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NORTH CLIN ISTANB 2019;6(1):1–5
doi: 10.14744/nci.2018.09225

ORIGINAL ARTICLE GENERAL SURGERY

Effects of weapon types, interventions, and transport times on complications in combat injuries to musculoskeletal system

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ABSTRACT

OBJECTIVE: To analyze the effects of weapon type, medical interventions, and transportation time on complications due to combat-related injuries of the musculoskeletal and soft tissue.

METHODS: A total of 108 patients treated at the emergency department over a period of 3.5 years were included in this study. The effects of weapon type, type of first intervention team, interventions at the emergency department, and transport time on complications were compared by retrospectively assessing patients' recorded data.

RESULTS: The average age of 108 patients with soft tissue injuries was 24 years. Twenty-five patients developed complications. The ratio of complications in patients with injuries from explosive weapons was 25.42% and was significantly greater ($p<0.05$) than the rate observed from non-explosive weapons. Regarding the transport time of patients reaching the hospital, the greatest complication rate was 30.77% in patients transported to the hospital in 2–4 hours; this rate was significantly ($p<0.05$) greater than for those transported in other time ranges. Regarding the emergency department procedures, the complication rate was 37.50% and significantly higher ($p<0.05$) in the group that received debridement + irrigation + late primary repair.

CONCLUSION: Transporting the injured to the emergency department within the first two hours, treatment including irrigation and debridement, and secondary healing following explosive injuries containing contamination and dead tissue appear to be good options for reducing complications.

Keywords: Combat related injuries; complication rates; musculoskeletal system; soft tissue.

Cite this article as: *Senocak R, Tas H, Ureyen O, Kaymak S, Hancerliogullari O. Effects of weapon types, interventions, and transport times on complications in combat injuries to musculoskeletal system. North Clin Istanb 2019;6(1):1–5.*

Combat injuries of the musculoskeletal system (MSS) in today's battles are as high as 60–70% [1]. Approximately 40% of these injuries occur from bullets, and 60% occur from the blast effect and fragmentation of explosive weapons [2, 3]. Explosive weapons are preferred by terrorist groups because of their ease of production, they are relatively inexpensive, and they are able to inflict numerous injuries and death.

In addition to the direct effects of explosive weapons, injuries of MSS also occur with blast effects, in which broken pieces of surrounding objects are dragged into soft and bony tissues. From the beginning, this type of injury is typically more contaminated than projectile injuries, thus, increasing the complication rates and sequelae [2–5]. The effectiveness of wound debridement and irrigation, antibiotherapy, and surgical procedures

Received: August 23, 2017 *Accepted:* January 21, 2018 *Online:* August 07, 2018

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on complication rates is well known [6–9]. However, there are some other factors affecting the complications of MSSs related to projectile injuries. According to various studies, it is still controversial whether the type of weapon, the person who makes the first intervention, the transport time, and the types of intervention at the emergency department (ED) have important effects on complications [8, 10].

The aim of this study was to present the effects of weapon type, type of first intervention team, interventions at the ED, and transport time on complications due to combat related injuries of musculoskeletal and soft tissue (ST), which is the most common injury type in modern battles.

MATERIALS AND METHODS

Included in this study were 108 patients with combat injuries of the ST and MSS who were treated at Role II military hospital over a period of 3.5 years. A retrospective review of hospital records for all patients who sustained injuries was approved by the institutional review board. Patients with fractures, major vascular injuries, and penetrating injuries of the head, chest, and abdomen were excluded from the study.

The first interventions made during the prehospital period were carried out by paramedics when there was an emergency medical service available. Under other conditions, interventions were carried out by non-paramedics including those who were well-trained in first aid. Patient transportation by air or highway was decided in accordance with the weather conditions and the general condition of the patient after communication with the ED.

Quick and effective systemic examinations were performed on the patients brought to the ED. At first, vital signs were evaluated, then vascular access was established, and blood sampling was made according to laboratory investigations that included a blood group determination. Anal region examinations and the urethral catheterizations of patients were also performed in patients with abdominal injuries. Prophylactic tetanus vaccines and intravenous isotonic solution with triple antibiotic therapy (first generation cephalosporins, aminoglycosides, and metronidazole) were then given to all cases, and the patients were subsequently monitored. Owing to the fact that we are a Role 2 hospital, during the blood transfusion given to the cases at the shock table, whole blood was used after cross-matches per patient.

Typing wounds was made according to the injured tissues Type ST (Soft-tissue wounds), Type F (Wounds with fractures), Type V (Vital wounds putting the patient's life at risk.) Type VF (Wounds with fractures and involving vital structures putting life or limb at risk). The wound was graded according to severity by International Committee of the Red Cross (ICRC). Grade 1 (Low energy transfer), Grade 2 (High energy transfer), Grade 3 (Massive energy transfer).

Superficial soft-tissue wounds required only simple local wound toilet. They were cleansed with soap, water, and a disinfectant and a simple dry dressing applied; the small wound was left open to heal by secondary intention. Grade 2 and 3 wounds required a full surgical exploration and excision, some required serial debridement or leave open and late primary repair except soft tissues of hand and head.

If less than 4 hours since wounding, immediate primary closure, after full debridement, with a subcutaneous drain was permissible. If more than 4 hours old, it was better to leave the wound open for delayed primary closure after 2–4 days. This was usually accomplished by direct suture: simple approximation of the deep structures and skin with minimal mobilization of the skin edges, and without tension. Once the wound was adequately excised, it was covered with a bulky absorbent dressing made of absorbent cotton wool.

Surgical interventions such as wound dressings, primary repairs, irrigation + debridement + late primary repair, and irrigation + debridement + secondary healing were applied to patients in stable conditions. In our ED, the weapon type causing the injury, the person who provided first aid, the transport time, and the treatments performed at the ED were recorded.

Patients' data were evaluated retrospectively, and the effects of the weapon type causing the injury, the type of first treatment team, the interventions made in the ED, and transport times on the complications were compared. The SPSS for Windows 15.0 program (SPSS, Inc., Chicago, IL,USA) was used for statistical analyses. For comparisons among groups, Student's t-tests and Mann Whitney U tests were applied. Relationships of numeric values were investigated with correlation analyses. Qualitative data were compared with chi-square tests. In statistical decisions, $p<0.05$ level was accepted as a significant difference.

RESULTS

The average age of the 108 patients evaluated in this study was 24 years. There were 91 extremity musculoskeletal injuries, 3 abdominal injuries, 2 chest injuries, and 12 head injuries (Table 1).

Among the patients included in the study, complications developed in 25 patients, 20 (80%) of whom had wound infections. Other complications included one patient with a colostomy construction for protecting the wound, two had a loss of extremity function, one had a secondarily applied amputation due to compartment syndrome and wound infection, and one had orchitis (Table 2).

Comparisons among complications, type of weapon causing the injury, interventions in the ED, and transport times are shown in Table 3. According to these data, 54.6% of injuries were due to explosive weapons and 45.4% of injuries were due to bullets. However, complication rates were 25.42% for injuries with explosive weapons and only 20.41% in bullet-related injuries ($p < 0.05$). In comparing complication rates in terms of whether the first intervention was made by paramedics or not, there was no significant difference ($p>0.05$). With regard to arrival times, 42.6% of patients arrived at the hospital within the first hour, 38.9% arrived in 1–2 hours, 12% in 2–4 hours, and 6.5% in more than 4 hours. There was a significantly higher complication rate (30.77%) for those patients who arrived within the 2–4 hours period ($p<0.05$). Treatment procedures in the ED included wound dressing to 37.04% of patients, primary repair to 6.48% of patients, irrigation + debridement + late primary repair to 22.22% of patients, and irrigation + debridement + secondary healing to 34.26% of patients. A significantly higher complication rate (37.5%) was observed in the irrigation + debridement + late primary repair group ($p<0.05$).

Table 1. Demographic data of the patients and anatomic locations of MSS-ST injuries

Average	n	%
Age (years)	24	
Male	102	94.4
Female	6	5.6
Anatomic locations of MSS-ST GSW		
Abdomen	3	2.78
Thorax	2	1.85
Head	12	11.11
Only MSS-ST injuries	91	84.26

MSS: Musculoskeletal system; ST: Soft tissue.

Table 2. Types and rates of various complications

	Quantity	%
Wound infection	20	80
Diverting colostomy	1	4
Extremity dysfunction	2	8
Amputation†	1	4
Orchitis‡	1	4
Total	25	100

†Secondary to wound infection and compartment syndrome; ‡Secondary to wound infection.

DISCUSSION

The purpose of weapons in modern warfare is to inflict damage on the military battlefield. Currently, the rate of explosive weapons usage is greater than the rate of bullet usage (60% vs. 40%, respectively) [2]. Likewise, explosive weapons are mostly preferred by terrorist groups because they can quickly cause numerous injuries and deaths. According to this study in which we have reported results from conflict zones, 54.6% of injuries were related to explosive weapons and 45.4% were related to bullets. This suggests that explosive weapons, whether they are used in a battlefield zone or terrorist zone, are much preferred in modern wars.

Many studies have examined complications with MSS injuries, which comprise 60–70% of injuries occurring in today's battles where the usage of explosive weapons has increased [9–11]. These studies also indicate that complication rates are much higher for MSS injuries inflicted with high kinetic energy weapons [11]. In our study, the complication rate was 23.5%, and all patients were injured by high kinetic energy bullets or mortar shells, or high kinetic energy weapons like antitank mines. Explosive weapons, due to their high levels of kinetic energy and blast effect, produce musculoskeletal injuries that tend to become contaminated. Therefore, complication rates are expected to be much higher (25.42%) than with bullet injuries.

Table 3. Comparisons among weapon types, first aid team, transport time to the hospital, and ED procedures

	Number of patients		Complication	
	n	%	n	%
Type of weapon				
Bullet	49	45.4	10	20.41
Explosive	59	54.6	15	25.42*
First Aid Team				
Paramedic	61	56.4	15	24.59
Non-paramedic	47	43.6	10	21.28
Transport time to hospital (hr)				
0–1	46	42.6	10	21.74
1–2	42	38.9	10	23.80
2–4	13	12.0	4	30.77*
>4	7	6.5	1	14.29
Procedure applied at the ED				
Surgical dressing	40	37.04	5	12.50
Primary suture	7	6.48	1	14.29
Irrigation + debridement + late primary suture	24	22.22	9	37.50*
Irrigation + debridement + secondary wound healing	37	34.26	10	27.03

*Significantly different that other groups (p<0.05).

In studies related to who provides the first intervention to trauma patients, complication rates have been shown to be less frequent in patients who first receive paramedic intervention [12]. In our study, although there were no statistically significant differences between these two groups, complication rates were less frequent for interventions made by non-paramedics. However, we think this may be due to several reasons. For instance, this reduced rate may be due to limited interventions in battlefield zones, better trained first aid teams, and most importantly, sending the patient to the nearest healthcare team by aircraft for those who are heavy trauma cases.

It is well known that complication rates increase when patient transportation times to the ED are prolonged [13, 14]. Moreover, some studies have reported that complication rates are increased if late debridement is delayed [10]. In our study, we generally found that complication rates increased as transportation times increased. A 30.77% complication rate was found in patients who were brought back within 2–4 hours. Although slightly wounded patients who did not require irrigation and debridement reached the ED in times longer than 4 hours due to transport by highway, a low complication rate of 14.29% was detected.

When surgical procedures applied at the ED were investigated for this study, only wound dressing or primary repair were applied to musculoskeletal injuries not requiring debridement, and low complication rates were found. Irrigation + debridement + late primary repair or irrigation + debridement + secondary healing procedures were applied to soft tissue and musculoskeletal injuries including wide, contaminated, highly dirty and devitalized tissue. In many studies [6] containing these types of musculoskeletal injuries, if the skin is covered without compartment syndrome, the irrigation + debridement + late primary repair method is suggested. Under these circumstances, we observed a complication rate of 37.50%, which is statistically significant. We conclude that this significant difference arises from the fact that all patients in this study were exclusively injured by high kinetic energy weapons.

In conclusion, the first intervention made by paramedics or non-paramedics, but well trained personnel, does not create a significant difference in terms of complication development in conflict zones where medical intervention is limited. Bringing wounded patients to the ED within two hours and performing irrigation + debridement + secondary healing is a good option for reducing the complications resulting from injuries from high kinetic energy weapons.

Acknowledgement: All 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.

Conflict of Interest: The authors declare no conflict of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

Authorship contributions: Concept – H.T., O.U.; Design – H.T., O.U.; Data collection &/or processing – H.T., O.U.; Analysis and/or interpretation – H.T., O.U.; Writing – H. T., S. K., R. S.; Critical review – H. T., S. K., R. S.

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