The Damage Control Orthopedics and External Fixation in traffic accident after 20 Years in the Bosnian War: Our Experience and a Review of the Literature.

Predrag Grubor[2], Gabriele Falzarano[3], Antonio Medici[3], Milan Grubor[2] Raffaele Franzese[4], Giacomo Errico[4], Alessandro Martino[4], Vincenzo Lucio Roberto[5], Luigi Meccariello[1].

(1) U.O.C. Ortopedia e Traumatologia Universitaria, A.O.U.S. Policlinico "Santa Maria alle Scotte", Siena, Italia.
(2) Orthopaedics and Traumatology, Klinical Center, University of Banja Luka, Banja Luka, Republika Srpska, Bosna and Herzegovina.
(3) U.O.C. Orthopedics and Traumatology, Azienda Ospedaliera "Gaetano Rummo", Benevento, Italy
(4) II Università degli Studi di Napoli.
(5) Clinica Ortopedica, II Università degli Studi di Napoli.

Corresponding Author:
Luigi Meccariello, MD
Department of Medical and Surgical Sciences, and Neuroscience, Section of Orthopedics and Traumatology, University of Siena, University Hospital "Santa Maria alle Scotte", Viale Bracci 1, 53100 Siena, Italy.
E-mail: drlordmec@gmail.com
Cell: +39 329 9419574.

ABSTRACT

Introduction: The Damage Control Orthopedics (DCO) with external fixation is the most valuable aid for a surgeon, when a quick and efficient solution to war and civil injuries to the extremities and pelvis is needed.

Material and methods: 2462 wounded patients were analyzed in this study. These patients sustained injuries to the extremities, abdomen, thorax and head, and received primary surgical treatment at the Orthopedics and Traumatology Clinic in Banja Luka in the period between September 15, 1991 and December 1, 1995. Out of the 2462 patients, 122 (4.59%) were women, 24 (0.9%) were children and 2269 (94.15%) were men. The average age of the patients was 33.73 years. 265 (10.77%) sustained muscular and cutaneous injuries to the extremities without bone fractures, and 2197 (89.23%) had broken bone fragments that required stabilization after the primary surgical treatment. Out of the 2197 patients with broken bones, 2043 (92.43%) sustained comminuted fractures with or without bone defects. In 1573 patients (72%) broken bone fragments were primarily stabilized with external fixators, and in 531(24%) with plaster casts and plaster casts combined with Steinmann pins and Kirschner wires. In 91 (4%) extensions were used. This retrospective study shows how to primarily treat the injured extremities, with and without fractures, as well as how to select the method for stabilizing fractured bones. During the period between January 1,2009 and December 31,2013, reveals the method used to treat 658 traffic accidents with injured extremities, who received primary treatment at Banja Luka Clinical Centre. Out of the 658 wounded people, 98 (14.90%) were women, and (94.15%) were men. The oldest wounded woman was 58 years old, the oldest man was 67. The average age of the wounded people was 24.31. In the emergency room we treated 596 (160 open fractures) patients with external fixation for DCO and only 62 patients with Trans-Skeletal Traction when we had problem in trauma team like anesthetists busy with other critically ill patients.

Results: The complications in War trauma with external fixators were as follows: 86 (5.46%) pin tract infections, 3 (0.19%) pin breakages, 42 (2.66%) fixator reassembly procedures due to inadequate primary placement of the external fixator, 6 (0.38%) iatrogenic vascular lesions inflicted with the drill or pin, and 4 (0.25%) iatrogenic nerve lesions. The complication in Traffic accident with external fixation as follows: Pin tract infection 18(3.02%), Pin breakage 0(0%), Fixator reassembly 8(1.34%) , Vascular lesions 1(0.16%),
Neurological lesions 2 (0.33%).
Conclusion: The experience gained during the Bosnian War and the results achieved justify the position that the method of choice for primary stabilization of bone fragments in war wounds and in traffic accidents is the External Fixation.

Key words: War injuries, External Fixation, Damage Control Orthopedics, Bosnian War, Traffic accident.

INTRODUCTION

The Bosnian War was an international armed conflict that took place in Bosnia and Herzegovina between April 6, 1992 [26-28] , and December 14, 1995. According to the October 1995 bulletin of the Bosnian Institute for Public Health of the Republic Committee for Health and Social Welfare [29] the war resulted in 146,340 killed and 174,914 wounded in the territory under the control of the Bosnian Army.
Any new war catches surgeons off guard because they bring with them experiences gained from previous wars, with no knowledge of new weapons that are more devastating than those used before. In the epidemiology of war trauma, medical and paramedical personnel gain experience quickly, but are largely outnumbered by the trauma cases requiring emergency treatment [1, 41, 42].
A war wound is damage to the body inflicted by firearms (blast, projectile, and burn) and sustained in wartime. It is characterized by massive destruction, primary contamination, and modified reactivity of the body [2, 3, 4, 5]. Bone fractures are multi-fragmented (95%), dislocated, deperiostated and accompanied by bone defects [6, 8]
The treatment of open fractures, such as the femoral fracture, especially in patients with multiple injuries, is a controversial problem. The main priority is to save the patient's life. To achieve this, it is essential for a rapid and rigid fixation of the femoral fracture, as well as the treatment of other life-threatening injuries [30].
As a side effect of the expansion of traffic there was a problem of traffic traumatology, which has long since reached the proportions of global epidemic. Over 1.2 million people are killed in traffic accidents worldwide per year, while the number of injured is up to 50 milions. In developed countries in recent years there is

a tendency to reduce the number of casualties in traffic accidents.3 In developing countries, pedestrians make up nearly 40% victims, while in some parts of Africa the percentage goes up to 55%. Approximately half of all victims are pedestrians, cyclists and motorcyclists, the three most vulnerable groups of traffic users, which is also more evident in the less developed countries[52].By treating a great number of injured people on a daily basis, one realizes that the selection of immobilization methods for bone injuries has a major effect on the amount of material used, the number of surgical interventions, the morale of the patients and medical staff, and the final outcome [9]. Damage Control Orthopedics (DCO) is a gradual approach for the management of patients with multiple injuries(**Figure 1**).

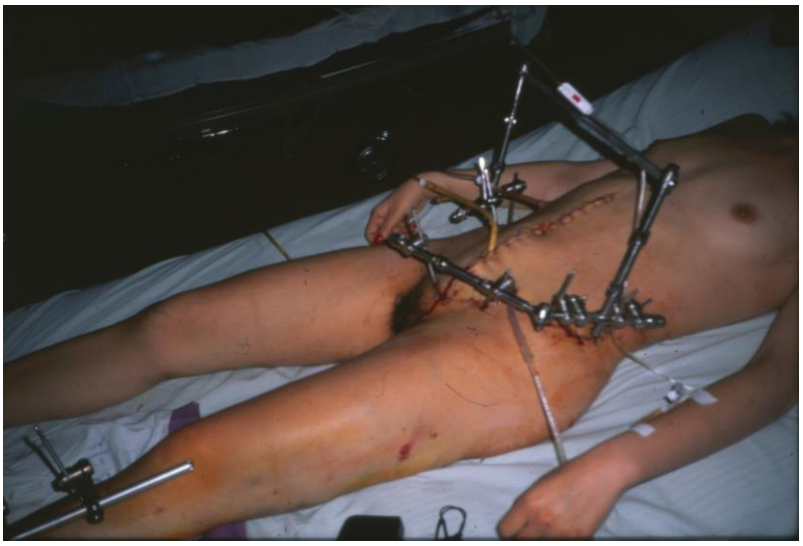

Figure 1: Example of Damage Control Orthopaedics, with External Fixation, in a young polytrauma girl.

It is ideal for patients presenting an unstable or extreme physiological state. It focuses on their rapid recovery by providing temporary stabilization of fractures while reducing, at the same time, the biological effects of surgery [31]. The perfect timing of final fracture stabilization represents an enigma for all orthopedic surgeons involved in the care of severely injured patients in view of DCO. The immediate and complete definitive operative care of all fractures provides the optimal treatment for polytrauma patients. The benefits of his approach have been demonstrated in numerous studies within the past two decades [32, 46, 47]. In their bio-mechanical works, published in 2011 and 2012, Predrag Grubor et.al [49, 50] have demonstrated that each fixator has its own indications; the selection should be based on mechanical characteristics, fracture geometry, and potential bone healing, with a permanent simplification of treatment, which has to be safe and acceptable for the patient. This retrospective study, over the period between September 15, 1991 and December 1, 1995, reveals the methods used to treat 2462 wounded patients with injured extremities, who received primary treatment at Banja Luka Clinical Centre [53] and the period between January 1,2009 and December 31,2013, reveals the method used to treat 658 traffic accidents with injured extremities, who received primary treatment at Banja Luka Clinical Centre.

MATERIAL AND METHODS

We reported a population of our published paper [53] involves 2462 wounded patients, with injuries to the extremities and multiple injuries to the abdomen, thorax and head, who received primary surgical treatment at the Orthopedics and Traumatology Clinic in Banja Luka in the period between September 15, 1991 and December 1, 1995. Out of the 2462 wounded people, 122 (4.59%) were women, 24 (0.9%) were children and 2269 (94.15%) were men. The oldest wounded woman was 82 years old (born in 1914), the oldest man was 87 (born in 1908), and the youngest child was 3 (born in 1992). The average age of the wounded people was 33.73[53].

Due to wounds sustained, 265 (10.77%) patients needed primary treatment for muscular and skin injuries to the extremities, and 2197 (89.23%) needed additional treatment to stabilize broken bone fragments. 2043 (92.43%) of them sustained multiple fractures with or without bone defects. In the first months of the war, attending physicians used plaster casts or a combination of plaster casts, Kirschner wires and Steinmann pins, as well as a limited number of external fixators available, to stabilize bone fragments and immobilize the extremities. Although hemostasis was surgically perfect after primary treatment of a war wound, the gauze and plaster cast became eventually soaked with blood and antiseptic, therefore jeopardizing the sterility of the wound. Replacing the plaster cast was painful, and there was a great possibility that the bone fragments would not be adequately repositioned[53].

During the war, extensions were mostly used as a temporary treatment method, due to lack of external fixators or until the forming of the initial callus. This method caused the patient to require extended care from other medical personnel, as well as discomfort, immobility, and long hospital bed occupancy. The epidemiology of war trauma [10] soon convinced physicians that patients using external fixators suffered fewer complications and had better results [53].

The more experience gained, the more stabilization by external fixation was preferred. This became clearly evident in the last six months of the war when, in the period between June 15 and December 1 1995 (period of major military operations), bone fragments were stabilized with external fixators in 92% of cases **(Table 1a)**[53].

Injured extremities	No.	External fixator	Percentage	Plaster cast Steinmann pin Kirschner needle	Percentage	Extension	Percentage
Upper leg	81	78	96.30%	0	0.00%	3	3.70%
Lower leg	122	122	100.00 %	0	0.00%	0	0.00%
Upper arm	61	52	85.25%	9	14.75%	0	0.00%
Lower arm	47	34	72.34%	13	27.66%	0	0.00%
	311	286	91.96%	22	7.00%	3	0.96%

External fixator	286
Plaster cast, Steinman pin, Kirschner needle	22
Extension	3
	311

Table 1a. Stabilization methods for bone fragments in people injured by firearms between 15 June and 1December 1995[53].

During the period between January 1,2009 and December 31,2013, reveals the method used to treat 658 traffic accidents with injured extremities, who received primary treatment at Banja Luka Clinical Centre. Out of the 658 wounded people, 98 (14.90%) were women, and (94.15%) were men. The oldest wounded woman was 58 years old (born in 1951), the oldest man was 67 (born in 1953), The average age of the wounded people was 24.31. In the emergency room(**Table 1b**) we treated 596 patients with external fixation for DCO(open fractures 160) and only 62 patients with Trans-Skeletal Traction when we had problem in trauma team like anesthetists busy with other critically ill patients.

Injured extremities	No.	External fixator	Percentage	Transkeletal traction	Percentage
Upper leg	303	278	91.17%	25	8.83%
Lower leg	184	162	88.04%	22	11.96%
Upper arm	130	118	90.77%	12	9.23%
Lower arm	41	38	92.68%	3	7.32%
	658	596	90.58%	62	9.42%

Table 1b. Stabilization methods in emergency for bone fragments in people injured by car accident between January 1,2009 until December 31,2013.

In the period between September 15, 1991 and December 1, 1995, 72% of patients (1573) were stabilized with external fixators, 24% (531) with plaster cast and plaster cast in combination with Steinmann pins and Kirschner wires, and 4% (91) with extensions (**Table 2a**).

Injured extremities	No.	External fixator	Percentage	Plaster cast Steinmann pin Kirschner needle	Percentage	Extension	Percentage
Upper leg	590	509	86.27%	9	1.53%	72	12.20%
Lower leg	695	589	84.75%	87	12.52%	19	2.73%
Foot	126	5	3.97%	121	96.03%		0.00%
Upper arm	388	297	76.55%	91	23.45%		0.00%
Lower arm	255	159	62.35%	96	37.65%		0.00%
Hand	141	14	9.93%	127	90.07%		0.00%
	2195	1573	71.66%	531	24.19%	91	4.15%

Table 2a. Overview of extremity fractures and primary treatment methods between 15 September 1991 and 1 December 1995 at Banja Luka CHC. Table 2 shows that plaster cast immobilisation is implemented more often in case of injuries to the hands and feet, while external fixators are used for long bones[53].

In the period between January 1,2009 and December 31,2013, we treated with definitive External fixation 596 patient and in 62 with ORIF. We chose the ORIF for fractures in 62 patients did not have an indication for external fixation(**Table 2b**).

Injured extremities	No.	External fixator	Percentage	ORIF	Percentage
Upper leg	303	278	91.17%	25	8.83%
Lower leg	184	162	88.04%	22	11.96%
Upper arm	130	118	90.77%	12	9.23%
Lower arm	41	38	92.68%	3	7.32%
	658	596	90.58%	62	9.42%

Table 2b. Overview of extremity fractures and treatment methods between between January 1,2009 until December 31,2013, at Banja Luka CHC.

14 different types of external fixators, using the Mitković fixator M20 in 1342 (85%) cases and the other types in 234 (15%) cases **(Table 3a)**. Functional plaster casts (Coldwell, Mooney, Delbeto, and Sarmiento) were always used after taking off the external fixator, which was placed on the injured extremity for an average of 40 days[53].

External fixator types	No.
Hoffman	62
Oganesian	3
Ortofix	32
Charnley	42
AO	12
Sherer	14
MMA Belgrade	9
Aesculap	12
French fixator	4
Mitković-M9	18
Instrumentar. Zagreb	15
Srakar	8
Kotajev	3
Mitković-M20	1342
	1576

Table 3: Number and Type of external fixator that we used[53].

To treat the traffic accident we used only 4 types of external fixator (**Table 3b**).

External fixator types	No.
Hoffman	95
Ortofix	73
AO	144
Mitković-M20	286
	596

Table 3b: Number and Type of external fixator that we used.

The injuries were the result of the impact of significant kinetic energy on the extremities. Special emphasis was given to the selection and methods for stabilizing the fractures. Patients were treated according to the Helsinki Declaration's ethical standards, and all of them were asked if they could read and understand the patient information sheet and sign the informed consent form.

RESULTS

In the course of primary treatment of the 2642 patients injured with firearms, physicians experienced some complications with the functioning of external fixators and other problems resulting from primary treatment of the wounds. The complications experienced in working with external fixators were as follows: 86 (5.46%) pin tract infections, 3 (0.19%) pin breakages, 42 (2.66%) fixator reassembly procedures, 6 (0.38%) iatrogenic vascular lesions inflicted with the drill or pin and 4 (0.25%) iatrogenic nerve lesions **(Table 4a)**. There were infections of muscle and cutaneous tissues, acute osteomyelitis (re-intervention sites), in 704 (28.59%) wounded patients. Despite surgical and drug therapy, there were 74 (2.92%) cases of chronic osteomyelitis classified by bones as follows: humerus 7, radius 4, ulna 5, femur 21, tibia 31, calcaneus 3, and metatarsal bone 1. There were 5 (0.2%) cases of gas gangrene. The bacteria derived from bacteriological analysis had the following percentages: Staphylococcus aureus 51.38%, Pseudomonas spp. 13.82%, Pseudomonas aeruginosa 12.50%, Enterobacteriaceae 5.50%, other 8.40%, and mixed infections 8.40% [53]. Out of the 2642 patients, re-interventions were performed in 704 (28.59%); 491 (69.73%) of them were executed following primary treatment, and the wounds were stabilized with plaster casts or plaster casts in combination with Steinmann pins and Kirschner wires, or extensions. The reasons for performing re-interventions were as follows: change of plaster cast soaked with blood, plaster cast maceration, inadequate position of bone fragments, and secondary infection. Out of the 1573 applied external fixators, 213 (13.54%) were re-interventions.

Complications	No.	Percentage
Pin tract infection	86	5.46%
Pin breakage	3	0.19%
Fixator reassembly	42	2.66%
Vascular lesions	6	0.38%
Neurological lesions	4	0.25%

Table 4a: Number and type of complications after the external fixation[53].

Instead the complication of our experience to treat the traffic accidents are follows(**Table 4b**):

Complications	No.	Percentage
Pin tract infection	18	3.02%
Pin breakage	0	0%
Fixator reassembly	8	1.34%
Vascular lesions	1	0.16%
Neurological lesions	2	0.33%

Table 4b: Number and type of complications after the external fixation

The complication in Traffic accident with external fixation as follows: Pin tract infection 18(3.02%), Pin breakage 0(0%), Fixator reassembly 8(1.34%) , Vascular lesions 1(0.16%), Neurological lesions 2 (0.33%).There were infections of Pin tract in 18(3.02%), the bacterial that was isolated is Staphylococcus Aureus. We treated the pin infection tract with debridment and antibiotic. The Fixator reassembly in 8 cases was only to change to DCO in modular external fixation to definitive treatment. 1 case of vascural lesion with 1 pin hitted the A. tibialis posterioris. 2 cases of Nerve Injury, 2 two stupor of N.Radialis.

By analyzing the patients with multiple injuries **(Table 5a)**, it became evident that external fixation was the best method to achieve adequate stabilization and mobility.

Out of the 2462 wounded people, the following sustained multiple injuries:	Abdomen: 98(3.98%) Thorax: 25 (1.01%) Cranio-cerebral: 34(1.38%)

Table 5a: Description of number and type of polytrauma[53].

By analyzing the patients with multiple injuries in traffic accidents (**Table 5b**), it became evident that external fixation was the best method to DCO and definitive treatments.

Injury	No.	Percentage	Arterial injuries	Nerve injuries
Upper leg	590	26.88%	a. femoralis 102 (17.29%) a poplitea 13 (2.20%)	nervus ischiadic 4 (0.67%)
Lower leg	695	31.66%	a tib. comunis 8 (1.15%) a. tib. posterior, anterior, fibularis 12 (1.72%)	nervus peroneus 3 (0.43%)
Ankle and Foot	126	5.74%	95 feet injuries accompanied by injuries to the abdomen, thorax, lower leg, 31 injuries to the foot only	
Upper arm	388	17.68%	a. brachialis 37 (9.53%)	nervus radialis 38 (9.79%)
Lower arm	255	11.62%	a. radialis and a. ulnaris 10 (3.92%)	
Wrist and Hand	141	6.42%	105 hand injuries accompanied by injuries to the abdomen, thorax, 36 injuries to the hand only	
Total	2195	100.00%		

Injury	No.	Arterial injuries	Nerve injuries
Upper leg	303	a. femoralis 102 (33.66%) a poplitea 58 (19.14%)	nervus ischiadic 24 (7.92%)
Lower leg	184	a tib. comunis 3 (1.63%) a. tib. posterior, anterior, fibularis 2 (1.08%)	nervus peroneus 8 (4.34%)
Upper arm	130	a. brachialis 24 (18.46%)	nervus radialis 38 (29.23%)
Lower arm	41	a. radialis and a. ulnaris 5 (12.19%)	nervus unlnaris 12 (29.27%) nervus medianus 2 (4.87%) nervus interosseous (9.74%)
Total	658		

Out of the 658 wounded people, the following sustained multiple injuries:	Abdomen: 280(42.55%) Thorax: 360 (54.71%) Cranio-cerebral: 136(20.67%)

Table 5b: Description of number and type of polytrauma in traffic accident group.

DISCUSSION

The complexity, specific nature, and peculiarity of every war trauma require expertise, experience, attention and diligence [9]. In this study, war wounds were most frequently localized on the extremities (70%) [2,10], 40% of which were accompanied by bone fractures[11]. Piščević maintains that one third of gunshot wounds to the arteries are accompanied by fractures[12]. Z. Popović states that the percentage of joint injuries in this war was of 5.7%, and 57.3% were penetrating joint injuries. Gunshot related joint
injuries constituted 8% of damages to the extremities[13]. Reports from the war in Afghanistan have shown that out of a series of 756 injured people, 20.3% sustained penetrating joint injuries with no bone lesions. Shoulder injuries occurred in 33.7%, and wrist injuries in 9.2% of cases[14]. Injuries to the extremities inflicted by mines and explosives during the Vietnam and Arab-Israeli Wars resulted in the loss of the extremities in 12.6% of cases. In the Afghan army, in the period between 1984 and 1987, that percentage was between 30% and 45% [15]. Approximately 20% of injuries were to the upper extremities, and 64% were to the lower extremities[16,17]. During the Afghan War, the United States Army 102nd Forward Surgical Team performed 112 surgeries on 90 patients during the course of 7 months. Three patients were female (all children). Twenty patients were 19 years old. Trauma accounted for 78% of cases; the remainders were non-trauma or elective cases. 67% of these surgeries were performed on Afghan military and civilians, 30% on United States soldiers, and 3% on other coalition forces. Mechanism of injury included gunshot wounds (34%), blasts (18%), motor vehicle crashes (14%), stab wounds (5%), and other trauma (7%). By physiological system, the trauma cases were broken down into extremity (44%), head and neck (17%), multisystem (13%), trunk (8%), and vascular (3%) [37]. In 2011, Cross JD et al [33] described a cohort of war-wounded service members in which 54% of the extremity wounds sustained were combat wounds, and identified the conditions resulting in discharge from service during the Operation Iraqi Freedom and Operation Enduring Freedom. The Army Physical Evaluation Board recorded that 464 service members, injured between October 2001 and January 2005 were reviewed to determine the codes indicating unfitting conditions. 69 % of these conditions were orthopedic. 57% had unfitting conditions that were only orthopedic. Of those evacuated from the theater of operations with a primary diagnosis of injury to the head, thorax, or abdomen, or suffering orthopedic injuries, 76% had an orthopedic diagnosis as the primary unfitting condition. Orthopedic-related disability has a significant impact on the affected patient, the health care system, and in the case of wounded service members, on military strength and readiness.

Type I and II open fractures of the extremities reacted well to treatment, while type III wounds constituted a major problem with the incidence of infection in as many as 24% of cases[18,19]. Primary care involves the prevention of infections in open fractures, especially in type III wounds, which is why this type was divided into three sub-types. According to Gustillo, the incidence of infections in these three sub-types was as follows: 4% in sub-type IIIa, 52% in sub-type IIIb, 42% in sub-type IIIc, and the incidence of amputations was as follows: 0% in IIIa, 16% in III b, 62% in IIIc [20,21].

Other than performing radical surgical treatments, the best way to prevent infection is to eliminate pockets and dead spaces where liquid-hematoma accumulates, as they are excellent grounds for the growth of bacteria[22]. A great number of authors recommend war wound re-excision within 24 – 48 hours, as it is difficult to accurately assess the vitality of tissue during the primary excision[23,24]. In his experimental research, Albreht found out that by local administration of antibiotics three hours after an injury, the primary surgical treatment of the wound may be postponed by up to 72 hours without increasing the prevalence of local infection. Jackson reached similar conclusions during the Falkland Islands War[25]. He began with antibiotic therapy within a period of up to 6 hours after injury. The results showed that there were no septic complications when the antibiotics were administered within three hours after sustaining the wound as they inhibited the growth of bacteria in gunshot wounds[25]. The International Committee of the Red Cross recommends administering crystalline penicillin 5,000,000 units, intravenously on admission and continuing every 6 hours for a minimum of 48 hours, and orally administering penicillin preparation 0.5 every 6 hours over the next six days. The complications experienced in working with external fixators were as follows: 86 (5.46%) cases of pin tract infections, 3 (0.19%) pin breakages, 42 (2.66%) fixator re-assembly procedures, 6 (0.38%) iatrogenic vascular lesions inflicted with the drill or pin, and 4 (0.25%) iatrogenic nerve lesions. 70% of gunshot injuries were localized on the extremities, and approximately 40% of them were accompanied by fractures. In the examined material, it was necessary to (primarily) treat muscle and cutaneous injuries to the extremities in 265 (10.77%) cases, and in 2195 (89.23%) cases bone fragments needed to be stabilized due to bone tissue injuries. Out of the 2195 bone tissue injuries (bones), 2043 (92.43%) cases were comminuted fractures with or without bone defects. In 2008, Berkowitz MJ and Kim DH[34] published the importance of the kickstand in the External Fixation operation. According to them, the kickstand can effectively support the extremity and eliminate the risk of ulcers caused by pressure. This kickstand modification, which also allows improved access for wound care and dressing changes, has proved to be an effective adjunct treatment of high-energy extremity trauma[34]. Karapetjev and Petrov presented their experiences in the treatment of 1361 patients with gunshot fractures of the long bones in Angola. In 17 patients, bone defects were longer than 5 cm[2]. The authors believe that they could perform, under antibiotic protection, internal osteosynthesis and autospongioplastic of gunshot fractures of the long bones 21 days after the primary surgical treatment[2]. Out of the 1361 gunshot fractures, Karapetjev and Petrov performed osteosynthesis in 71 patients within the first 48 hours; in 88 after 3 to 6 days, in 659 after 7 to 10 days, in 39 after 10 to 29 days, and in 21 patients it was performed after 21 days[2]. The same authors claimed to have had positive results in 113 (12.88%), and negative results in 765 (87.12%) patients[2]. In 1988, Mussa published treatment results for 258 patients. The most frequent method of stabilization at the stage of primary surgical treatment was the plaster splint in 26.4% of patients and definitive window plaster cast in 58.1% of patients[2]. Plate osteosynthesis at the stage of primary surgical treatment was performed in 1.2% of patients; delayed primary osteosynthesis in 0.4% of patients, and secondary in 2.7%. The external fixator in primary war surgery was applied in 2% of patients. 24.8% of patients had an infection, and 10.8% had nonunion[2]. Based on his experience from

the Afghan war, Gricanov et al. favored external fixators including the joint, and compression/distraction external fixators[7]. In 1994, Jovanović Z. et al. analyzed 820 gunshot fractures. 670 (77.2%) patients were military members and 105 (12.8%) were civilian victims of war who sustained their injuries in the period between July 1991 and September 1992[12]. The injuries, divided by segments, were as follows: femur 213 (26%), tibia and fibula 324 (39.5%), foot 39 (4.8%), humerus 141 (17.2%), radius and ulna 103 (12.5%). 84 (10.2%) patients had multiple injuries and 37 (4.9%) of them had injuries to internal organs[12]. The methods used for stabilizing fractures at the stage of primary surgical treatment were as follows: external fixators 447 (54.5%), plaster cast 279 (34.0%), trans-skeletal traction 13 (1.6%), and other methods 81 (9.7%)[12]. Speed with which a wounded person is taken from the site of injury to the surgical station is very important[13]. In Vietnam for example, the wounded were transported by helicopter to an aircraft carrier with an extremely well equipped surgical station, and treated within 1 to 1.5 hours[13]. In the examined material, the wounded were treated within 3 hours. A similar transportation method resulting in the lowest infection percentage (1.5 - 5%) was used in 1973 in the war between Israel and Egypt[13]. In 2006, Lerner et al.[35] reported their experience with staged external fixation for war injuries to the extremities. Forty-seven patients with 64 high-energy limb fractures caused by war weapons were retrospectively reviewed. The fractures were associated with severe soft tissue damage. There were 14 Gustilo-Anderson Type IIIA fractures, 40 Type IIIB fractures, and 10 Type IIIC fractures. Soft tissue débridement followed by axial realignment of the fractured bones with immediate skeletal stabilization using the AO/ASIF unilateral tubular external fixator was performed on the day of admission. The primary tubular fixators were replaced 5 to 7 days later with Ilizarov frames. Delayed primary closure, skin grafts, or flaps were used for soft tissue coverage. The mean follow-up was 40 months, and the Ilizarov /hybrid external fixator was the definitive treatment in all patients. Bone union was achieved at an average of 8 months in 58 (90.6%) fractures. Three patients had non-unions and one patient required amputation. They concluded that staged external fixation is a valuable strategy for treatment of war injuries to the extremities [35].

In 2010, Golubovic et al.[36] described a case report of a 24-year old soldier after multiple wounding by a cluster bomb. He reported: left supracondylar humeral fracture, comminuted fracture of the distal right tibia, fracture of right trochanter major, without dislocation, and fracture of the second right metacarpal bone. After short preoperative preparation, a surgical debridement of all wounds was done under general anesthesia and the fractures of the humerus and tibia were stabilized with the Mitkovic-type external fixator after adequate repositioning. For the reconstruction of bone defect of the tibia the method of bone transport with the Ilizarov external fixator was used. They concluded that external fixation and early reconstruction of soft tissue and bone defects are the basic elements for treating serious fractures caused by war injuries and aimed at saving the extremities[36]. The effectiveness of temporary external fixation in preventing unexpected systemic complications became also evident[31]. Pape et al.[38] in a multicenter prospective randomized trial demonstrated that patients in critical condition benefited when initial stabilization with an external fixator was performed instead of early treatment with intramedullary nailing. In particular, it was shown that in borderline patients, a higher incidence of pulmonary

complications occurred in those who underwent initial fixation of the femur with intramedullary nails, than those for whom external fixators were used, following the Damage Control Orthopedics (DCO) principles[38].

Mathieu L et al.[39] reported the cases of sixteen French soldiers wounded on the battlefield between 2004 and 2009 who were treated by DCO, included in this retrospective series. All patients were males with a mean age of 30 years (20 to 53 years). Eighteen external fixators were applied in the theater of operations for multiple injuries (five cases), closed fractures of the pelvis or long bones (three cases) and open osteoarticular lesions (ten cases). After medical evacuation from the original theater, conversion to internal fixation was possible in five cases. Due to the severity of the lesions or infectious complications, external fixation was maintained in thirteen cases. Bone union was achieved in all cases. The mean time for bone union was 2.8 months (2 to 3 months) in case of conversion to internal fixation, and 6.3 months (1.5 to 17 months) when external fixation was extended. To achieve bone union, three devices were removed after a three or four month period and converted to rigid internal fixation associated with bone grafting. No case of septic complication was observed after early conversion. The only case of post-conversion infection occurred after three months of external fixation. After a mean follow-up of 19 months (6 to 49 months) all patients recovered functional autonomy and thirteen could return to duty. Their conclusions were: whenever possible, early conversion from external to internal fixation improves bone union and functional recovery after war limb injuries in properly selected patients. Lebel et al.[40] describe the use of external fixator frames, during the 10 day period after the Haiti's Earthquake, that were used for Damage Control Orthopedics (DCO), whereby bone stabilization in conjunction with soft tissue care served as a stopgap, until more comprehensive therapy was available. Min et al.[45] have also described their experience during Wenchuan and Yushu earthquakes with external fixation. In the 2007, the EPOFF study group reported in his paper[54] 165 patients, mean age 32.7 ± 11.7 years. Group intramedullary nailing, n = 94; group external fixation, n = 71. Preoperatively, 121 patients were stable and 44 patients were in borderline condition. After adjusting for differences in initial injury severity between the 2 treatment groups, the odds of developing acute lung injury were 6.69 times greater in borderline patients who underwent intramedullary nailing in comparison with those who underwent external fixation, $P < 0.05$. Intramedullary stabilization of the femur fracture can affect the outcome in patients with multiple injuries. In stable patients, primary femoral nailing is associated with shorter ventilation time. In borderline patients, it is associated with a higher incidence of lung dysfunctions when compared with those who underwent external fixation and later conversion to intermedullary nail. Therefore, the preoperative condition should be when deciding on the type of initial fixation to perform in patients with multiple blunt injuries.It is accepted that primary definitive stabilization of major fractures in patients with blunt multiple injuries is advantageous in terms of reduced ventilation time, shorter hospital stay, and improved early mobilization of the patient.However, there is controversy in the orthopedic literature as to whether all patients benefit from this approach. A certain subset of patients, specifically those in severe shock or those who have additional severe head or chest injuries may be at increased risk for complications after primary definitive stabilization of major fractures. It is still unclear whether initial temporary

stabilization of fractures by external fixation DCO, or definitive stabilization of all major fractures should be performed in all cases .To date, any recommendations and guidelines described above have been based only on level II to III evidence. Currently, there are several prospective randomized studies dealing with fracture management in generalbut no level I studies have investigated whether temporary fracture fixation should be recommended for certain patient populations. This prospective, randomized, controlled analysis therefore tests the hypothesis that initial temporary fracture stabilization is more advantageous than initial definitive stabilization for femoral shaft fractures in patients with more severe injuries with regard to the development of systemic complications[54]. Ristic et al.[55] described various method to treated 61 Humeral shaft fractures. They compared the functional results of non-operative and different operative techniques of managing humeral shaft fractures. They did Intramedullary nails (n = 20) and the control groups were: Hanging cast (n = 22), dynamic-compressive plates and screws (n = 10), external fixators (n = 9). The outcomes were: Presence of bone union by radiographic and clinical evaluation, Constant and Mayo scores, elbow contractures, functional scales, rehabilitation period. The results were: the hanging cast group had the most of elbow contractures and insufficient results of functional scales; the plating group had lower average values of scores than nails, especially considering the elbow function; among subgroups, the locked intramedullary nails had better results than Ender nails, the most complicated cases treated with Ilizarov and Mitkovic's external fixators had good results, especially in the treatment of open humeral shaft fractures; however, the rehabilitation period was longer the best average functional results were recorded in the nailing group because of rigid fixation, solid callus formation and return to everyday activities in the shortest time[55].The Swedish Register reported[56] the decrasing of tibial shaft in traffic accident and only 12% of the fracture were treated by External fixation. Dalibor et al.[52] reported 462 autopsied during the observed period between 2010 and 2012 in Baja Luka, 186 (40.2%) were fatally injured traffic users; 160 (86%) men and 26 (14%) women. In relation to the type of traffic users, most of fatally injured were drivers (total of 60, of whom 58 men!), followed by pedestrians (52, 14 of whom were women), front seat passengers (28), rear seat passengers (16), motorcyclists (14), cyclists (13) and three tractor drivers. According to the age there were two noticeable peaks:the third decade of life and older age (the seventh decade and older). From a total of 60 fatalities of drivers, 25 or 42% were aged 20 -29 years (figure1). Generally speaking for all participants, the most common cause of death were head injuries (46%), followed by polytrauma (26%) and chest injuries (24%). Among other causes (< 5%) were abdominal injuries and asphyxia. The two main groups of fatally injured traffic users were drivers (32%) and pedestrians (28%). Co-drivers have a similar distribution of injuries and causes of death. Of 28 died co-drivers, in 12 cases the cause of death was head injury andin 11 cases chest injuries, which are the most frequently injured body parts. Out of 60 fatally injured drivers, in 47 of them blood alcohol concentration at the time of the accident was measured. Of these, 26 (55%) had a blood alcohol concentration above the legal limit (more than 0.3‰ for drivers). Of 52 pedestrians killed, in 39 of them alcoholemia was measured. In 22 (56%) of pedestrians the illegal blood alcohol concentration was found (over 0.8 ‰ for pedestrians)[52].

In the Bosnian War, external fixation was for the first time used more frequently to treat open injuries to the extremities. In the period between September 15, 1991 and 1 December 1 1995, 72% (1573 external fixators) cases were stabilized by external fixation; plaster cast, and plaster cast in combination with Steinmann pins and Kirschner wires were used in 24% (531) of cases, and extension procedures were used in 4% (91) of cases[2]. In an AAOS (American Academy of Orthopedic Surgery) notification the following were stated as causative agents of chronic bone infection: Staphylococus aureus 84.2%, Escherichiae Coli 3.2%, Klebsilla 2.9%, Streptococus B hemoliticus 2.3%, Pseudomonaes aeruginosa 2.0%, and all others make up to 5% [25]. The data presented by I. Gavrankapetanović of Sarajevo Orthopedics and Traumatology Clinic, while monitoring causative agents are interesting. They are as follows: Staphylococcus aureus occurs in 36% of cases, Pseudomonas aeruginosa in 16% of cases, Seratia marcescens in 15% of cases, Proteus mirabilis in 5% of cases, and fatal Enterococcus fecalis in 3% of cases[6]. Based on the antibiogram done on the fistula, the following infectious agents were found: Staphylococus aureus 31 (51.4%), Pseudomonas spp. 8 (13.8%), Pseudomonas aeruginosa 7 (12.5%), Enterobacteriaceae 3 (5.5%), and other 5 (8.45%) (Stapphyloccocus epidermalis; Esecherichia Coli; Streptococus B haemoliticus; Bacilus pyogeneus, Klebsilla spp). 5 (8.4%) patients suffered from mixed infection: Pseudomonas aeruginosa + Enterobacteriaceae, Staphylococcus aureus + Enterobacteriaceae, Pseudomonas aeruginosa + Klebsiella spp[1]. There were 5 (0.2%) cases of gas gangrene in the examined cases. Re-interventions following primary treatment of the wound were performed, and in 491 (69.73%) cases, plaster casts were used, or a combination of plaster casts and Steinmann pins, Kirschner wires or extensions were used. The reasons for performing re-interventions were as follows: change of plaster cast because it was soaked with blood, plaster cast maceration, inadequate position of bone fragments, and secondary infection of the wound[1]. In 1976, Böhm and Könn described the morphological changes in chronic post-traumatic osteomyelitis based on 760 cases of exogenous osteomyelitis. Aggressive chronic osteomyelitis with characteristic histological finding, showing purulent inflammation lined with fibrous wall and granulation tissue, and chronic (persistent) osteomyelitis characterized by connective tissue rich in cells and capillaries, and cell infiltration for the purpose of bone formation[8,9]. There were infections of muscle and cutaneous tissue, acute osteomyelitis, where re-interventions were performed, in 704 (28.59%) wounded patients. Despite surgery and drug therapy, chronic osteomyelitis occurred in 74 (2.92%) cases, classified by bones as follows: humerus 7, radius 4, ulna 5, femur 21, tibia 31, calcaneus 3, and metatarsal bone 1. In 1994, Jovanović Z. Popović Z. et al. described the criterion for handling bone defects of the long bones by bone auto-transplant and stabilization of bone fragments by the AO compression plate. They describe their experience of treating 129 diaphisary gunshot fractures. The requirements for using this method are as follows: good soft-tissue cover, absence of clinical and laboratory signs of infection, and bone defects not exceeding 4 cm [2]. Ardashov describes a series of 32 upper arms occurring after gunshot fractures. He performed closed compression osteosynthesis by the Ilizarov method in 15 upper arms where there was contact between fragments with minimum 2/3 of the diaphyseal cross-section[11]. Corticotomy was performed and the Ilizarov distraction osteogenesis method was used in 11 cases; in 6 cases he used the AO compression

plate for stabilizing the fragments. He had good results in 23 (72%) patients – which were determined by the achievement of bone consolidation [11]. In 7 (22%) patients the results were satisfactory, and in 2 (6%) patients healing did not take place. Murray et al.[42], in the second Iraqi War, described 16,742 patients' entries (15,021 from Operation Iraqi Freedom (9,883 battle injuries [BI]) and 1,721 from Operation Enduring Freedom (1,090 BI)). A total of 96.6% were men and 77.6% of them were Army personnel. The majority of BI injuries were caused by explosive devices (36.3%). There were 921 patients (5.5%) who had one or more infection codes, with only 111 (0.6%) recorded deaths (16 with infections). Infections were commonly gram-negative bacteria (47.6%) involving skin/wound infections (26.7%), and lung infections (14.6%). Risk factors or associations were most notable in univariate and multivariate analysis through a calendar year of trauma, ISS, and pattern of injury. The 5.5% infection rate is consistent with previous military and civilian trauma literature.

Meccariello et al.[51] reported 59 cases of open tibial shaft fractures (Gustilo IIIB, Cierny-Mader IIIB) by war trauma, treated with modular external fixation, developing chronic osteomyelitis. Based on the antibiogram taken from the fistulous channel, the representation of infection was: Staphylococus aureus 31 (52%), Pseudomonas spp. 8 (14%), Pseudomonas aeruginosa 7 (12%), Enterobacter 3 (5%), Stapphylococus epidermalis 1 (2%), Esecherichia Coli 1 (2%), Streptococus B haemoliticus 1 (2%), Bacilus pyogeneus 1 (2%), Klebsiella spp 1 (2%). Mixed infections were represented in 5 patients (9%): Pseudomonas aeruginosa + Enterobacter, Staphylococcus aureus + Enterobacter, Pseudomonas aeruginosa + Klebsiella spp. These chronic osteomyelitis were treated by Papineau's method in 5 (8.50%), sequestration in 28 (47.45%), fenestration and sequestration in 17 (29%), only Forage of the tibia in 3 (5%), and decortication and resection in 6 (10%). In this study the instantaneous vacuum for 36 (61%) patients [51] was used.

Kumar AR et al.[43] reported and reviewed 26 cases of flap reconstruction of soldiers with significant upper extremity injuries with complex open fractures from Operation Iraqi Freedom and Operation Enduring Freedom-Afghanistan who underwent tissue transfer flaps (n = 26, free flaps n = 6). The mean age was 25 years. The mean number of pre-reconstructive washouts was six (range, 3-22). The cause of injury consisted of improvised explosive device (61%), rocket-propelled grenades (15%), motor vehicle crash (8%), land mine (8%), and gunshot wound (4%). Forty-six percent of wounds were culture positive at admission (75% were Acinetobacter species). All patients had other coexisting extremity, trunk or facial injuries. Average time to flap reconstruction was 31 days (range, 9-161). In 66% of the cases, a fasciocutaneous flap was used, and in the remaining cases, muscle (19%) and adipofascial (15%) flaps were performed. Flap success rate was 96%, with one flap loss because of venous congestion (managed with limb shortening). Infection rate was 8%. Complete coverage was achieved in all upper extremity wounds and early occupational therapy resulted in improved return to function. In 2011, Grubor P et al.[48] concluded in their paper that conservative treatment is the treatment of choice for external fixator in treating Tile's Type B fractures (including all subtypes) as well as for the external fixation for saving life and definitive treatment.

CONCLUSIONS

The experience gained during the Bosnian War and the results achieved justify the position that the method of choice for primary stabilization of bone fragments in war wounds is EXTERNAL FIXATOR. During the Bosnian War, physicians worked with a great number of different types of external fixators. Following the general principles of ATLS, wound management and external fixation did not differ when performed in the settings of civilian versus war trauma, but there are special considerations and alterations in standard practice that become necessary when providing this care in an austere environment[44]. This paper demonstrates the necessary review of the principles and techniques of Damage Control Orthopedics (DCO) and external extremity trauma in combat related injuries during the Bosnian War and in both past and traffic accidents[57-65]. Physicians can resume their indication for temporary and definitive treatment of the war trauma and traffic accident[57-65] **(See Table 6)**.

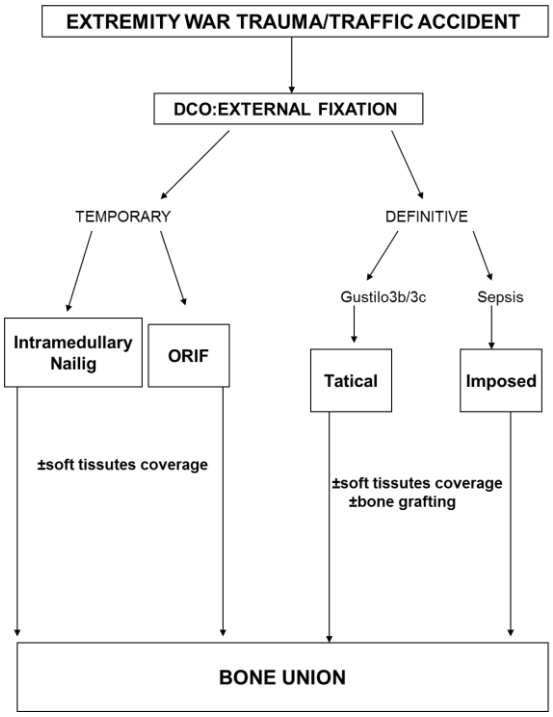

Table 6: Algorithm of damage control Orthopaedics temporary and definitive external fixation for extremity war trauma and traffic accident.

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