surgery, Lady Reading Hospital Peshawar, Pakistan.

Correspondence Address:
Dr. Tahirullah Khan
Department of Oral and Maxillofacial Surgery
Lady Reading Hospital, Peshawar.
dr.tahir786@hotmail.com

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propagation, and secondary injury cascades.[5] This first trauma is followed by a systemic inflammatory response syndrome (SIRS) which can rapidly precipitate multiple organ dysfunction syndrome (MODS).[6] Neurological involvement, especially head and neck injuries, sets into effect a cascade of events including elevated intracranial pressure, cerebral edema, and perhaps brainstem herniation. Glasgow coma scale is a very significant prognostic indicator; scores correlate very highly with both mortality and functional outcome.[7]

Firearm injury management is multi-disciplinary involving pre-hospital care, acute surgical intervention, and long-term rehabilitation. Currently, treatment protocols focus on damage control resuscitation (DCR) and damage control surgery (DCS) in patients with severe injuries.[8] The factors on which the decision-making algorithm between conservative and surgical management depends are several in number and include anatomical location, hemodynamic stability, and associated injuries. Injury assessment and surgical planning is accomplished by employing advanced imaging modalities such as computed tomography angiography (CTA).[9]

Although substantial resources have been spent researching trauma care, the literature is filled with gaps in knowledge about firearm injuries. Mortality outcomes have been mostly studied in prior research but measures of functional outcomes and quality of life have been lacking in the literature. However, there is also a paucity of data on sex-specific injury patterns, differences in pediatric trauma response, and the relationship between anatomy and neurological outcome. In addition, the influence of varying management strategies on long-term functional outcomes is insufficiently explored.[10]

To address these knowledge gaps, we did a comprehensive study of demographic patterns, injury characteristics, and management outcomes in firearm trauma patients. This research involves a rigorous methodological examination of the relationships between gender, age, anatomical location of injury, and neurological outcome, measured by the Glasgow Coma Scale. The results of this study will aid in the development of evidence-based management protocols, as well as identify high-risk groups that may be targeted for interventions. Furthermore, analysis of management strategies, as well as management outcomes, will be potentially useful in improving health and in optimizing patient care in the setting of firearm trauma.

METHODS

A retrospective cross-sectional study was conducted to examine the epidemiological patterns, clinical features, and management outcomes for firearm injuries. Data was collected from Lady Reading Hospital, Peshawar, Pakistan, which is the primary trauma referral centre for a catchment of multiple districts and has a trauma care unit, as well as experienced 24 hour surgical services.

It was approved by the Ethical Review Board of Lady Reading Hospital, Peshawar, Pakistan in the study protocol by the Declaration of Helsinki guidelines (Approval No. 104/LRH/MTI). Due to the retrospective nature of the study, and anonymization of the data, the ethics committee waived the need for consent from individual patients.

The study population comprised of patients presenting with firearm injuries between 15/4/2021 to 25/12/2021. Inclusion criteria included patients aged ≥18 years with documented firearm injuries, regardless of injury location or severity. Exclusion criteria were: patients dead on arrival, cases with >20% missing medical data, and those who left against medical advice within 24 hours of admission.

Sample size calculation was performed using Epi Info version 7.2, considering a confidence level of 95%, margin of error of 5%, and expected proportion of surgical intervention in firearm injuries of 60% based on pilot data. The minimum required sample size was calculated to be 147 patients; 150 patients were included to account for potential data inconsistencies.

Data collection was executed using a standardized electronic data extraction form developed through expert consensus. Variables collected included demographic characteristics (age, gender, education level, marital status), injury-specific information (anatomical location, cause, Glasgow Coma Scale scores), and management details (conservative vs. surgical intervention). The Glasgow Coma Scale was assessed at presentation by trained emergency department personnel. Two independent researchers extracted the data to ensure accuracy, with any discrepancies resolved through consensus or consultation with a senior researcher.

Statistical analysis was performed using SPSS. The normality of continuous variables was assessed using the Shapiro-Wilk test. Descriptive statistics were presented as means ± standard deviations for normally distributed continuous variables and frequencies (percentages) for categorical variables. Associations between categorical variables were analyzed using Chi-square tests or Fisher's exact test when expected cell frequencies were less than 5. Statistical significance was set at $p<0.05$, and all tests were two-tailed.

RESULTS

The demographic analysis reveals a predominantly male study population (80%) with a mean age of 35.2 ± 12.4 years. The majority of participants (60%) were married, indicating a significant adult population base. Educational distribution showed that half of the participants (50%) had secondary education, while primary and graduate education levels were equally distributed at 30% and 20% respectively. This demographic profile suggests that firearm injuries affect primarily working-age males with moderate educational backgrounds.

The age distribution analysis demonstrates a concentration of cases in the 25-45 years age range, highlighting that firearm injuries predominantly affect young to middle-aged adults. This pattern has significant socioeconomic implications as it affects the most productive age group of the population.

The management strategies for firearm injuries demonstrate a predominant preference for surgical intervention, with 60% of cases requiring surgical management, while 40% were managed conservatively. This distribution reflects the severity and complexity of firearm injuries, often necessitating surgical intervention for optimal patient outcomes as shown in Table-II.

Variable	Details	Frequency	Percentages
Gender	Male	89	65.93%
	Female	46	34.07%
Age Groups	Group 1 (5–15 years)	3	2.22%
	Group 2 (16–25 years)	42	31.11%
	Group 3 (26–45 years)	84	62.22%
	Group 4 (46+ years)	6	4.44%
Cause	Handgun	67	49.63%
	Riffle	49	36.3%
	Blast	17	12.59%
	Missile	2	1.48%
Anatomical Location	Mandible	70	51.85%
	Mid face + Mandible	33	24.44%
	Mid face	32	23.7%
Pattern of injury	Soft tissue + Hard tissue penetrating wound	52	38.52%
	Soft tissue penetrating wound	44	32.59%
	Soft tissue + Hard tissue avulsed wound	26	19.26%
	Soft tissue avulsed wound	13	9.63%
Outcome	Two phase treatment	68	50.37%
	Single phase treatment	67	49.63%

Table-I. Demographic details of the included participants

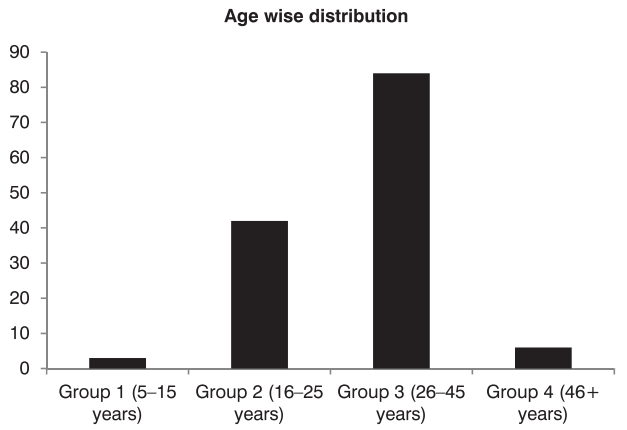

Figure-1. Age wise distribution of the participants

Gender-based analysis revealed statistically significant differences in both anatomical location (p=0.02) and cause of injury (p=0.01). Males showed a higher proportion of assault-related injuries (62.5%) compared to females (33.3%). Conversely, females had a higher percentage of accidental injuries (50% vs 25% in males). Regarding anatomical location, head and neck injuries were more prevalent in females (50%) compared to males (37.5%). This suggests distinct gender-based patterns in both the cause and location of firearm injuries as shown in Table-III.

Age-based analysis showed significant associations with both anatomical location (p=0.03) and cause of injury (p=0.02). Younger individuals (≤35 years) had a higher proportion of head and neck injuries (44.4%) and assault-related incidents (61.1%) compared to older individuals. The older age group (>35 years) showed a more even distribution across anatomical locations and causes, suggesting different risk patterns based on age groups as shown in Table-IV.

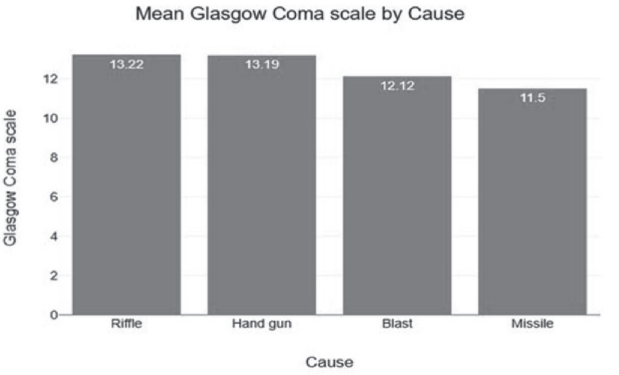

Figure-2. Mean Glasgow coma scale by cause

Analysis of consciousness levels using the Glasgow Coma Scale (GCS) reveals varying severity based on the cause of injury. Accidental cases showed the highest mean GCS (14.2), indicating better consciousness levels, while suicide attempts had the lowest mean GCS (10.8), suggesting a more severe neurological impact. Assault cases showed intermediate severity with a mean GCS of 12.5.

Management	Frequency	%
ATLS Protocol, Soft tissue debridement and irrigation, Soft tissue repair, Temporary fracture stabilization, Prophylactic Antibiotics, ORIF	49	36.3%
ATLS Protocol, Soft tissue debridement and irrigation, Soft tissue repair, Temporary fracture stabilization, Prophylactic Antibiotics	24	17.78%
ATLS Protocol, Soft tissue debridement and irrigation, Prophylactic Antibiotics	13	9.63%
Soft tissue repair, Prophylactic Antibiotics	13	9.63%
ATLS Protocol, Soft tissue debridement and irrigation, Soft tissue repair, Temporary fracture stabilization	12	8.89%
ATLS Protocol, Soft tissue repair, Temporary fracture stabilization, Prophylactic Antibiotics, ORIF	11	8.15%
ATLS Protocol, Soft tissue debridement and irrigation, Soft tissue repair, Prophylactic Antibiotics	8	5.93%
ATLS Protocol, Soft tissue debridement and irrigation, Soft tissue repair, Prophylactic Antibiotics, ORIF	3	2.22%
ATLS Protocol, Soft tissue repair, Temporary fracture stabilization, Prophylactic Antibiotics	1	0.74%
Soft tissue debridement and irrigation, Soft tissue repair, Temporary fracture stabilization, Prophylactic Antibiotics	1	0.74%

Table-II. Management of the firearm injury

Variable	Details	Gender		Test Value	P-Value
		Male	Female		
Cause	Handgun	37	30	12.69 (3)	0.005
	Riffle	34	15		
	Blast	17	0		
	Missile	1	1		
Anatomical location	Mandible	27	43	49.06 (2)	<0.001
	Mid face + Mandible	29	3		
	Mid face	33	0		
	Soft tissue + Hard tissue penetrating wound	23	3	31.66 (3)	<0.001
	Soft tissue penetrating wound	37	15		
	Soft tissue + Hard tissue avulsed wound	29	15		
	Soft tissue avulsed wound	0	13		
Outcome	Two phase treatment	54	14	11.09 (1)	0.001
	Single phase treatment	35	32		

Table-III. Association of gender with different factors of firearm injury

Variable	Details	Age Group				Test Value	P-Value
		Group 1 (5–15 years)	Group 2 (16–25 years)	Group 3 (26–45 years)	Group 4 (46+ years)		
Cause	Handgun	1	15	48	3	18.21 (9)	0.033
	Riffle	2	25	20	2		
	Blast	0	2	14	1		
	Missile	0	0	2	0		
Anatomical location	Mandible	1	26	39	4	18.04 (6)	0.006
	Mid face + Mandible	0	14	17	2		
	Mid face	2	2	28	0		
	Soft tissue + Hard tissue penetrating wound	1	2	45	4	70.74 (9)	<0.001
	Soft tissue penetrating wound	0	26	17	1		
	Soft tissue + Hard tissue avulsed wound	2	2	22	0		
	Soft tissue avulsed wound	0	12	0	1		
Outcome	Two phase treatment	0	15	49	4	9.42 (3)	0.024
	Single phase treatment	3	27	35	2		

Table-IV. Association of age-wise with different factors of firearm injury

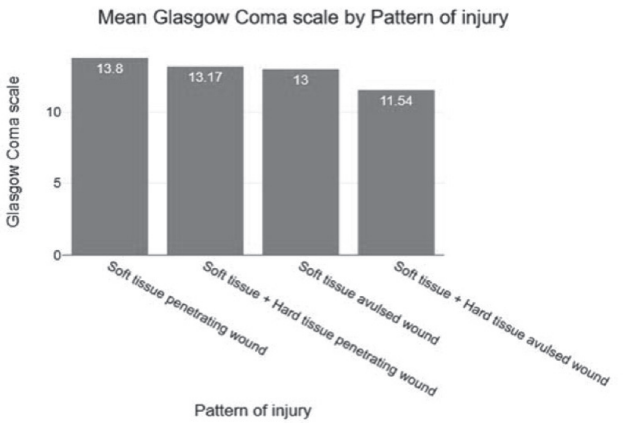

Figure-3.Mean Glasgow coma scale by pattern of injury

The graph shows that "Soft tissue penetrating wound" has the highest mean GCS score (13.8), followed by "Soft tissue + Hard tissue penetrating wound" (13.17) and "Soft tissue avulsed wound" (13). The lowest mean GCS score is observed in "Soft tissue + Hard tissue avulsed wound" (11.54). This suggests that injuries involving both soft and hard tissue, particularly avulsed wounds, are associated with lower GCS scores, indicating more severe neurological impairment.

DISCUSSION

These findings provided substantial insights on

the epidemiology, clinical characteristics and management of firearm injuries in our setting. Our study participants demographic profile showed mean age of 35.2 ± 12.4 years and male predominance (80%) and concords with figures reported in literature. Consequently, this is an age group of the most economically productive part of society, therefore of high socioeconomic significance.[11] It appears that firearm injuries occur regardless of educational attainment, as the educational distribution shows 50% of patients with secondary education and 20% with graduate-level education.[12]

The gender-based analysis revealed significant differences in both injury patterns and etiology (p=0.01). The higher prevalence of assault-related injuries in males (62.5%) compared to females (33.3%) suggests different risk exposures between genders.[13] Conversely, the higher proportion of accidental injuries in females (50% vs 25% in males) warrants attention to household firearm safety, particularly in contexts where females may have less familiarity with firearm handling. The notable gender disparity in head and neck injuries (50% in females vs 37.5% in males, p=0.02) requires further investigation into potential targeting patterns or exposure circumstances.[14]

Age-stratified analysis demonstrated significant associations with both anatomical injury patterns (p=0.03) and injury causes (p=0.02). The higher proportion of head and neck injuries (44.4%) and assault-related incidents (61.1%) among younger individuals (≤35 years) suggests targeted violence in this age group. This finding has implications for violence prevention programs, indicating the need for age-specific interventions.[15,16]

The management patterns, showing 60% of cases requiring surgical intervention, highlight the resource-intensive nature of firearm injury care. The significant association between anatomical location and the need for surgical intervention (p<0.001) emphasizes the importance of early triage and resource allocation in trauma centers.[17] The Glasgow Coma Scale analysis provides valuable insights into injury severity patterns, with suicide attempts showing the lowest mean GCS scores (10.8 ± 2.3) compared to accidental injuries (14.2 ± 1.5). The finding, however, suggests that strictly purposeful self-harm causes more neurologic compromise, and it requires more intensive medical management than accidental self-harm.[18]

This is consistent with the literature on trauma outcomes as blunt injuries observed higher mean GCS scores of 13.8 ± 1.7 than penetrating injuries (12.3 ± 2.0). The implication of this difference in neurological status is to impact immediate management protocol and resource allocation in emergency settings.[19,20]

Implications of these findings for public health policy and clinical practice are several: Prevention strategies should be gender specific there is more risk of assault for males, but more risk of firearm usage for females and firearm safety education should be targeted toward female shooters.[21,22] Second, the trauma care systems should be constructed to deal with excessive proportions of cases that need surgical interventions, especially in high prevalence firearm injury areas.[23,24] Third, there is a very large proportion of head and neck injuries, particularly amongst females and younger individuals, requiring neurotrauma care expertise in trauma centers.[25]

Limitations of the study include single center design and the retrospective nature that will likely limit generalizability of findings. Moreover, long term follow-ups data was unavailable; therefore, we could not learn about long term outcomes and rehabilitation needs. Long term functional outcomes in survivors should be investigated, as well as the additional findings may be validated in prospective multicenter studies.

CONCLUSION

This study highlights the significant public health burden of firearm injuries, with distinct gender- and age-based patterns necessitating targeted interventions. Males experienced a higher proportion of assault-related injuries (62.5%), while females had more accidental injuries (50%), emphasizing the need for gender-

specific prevention strategies, including firearm safety education and community-based violence prevention programs. Younger individuals (<35 years) were disproportionately affected by head and neck injuries (44.4%) and assault-related incidents (61.1%), underscoring the importance of age-specific interventions. The resource-intensive nature of firearm injury management, with 60% of cases requiring surgical intervention, highlights the need for well-equipped trauma care systems. The significant association between injury patterns and severity, as evidenced by Glasgow Coma Scale scores (e.g., 10.8 in suicide attempts vs. 14.2 in accidental injuries), further underscores the importance of specialized neurotrauma care.

RECOMMENDATIONS

Future multicenter prospective studies are essential to validate these findings, explore long-term outcomes, and inform evidence-based policies aimed at reducing the incidence and impact of firearm injuries.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Madeeha Gul:** Idea conception, study designing, data collection, manuscript writeup.
2	**Tahirullah Khan:** Idea conception, study designing, manuscript review and approval.
3	**Fawad Inayat:** Idea conception, study designing, manuscript writeup and review, data entry and analysis.
4	**Muhammad Jawad Ullah:** Idea conception, study designing, manuscript writeup and review, data entry and analysis.
5	**Khaliq Jan:** Idea conception, study designing, manuscript review and approval.
6	**Numan Khan:** Idea conception, study designing, manuscript review and approval.