Limb Injuries in Combat Trauma: A Retrospective Analysis of 166 Cases at a Tertiary Care Center in Counter Insurgency Operational Area

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Abstract

Background: Limbs are the most common site of injuries in combat trauma. There is insufficient data on limb injuries sustained in the combat zone of the Indian Armed Forces. This study aims to analyze limb injuries in 166 cases at a tertiary care center in counter insurgency operational area.

Materials and Methods: All casualties with limb injuries who presented to the center from January 2014 to December 2019 were included in the study. Data were obtained from admission and discharge registers, central registry, and operation theater registers. Casualties who were killed in action were excluded from the study. The extremity involved, wounding agent, type of injury, length of hospital stay (LOHS), number of surgical interventions, and type of reconstruction undertaken were recorded.

Results: Limb injuries accounted for 61% of all casualties, with a mean age of 30.45 ± 6.72 years. Nearly 67% of all injuries were caused by fragmentation device, 61% were of soft-tissue (ST) type, and 39% were of ST injuries with fractures (STFs). The LOHS and number of surgical interventions for STFs were statistically significantly higher (P < 0.001). There was a moderate correlation between the grades of injuries, LOHS, and number of surgeries. The most common reconstruction undertaken was split skin graft in 32% cases.

Conclusion: This study for the first time evaluates limb injuries in combat-related trauma in Indian Armed Forces. It also analyzes the LOHS, and number of surgeries with the type of injuries and their correlation.

Keywords: Combat trauma, length of hospital stay, limb injuries

Introduction

Limbs are the most common site of injuries in combat trauma as compared to other body parts.[1] These injuries may not pose an immediate threat to life unless associated with injuries to vital structures. Nevertheless, they cause significant disability to the soldiers and require long-term rehabilitation. The orthoplastic approach in the management of these injuries has improved the outcomes and more limbs have been salvaged, combining the team approach.[2] There is insufficient information about the limb injuries sustained during combat in the Indian Armed Forces. Most studies that have been published for the Indian Armed Forces are related to combat trauma encompassing all the regions of the body or to any specific region of the body.[3] This study aims to describe and analyze 166 cases of limb injuries managed at a tertiary care center of Northern Command situated in a counter insurgency operational area (CI Ops). The study also focuses on the nature of injury concerning the wounding agents, length of hospital stay (LOHS), and number of surgeries and their correlation.

Materials and Methods

This was a retrospective study of all cases of combat-related extremity injuries evacuated to a tertiary care center at Northern Command between January 2014 and December 2019. All casualties with limb injuries who presented to the center were included in the study. Data were obtained from admission and discharge registers, central registry, and operation theater registers. Casualties who were killed in action were excluded from the study. The extremity involved, wounding agent, type of injury, length of hospital stay (LOHS), number of surgical interventions, and type of reconstruction undertaken were recorded.

Results: Limb injuries accounted for 61% of all casualties, with a mean age of 30.45 ± 6.72 years. Nearly 67% of all injuries were caused by fragmentation device, 61% were of soft-tissue (ST) type, and 39% were of ST injuries with fractures (STFs). The LOHS and number of surgical interventions for STFs were statistically significantly higher (P < 0.001). There was a moderate correlation between the grades of injuries, LOHS, and number of surgeries. The most common reconstruction undertaken was split skin graft in 32% cases.

Conclusion: This study for the first time evaluates limb injuries in combat-related trauma in Indian Armed Forces. It also analyzes the LOHS, and number of surgeries with the type of injuries and their correlation.

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Command. Data from January 2014 to December 2019 were collected and evaluated. Institutional Ethical Committee clearance was obtained for the study. The data were obtained from the admission and discharge book, computer data at the central registry, and the operation theater registers, which document all the cases undergoing operative intervention. Patients were identified by the admission and discharge number (A and D) in the data sheet. All fresh cases presenting during the period were included in the study. Casualties who were killed in action were excluded. These casualties were the ones who were brought in dead. There were no deaths in the study group. The demographic profile, extremity involved, the wounding agent which were categorized as bullet and fragmentation were recorded. The fragmentation agents were further subcategorized as artillery shells, grenade blasts, improvised explosive devices (IEDs), and antipersonnel land mines (APLM). The type of wound was classified as soft tissue only (ST), which was further subclassified into Grade 1 – ST injury with no tissue loss and with minimal contamination; Grade 2 – ST injury with tissue loss and severe contamination without associated fracture, vascular, or nerve injury; and Grade 3 – ST injury with vascular or peripheral nerve injury. ST injury with fractures (STFs) which was classified as per Tscherne classification was as follows: Grade 1 – simple fracture, skin laceration with minimal ST damage; Grade 2 – simple fracture with skin laceration with moderate contamination and ST damage; Grade 3 – comminuted fracture with extensive ST damage with or without vascular or nerve injury; and Grade 4 – subtotal or complete amputation, extensive ST damage with or without major vascular or nerve damage. All injuries with loss of a part of an extremity were included in this category. Associated injuries to other parts of the body were also recorded. The number of surgical interventions and LOHS and the reconstructive surgical procedure undertaken for the injuries were also documented.

**Statistical analysis**

The details were entered in the Mac Numbers (Apple Inc.), and data were expressed as mean and standard deviation. The data were analyzed using SPSS statistical analysis software version 20 (IBM®). *P* < 0.05 was taken as statistically significant. Pearson’s correlation coefficient was calculated to determine the correlation between the grades and LOHS and number of surgeries. The clinical outcomes were compared using Student’s *t*-test for the difference between the means of the two groups.

**RESULTS**

From January 2014 to December 2019, we received 272 casualties, of which 166 (61.02%) were with limb injuries. The temporal distribution is shown in Figure 1. The mean age was 30.45 ± 6.72 years. Seventy-three (43.9%) casualties had isolated upper limb injuries, 71 (42.77%) had isolated lower limb injuries, and 22 (13.2%) casualties had concomitant injuries. A total of 112 (67.4%) injuries were caused by explosives or fragmentation devices, whereas 54 (32.5%) were caused by bullets. The distribution of the wounding agent with details is shown in Figure 2. There were 101 (60.8%) casualties with ST injuries and 65 (39.1%) were of ST injuries with fractures (STFs). There was no casualty with STF Grade 1 injury. Details of injuries and their grades are shown in Table 1. The mean LOHS for ST injuries was 23.36 ± 7.98 days and for STF injuries was 30.11 ± 10.35 days. This difference was found to be statistically significant (*P* = 0.0001). The mean number of surgeries performed in ST group was 2.32 ± 0.81 and in STF group was 3.22 ± 0.76. This difference was also found to be statistically significant (*P* = 0.0001). The mean LOHS in bullet injuries was 25.35 ± 10.20 and for fragmentation device injury was 26.17 ± 9.35. The difference was not found to be statistically significant (*P* = 0.30). The mean number of surgeries in bullet injuries was 2.70 ± 0.90 and in fragmentation injuries, it was 2.65 ± 0.90. This difference was not found to be statistically significant (*P* = 0.36). The details of the LOHS and number of surgeries in various subgroups are shown in Table 2. The grade of injuries showed a positive correlation for LOHS and the number of surgeries in both the groups. Pearson’s R value for ST group and STF was 0.5199 and 0.3065, respectively, with *P* < 0.05. The correlation between the variables is shown in Figures 3 and 4. The most common reconstructive surgical procedure undertaken was split skin grafting to cover the wound in 53 (31.9%) cases, followed by secondary suturing in 23 (13.8%) cases. Pedicle flap reconstruction was undertaken in 19 cases. The details of reconstruction undertaken are summarized in Table 3.

**DISCUSSION**

Most of the studies published on combat trauma are retrospective in nature, and our study also retrospectively evaluates the 5-years extremity trauma sustained in CI Ops. The study allowed us to ascertain the incidence of limb injuries, mechanism of injury, LOHS, number of surgical interventions, and the nature of reconstruction aimed at limb salvage. To the best of our knowledge, the present study is first of its kind related to Indian Armed Forces, which focuses on limb trauma. Limb injuries are commonly involved in combat trauma and account for about 60%–70% of all injuries. This may be due
Maurya, et al.: A retrospective analysis of 166 cases at a tertiary care center in counter insurgency operational area

Table 1: Details of injury with their grades (percentages are expressed in brackets)

| Type of wound | Bullet | Artillery shell | Mines | Grenades | IEDs | Total |
|---------------|--------|----------------|-------|----------|------|-------|
| ST Grade 1    | 13 (7.8) | 16 (9.6)       | 0     | 1 (0.6)  | 1 (0.6) | 31 (18.6) |
| ST Grade 2    | 14 (8.4) | 7 (4.2)        | 14 (8.4) | 10 (6.0) | 5 (3.0) | 50 (30.1) |
| ST Grade 3    | 9 (5.4)  | 10 (6.0)       | 0     | 0        | 1 (0.6) | 20 (12.0) |
| Total         | 36 (21.6)| 33 (19.8)    | 14 (8.4) | 11 (6.6) | 7 (4.2) | 101 (60.8) |
| STF Grade 2   | 6 (3.6)  | 4 (2.4)        | 6 (3.6) | 2 (1.2)  | 2 (1.2) | 20 (12.0) |
| STF Grade 3   | 10 (6.0) | 1 (0.6)        | 11 (6.6) | 0        | 0      | 22 (13.2) |
| STF Grade 4   | 2 (1.2)  | 1 (0.6)        | 15 (9.0) | 2 (1.2)  | 3 (1.8) | 23 (13.8) |
| Total         | 18 (10.8)| 6 (3.6)       | 32 (19.2)| 4 (2.4)  | 5 (3.0) | 65 (39.1) |

1IEDs: Improvised explosive devices

Table 2: Length of hospital stay, number of surgeries, and grades of injury

| Injury | Mean length of hospital stay | Mean number of surgical interventions |
|--------|------------------------------|--------------------------------------|
| ST1    | 17.74±4.09                   | 1.68±0.60                            |
| ST2    | 24.46±6.76                   | 2.4±0.61                             |
| ST3    | 29.30±9.97                   | 3.10±0.79                            |
| STF2   | 25.90±7.64                   | 2.85±0.67                            |
| STF3   | 32.00±10.85                  | 3.23±0.69                            |
| STF4   | 31.96±11.19                  | 3.52±0.79                            |

Figure 2: Wounding agents

to the body armor worn by the soldiers and improved overall survival in soldiers who sustain such injuries. The present study accounts for about 61.02% of all the injuries sustained in combat trauma. This is similar to other published studies by various authors, namely Chandler et al.[5] (76%), Zarei et al.[6] (67%), and Rai et al.[7] (59%).

In most of the wars, the fragmentation devices account for the majority of injuries.[8,9] The fragmentation devices include IEDs, rocket-propelled grenades, mortar fire, APLM, and artillery shells. Rai et al.[7] reported that 55.6% of injuries were caused due to explosive devices, however, they did not qualify the type of explosive device though they mentioned IEDs as a passing reference. The present study shows similar findings, with 63% of injuries caused by an explosion. However, when we specified the explosive device, it was found that 80% of these were caused by artillery shells and APLM. This high incidence is due to continuing hostilities across the Western border, where artillery shelling by the hostile nation is a constant feature. The movement of troops in the region of APLM during CI Ops also contributed to such high figures of land mine injuries. These findings can have implications for its administrative and logistic support for the military commanders.

In extremity injuries, there are two components to an injury which are the ST component and the associated osseous involvement. In this study, we identified two distinct types of injuries. The ST type and the ST associated with fractures and osseous involvement. The type of injuries can influence outcomes, hospitalization time, and number of surgeries. When analyzing the ST injuries, we were able to grade them into three different grades (from minimal to major ST involvement and with degrees of contamination). The nerve injuries and vascular injuries were graded separately as they have a bearing on surgical procedures, outcomes, LOHS, and number of surgeries. This grading has not been documented in the literature, and most of the ST injuries are described in association with fractures of the extremities such as AO (Arbeitsgemeinschaft für Osteosynthesefragen) or the Association of the Study of Internal Fixation (ASIF) classification[10] and Gustilo and Anderson classification.[11] In a retrospective study of this nature, these are seldom documented and therefore can lead to errors in data interpretation. Moreover, the Gustilo and Anderson classification is helpful in treatment planning rather than retrospective data analysis. In this study, we were able to classify STFs as per Tscherne classification[3] based on the documented injury characteristics. The numerical grading of injury helped us to calculate the LOHS and number of surgeries and compare the difference between the two groups and their correlation.

The LOHS and number of surgical interventions can be an indicator of the complexity of the injury. With the current approach of orthoplastic procedures, limb salvage is feasible with low amputation rates.[12,13] The difference in LOHS and number of surgical procedures between the two groups (ST and STF) gains significance as it can predict the outcomes early.
Maurya, et al.: A retrospective analysis of 166 cases at a tertiary care center in counter insurgency operational area

Table 3: Details of reconstruction (miscellaneous includes foreign body removal and tendon repair)

| Reconstruction                  | ST1 | ST2 | ST3 | STF2 | STF3 | STF4 | Total (%) |
|---------------------------------|-----|-----|-----|------|------|------|-----------|
| SSG                             | 5   | 29  | 1   | 9    | 6    | 3    | 53 (31.9) |
| Secondary suturing              | 14  | 8   | 0   | 0    | 0    | 1    | 23 (13.8) |
| Local flap cover                | 0   | 6   | 0   | 0    | 0    | 1    | 7 (4.2)   |
| Pedicle flap                    | 0   | 4   | 0   | 4    | 1    | 10   | 19 (11.4) |
| Free flap                       | 0   | 0   | 0   | 0    | 0    | 2    | 2 (1.2)   |
| NPWT and SSG                    | 0   | 2   | 0   | 0    | 5    | 1    | 8 (4.8)   |
| Nerve repair with cable grafts  | 0   | 7   | 0   | 2    | 0    | 9    | 5 (3.4)   |
| Nerve repair                    | 0   | 4   | 0   | 3    | 0    | 7    | 5 (4.2)   |
| Nerve transfers                 | 0   | 0   | 2   | 0    | 0    | 0    | 2 (1.2)   |
| Neurolysis                      | 0   | 0   | 5   | 0    | 2    | 0    | 7 (4.2)   |
| Arterial repair                 | 0   | 0   | 2   | 0    | 0    | 0    | 2 (1.2)   |
| Major amputations               | 0   | 0   | 0   | 0    | 0    | 7    | 7 (4.2)   |
| Miscellaneous                   | 12  | 0   | 0   | 7    | 1    | 0    | 20 (12.0) |
| Total                           | 31  | 49  | 21  | 20   | 20   | 25   | 166       |

SSG: Split skin graft, NPWT: Negative pressure wound therapy

Figure 3: Correlation between grade of injury (soft-tissue type), length of hospital stay, and number of surgeries

on during the hospitalization. Very few studies have compared the difference between the two groups. Bertani et al. in their series of 89 war-related extremity injuries in children found 83 ST injuries and 54 bone injuries.\(^\text{[14]}\) The median LOHS in the cohort of 89 cases was 9 days, and the median operating room admissions were 2 days. The total number of surgical procedures was higher in the group with bone injuries, though they did not comment upon the LOHS. In our study, the mean LOHS for ST and STF groups (23.71 and 30.25 days, respectively) was higher as compared to that of other studies, which could be due to our policy of hospitalization of soldiers till their injury has healed completely and were self-reliant for their activities of daily living at the time of discharge. The difference between the two groups in terms of LOHS was found to be statistically significant. The mean number of surgeries performed in the ST group was also less than the STF group, which is due to the complexity of wound when there is bone involvement. This difference was also found to be statistically significant. We also found a moderate linear correlation between the grades of injury, the LOHS, and the mean number of surgical interventions. These findings, however, have not been reported in the published studies on combat-related extremity trauma. This correlation can be attributed to the complexity of the wound and the definitive reconstruction undertaken in the extremity trauma.

Early ST and bone reconstruction assumes importance in a successful outcome. As combat wounds are sustained due to high-velocity missiles and explosions, the wounds are heavily contaminated with dirt, soil, and other organic components. Besides, there is severe ST and osseous destruction. Therefore, the fundamental principle of wound debridement and skeletal stabilization is of importance in these injuries. Multiple sittings of debridement may be necessary for explosive injuries, and reconstruction is planned once the wound is found to be devoid of any devitalized tissue.\(^\text{[15]}\) In these injuries, the simplest and reliable option is carefully selected keeping in view of the reconstructive ladder.\(^\text{[16]}\) In their series of 83 children with war injuries, Kahraman et al. reported that skin grafting was the most common reconstructive surgical procedure accounting for 21% of cases.\(^\text{[17]}\) In their study of 1319 patients requiring
orthoplastic approach in a role 3 Medical treatment facility of Kabul, Barbier et al. reported that skin grafting was used in 23% of all surgeries performed for combat-related limb trauma.\(^{[18]}\) In our study, the split skin graft was the most common method of reconstruction accounting for 32% of all cases. This is marginally higher, as 61% of the injuries were involving ST only. However, flap reconstruction is indicated in complex injuries involving bone and STs. In this study, flap reconstruction was used in 28 cases (16.8%), of which 19 were pedicled, accounting for a majority of flap reconstruction. This method of reconstruction is rapid and does not require technical expertise and infrastructure of microvascular surgery though we believe that microvascular reconstruction has a distinct role in large complex defects. Our findings are consistent with those of other studies of combat trauma reconstruction with flaps.\(^{[19-21]}\)

Most of the data that have been published in the literature on combat limb injuries are related to the Iraq and Afghanistan wars.\(^{[22,23]}\) This study retrospectively evaluates limb injuries in combat trauma for the Indian soldiers engaged in CI Ops and deployed along the Western border facing hostilities for more than three decades. Therefore, this study fills the gap of the lack of data in Indian Armed Forces.

There are some inherent limitations to this study. Being retrospective in nature, the study relies on the data from the hospital records and central registry. This is prone to errors, though all efforts have been made to countercheck each and every record obtained from various sources and hence, data discrepancy has been minimized. While it is important to classify the injuries into various groups for data analysis, retrospective classification, however, does not accurately define the disparate nature of such injuries. Another factor which could influence the outcome is the time lapse for the casualties to reach the tertiary care center. It could have also been a part of the study; however, these data were not available to us for inclusion. In addition, it is possible to argue that outcomes should have also been the part of the study, however, due to lack of long-term follow-up record in our soldiers, this was currently not feasible. This could be another subject of evaluation and will give insight into the long-term outcomes of such injuries.

**Conclusion**

The study for the first time evaluates limb injuries in the combat zone and demonstrates the grade of injuries, hospitalization time, number of surgeries, and their correlation in the ongoing military operation by the Indian Armed Forces. This study can form a basis of logistic and administrative support in providing quality combat trauma care and also focus on preventive aspects.

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**Conflicts of interest**

There are no conflicts of interest.

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