received 11-06-2013
approved 30-03-2014

IMPORTANCE OF EXTERNAL FIXATION IN PRIMARY TREATMENT OF WAR WOUNDS

Predrag Grubor
Orthopaedics and Traumatology, Klinical Center, University of Banja Luka, Banja Luka, Republika Srpska, Bosna and Herzegovina
Gabriele Falazarano
Antonio Medici
U.O.C. Orthopedics and Traumatology, Azienda Ospedaliera "Gaetano Rummo" Benevento - Italy
Luigi Meccariello
Department of Medical and Surgical Sciences, and Neuroscience, Section of Orthopedics and Traumatology, University of Siena, Siena, Italy
Milan Grubor
School of Medicine Banja Luka, Republic of Srpska, Bosnia and Herzegovina

ABSTRACT

Introduction - A war wound is damage to the body, inflicted by firearms with a lot of kinetic energy (blast, projectile, burn) and sustained in wartime. It is characterised by massive destruction, primary contamination and modified reactivity of the body.

Objective - This retrospective study shows how to primarily treat the injured extremities, with and without fractures, as well as how to select the method for stabilising fractured bones.

Material and methods - 2462 wounded persons are analysed in this study. They sustained injuries to the extremities, abdomen, thorax and head, and, having sustained the wounds, they received primary surgical treatment at the Orthopaedics and Traumatology Clinic in Banja Luka in the period between 15 September 1991 and 1 December 1995. Out of the 2462 wounded persons, 122 (4.59%) were women, 24 (0.9%) were children and 2269 (94.15%) were men. The average age of the wounded persons was 33.73 years. 265 (10.77%) sustained muscular and cutaneous injuries to the extremities, without bone fractures, and 2197 (89.23%) wounded persons had broken bone fragments that required stabilisation after primary surgical treatment. Out of the 2197 wounded persons with broken bones, 2043 (92.43%) sustained cuminutive fractures with or without bone defects. In 1573 (72%) cases, broken bone fragments were primarily stabilised using external fixators, in 531(24%) cases using plaster cast and plaster cast in combination with Steinmann pins and Kirschner needles, and in 91(4%) cases we used extension.

Results - The complications we 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 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.

Discussion - The complexity, specific nature and uniqueness of every war wound require expertise, experience,

attention and diligence. Every patient is a separate entity and requires an active approach throughout the course of treatment.
Conclusions - The experiences gained in the last war (working with 28 types of external fixators) and the results achieved give me the right to maintain that the method of choice for primary stabilisation of bone fragments in war wounds is Mitkovic's external fixation type M20.

KEYWORDS: INJURED EXTREMITIES, FRACTURE, EXTERNAL FIXATOR, BONE FRAGMENTS

INTRODUCTION

When a war ends, people no longer talk about war surgery. Meanwhile, military technology is developed, perfected and becomes more and more sophisticated. When a new war breaks out, surgeons are caught unprepared because they can only use experiences gained from the previous war, with no knowledge of new technologies which are more devastating than the ones used in previous wars. In the epidemiology of war trauma, a surgeon gains experience quickly, irrespective of the fact that the number of surgeons compared to the number of the injured is disproportionate and detrimental to both sides[1]. A war wound (Figure 1) is damage to the body, inflicted by firearms (blast, projectile, burn) and sustained in wartime. It is characterised by massive destruction, primary contamination and modified reactivity of the body[2]. The treatment of a war wound starts with primary treatment of the wound, which must be 'sterilisation of the war wound'. In order to achieve this, the injured extremity is washed under an anaesthetic with a brush, soap and warm water. Having washed the extremity, the underwear and gloves are changed, and the surgical site is prepared following all aseptic postulates[3]. A war wound needs to be flushed out with up to 10 litres of physiological solution which mechanically removes dead tissue and foreign bodies[4]. Primary treatment of the skin is done by making an incision of up to 2 mm in healthy skin. The skin is relatively well vascularised and infection-resistant[4]. Subcutaneous adipose tissue is poorly vascularised and not resisitant to infections and it is thus necessary to make an excision up to 5 cm from the wound edge[5]. The 4Cs rule (contractility, capillary bleeding, colour, consistency) should be followed when primarily treating muscle tissue. Bone fractures are multi-fragmented (95%), dislocated, de-periosteal and accompanied by bone defects[6].

Following the primary treatment of a war wound it is necessary to immobilise the injured extremity. Adequate immobilisation of the broken bone enables the injured person to become mobile relatively quickly, not to feel pain and to have the wound re-dressed less frequently[7]. No matter how surgically perfect haemostasis after the primary treatment of a war wound is, gauze eventually becomes soaked with blood and antiseptics, and it jeopardises the sterility of the wound[8]. We used the following for immobilisation: plaster cast, plaster cast in combination with Kirschner needles and Steinmann pins, extensions, external fixators[1].

By seeing a great number of injured persons on an everyday basis, one realises that the selection of immobilisation methods for injured bones has a major effect on the amount of spent material, number of surgical interventions, morale of the wounded and medical staff, i.e. on the final result[9].

OBJECTIVE

This retrospective study, covering the period between 15 September 1991 and 1 December 1995, shows the ways used to primarily treat 2462 wounded persons with extremity injuries who received their primary treatment at Banja Luka Clinical Centre. The injuries were the result of the impact of a lot of kinetic energy on the extremities. Special emphasis is given to the selection and methods for stabilising the fractured bone fragments.

MATERIAL AND METHODS

This study involves 2462 wounded persons, with injuries to the extremities and multiple combined injuries to the abdomen, thorax and head, who received their primary surgical treatment at the Orthopaedics and Traumatology Clinic in Banja Luka in the period between 15 September 1991 and 1 December 1995. Out of the 2462 wounded persons, 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). 1654 (67.18%) of them were carrying documentation (first and family name, place of living, military post, vaccination data ...). The average age of the wounded persons was 33.73. Due to sustained wounds, 265 (10.77%) of them needed to receive primary treatment of muscular and skin injuries to the extremities, and 2197 (89.23%), in addition to this, needed to have their broken bone fragments stabilised. 2043 (92.43%) of them sustained cominutive fractures with or without bone defects. In the first months of the war we used plaster cast or a combination of plaster cast and Kirschner needles and Steinmann pins, as well as the small number of external fixators found in the hospital, to stabilise the bone fragments and immobilise the extremities. In the beginning of the war, we used plaster cast to immobilise injured extremities. No matter how surgically perfect haemostasis after primary treatment of a war wound is, gauze and plaster cast eventually become soaked with blood and antiseptics and that jeopardises the sterility of the wound. Changing of the plaster cast is painful and there is a great possibility that the fragments will not be adequately repositioned. During the war, I used extension as a treatment method mostly temporarily, due to the lack of external fixators or until initial callus formation. This method causes long-term dependence of the wounded person on other people's assistance, as well as discomfort, immobility and long hospital bed occupancy. The epidemic of war trauma[10] soon convinced us that those injured persons for whom we used external fixators suffered fewer complications and had better results. The more experience we gained, the more I preferred stabilisation by external fixation. This is best seen in the last six months of the war when, in the period between 15 June and 1 December 1995 (time of major military operations), we stabilised bone fragments with external fixators in 92% of cases (Table 1). In the period between 15 September 1991 and 1 December 1995, we stabilised 72% (1573 external fixators) of cases with external fixators; 24% (531) with plaster cast and plaster cast in combination with Steinmann pins and Kirschner needles; 4% (91) with extensions (Table 2). 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. We stabilised by means of 14 different types of external fixators, using Mitković's fixator M20 in 1342 (85%) cases and other types in 234 (15%) cases (Table 3). I always use functional plaster casts (Coldwell, Mooney, Delbeto, Sarmiento) after taking off the external fixator, which would have been placed on the injured extremity for 40 days on average. As early as the beginning of 1992 we had to manufacture external fixators because everyday practice favoured stabilisation with external fixators. Although Čajavec company had the technological capacity to manufacture any type of external fixators, earlier experiences made me opt for the use of Mitković's external fixator type M20. It was easy to manufacture and cheap. The M20 is a unilateral external fixator with a great mobility of movable clamps and pin holders which enables the placing of convergent bone pins, which, if necessary, is used at different stages of the treatment

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	**311**	**91,96%**	**22**	**7,00%**	**3**	**0,96%**

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

Table 1. Stabilisation method for bone fragments in persons injured by firearms between 15 June and 1 December 1995.

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 2. Overview of extremity fractures and primary treatment methods between 15 September 1991 and 1 December 1995 at Banja Luka CHC.

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

Table 3.

to adequately stabilise, neutralise and biocompress the extremity, and which provides easy access to the wound at all times. It is rarely indicated (bone defects exceeding 5 cm) to assemble a bilateral, triangular or semi-circular frame from a unilateral one, by placing Kirschner needles with olives, the distraction osteogenesis method is used (Fig. 2 and Fig. 3). In minor pin tract infection, the pin is removed in order not to develop major infection, and the mobility of the clamp and pin holder allows the placement of another pin under local anaesthesia, in order to keep the same stability. One spanner is necessary for the assembly of the frame and, most importantly, it is easy to train doctors who have never worked with external fixators on how to use them.

RESULTS

In the course of primary treatment of the 2642 persons injured with firearms we experienced some complications with the functioning of external fixators and complications resulting from primary treatment of wounds.

The complications we 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 4). There were infections of muscle and cutaneous tissue, acute osteomyelitis (re-intervention sites) in 704 (28.59%) wounded persons. Despite the surgical and drug therapy, we had 74 (2.92%) cases of chronic osteomyelitis, classified by bones as follows: humerus 7, radius 4, ulna 5, femur 21, tibia 31, calcaneus 3, 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%, mixed infections 8.40%. Out of the 2642 wounded persons, re-intervententions were performed in 704 (28.59%), out of which 491 (69.73%) were performed following primary treatment of the wound, where we stabilised with plaster cast or with plaster cast

Complications	No.	Percentage
Hoffman	62	5,46%
Oganesian	3	0,19%
Orthofix	32	2,66%
Charnley	42	0,38%
AO	12	0,25%

Table 4.

in combination with Steinmann pins and Kirschner needles, or extensions. 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 war wound. Out of the 1573 applied external fixators, 213 (13.54%) of them were re-interventions.

If we have a look at the injured with multiple injuries (Table 5), we see that it is very difficult to achieve adequate stabilisation and mobility with any other method but external fixation.

DISCUSSION

The complexity, specific nature and originality of every war wound require expertise, experience, attention and diligence[9].

War wounds were most frequently localised on the extremities - 70%[2,10], out of which 40% 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 joint injuries in this war occurred in 5.7% of cases, out of which 57.3% were penetrating joint injuries. Gunshot joint injuries make up 8% of gunshot injuries to the extremities[13]. Reports from the war in Afghanistan showed that out of 756 injured persons, 20.3% sustained penetrating joint injuries with no bone lesions. Shoulder injuries occurred in 33.7%, and wrist joint 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 extremity in 12.6% of cases, and in the Afghan army, in the period between 1984 and 1987, that percentage was between 30% and 45%[15]. The latter war has also been called 'mine war' by some. Approximately 20% of injuries were injuries to the upper extremities, and 64% were injuries to the lower extremities[16,17].

Type I and II open fractures of the extremities react well to treatment, while type III wounds constitute a major problem with the incidence of infection in as many as 24% of cases[18,19]. Primary care is the prevention of infections in open fractures, especially in type III wounds, and that is why this type was divided into three sub-types. According to Gustillo, the incidence of infection 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].

The best way to prevent war wound infections, other than to perform radical surgical treatments, is to eliminate pockets and dead-spaces where collections of liquid-haematoma, which are an excellent ground for the growth of bacteria, accumulate[22]. A great

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%)
Foot	126	5,74%	95 feet injuries accompanied by injuries to the abdomen, thorax, lower leg, 31 injuries to the foot only	
Upper arm	338	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%)	
Hand	141	6,42%	105 hand injuries accompanied by injuries to the abdomen, thorax, ..., 36 injuries to the hand only	
Total	**2195**	**100,00%**		

Out of the 2462 wounded persons, the following sustained multiple injuries:	Abdomen: 98(3.98%)
	Thorax: 25 (1.01%)
	Craniocereb.: 34(1.38%)

Table 5.

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 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 commenced with antibiotic therapy within a period of up to 6 hours. The results showed him that there were no septic complications when the antibiotics were administered up to three hours after sustaining the wound as they inhibit the growth of bacteria in gunshot wounds[25].

The International Committee of the Red Cross recommends administering crystalline penicillin, 5000000 units, intravenously every six hours on admission and continuing for minimum 48 hours, orally administering penicillin preparation 0.5 every 6 hours over the next six days.

The complications that we had 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 localised on the extremities, and approximately 40% of these injuries were accompanied by fractures.

In the examined material, it was necessary to treat (primarily) muscle and cutaneous injuries to the extremities in 265 (10.77%) cases, and in 2195 (89.23%) cases bone fragments needed to be stabilised due to bone tissue injuries. Out of the 2195 bone tissue injuries (bones), 2043 (92.43%) were cominutive fractures with or without bone defects.

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 can 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 first 48 hours, in 88 after 3-6 days, in 659 after 7-10 days, in 39 after 10-29 days, and in 21 patients it was performed after 21 days[2].The same authors claim to have had good and satisfactory results in 113 (12.88%) patients, and bad results in 765 (87.12%)[2].

In 1988, Mussa published treatment results of 258 patients. The most frequent method of stabilisation at the stage of primary surgical treatment was plaster splint in 26.4% of patients and definitive plaster cast with window 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 pseudoarthrosis.

Based on experience in the Afghanistan war, Gricanov et al. favour external fixators, pressing ahead with compression/distraction external fixators with hinged joints[7].

In 1994, Jovanović Z. et al. analysed 820 gunshot fractures, out of which 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 stabilising fractures at the stage of primary surgical treatment were as follows: external fixator - 447 (54.5%), plaster cast - 279 (34.0%), skeletal traction - 13 (1.6%), other methods - 81 (9.7%)[12].

The time taken to transport a wounded person from the site of wounding 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, so that the wounded were treated within 1 - 1.5 hours. In the examined material, the wounded were treated within 3 hours. A similar transportation method, with the lowest infection percentage (1.5 - 5%), was used in 1973 in the war between Israel and Egypt.

In the war, for the first time external fixation was used more frequently to treat open injuries to the

extremities. In the period between 15 September 1991 and 1 December 1995, in 72% (1573 external fixators) of cases, injuries were stabilised by external fixation; plaster cast and plaster cast in combination with Steinmann pins and Kirschner needles were used in 24% (531) of cases, and extension procedures were used in 4% (91) cases.

In an AAOS (American Academy of Orthopedic Surgery) notification, the following are stated as the causative agents of chronic bone infection: Staphylococus aureus 84.2%, Escherichiae colli 3.2%, Klebsilla 2.9%, Streptococus B hemoliticus 2.3%, Pseudomonaes aeruginosa 2.0%, and all others make up 5%[25]. The data that I. Gavrankapetanović of Sarajevo Orthopaedics and Traumatology Clinic presents while monitoring causative agents is interesting and is 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). On the basis of the antibiogram done on the fistula, the following infectious agents were found in our patients: Staphylococus aureus 31 (51.4%), Pseudomonas spp. 8 (13.8%), Pseudomonas aeruginosa 7 (12.5%), Enterobacteriaceae 3 (5.5%), other 5 (8.45%) (Stapphyloccocus epidermalis, Esecherichiaa colli, Streptococus B haemoliticus, Bacilus pyocineus, Klebsilla spp). 5 (8.4%) patients suffered from mixed infection: Pseudomonas aeruginosa + Enterobacteriaceae, Staphylococcus aureus + Enterobacteriaceae, Pseudomonas aeruginosa + Klebsiella spp.

There were 5 (0.2%) cases of gas gangrene in the examined material. Re-interventions were performed and 491 (69.73%) of them following primary treatment of the wound, which we stabilised with plaster cast, or with the combination of plaster cast and Steinmann pins, Kirschner needles or with extensions. 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 war wound.

In 1976, Böhm and Könn described morphological changes in chronic post-traumatic osteomyelitis on the basis of 760 cases of egzogenous osteomyelitis. Aggressive chronic osteomyelitis shown in characteristic histological finding revealed purulent inflammation lined with fibrous wall and granulation tissue, and chronic (persistent) osteomyelitis characterised 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 persons. Despite surgical 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, metatarsal bone 1.

In 1994, Jovanović Z., Popović Z. et al. presented the criterion for handling bone defects of the long bones by bone auto-transplant and stabilisation 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.

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, and in 6 cases he used the AO compression plate for stabilising the fragments. He had good results in 23 (72%) patients – achieved bone consolidation[11]. In 7 (22%) patients the results were satisfactory, and in 2 (6%) patients, healing did not take place.

Dr. Gabriele Falazarano.

CONCLUSIONS

The experiences gained during the war and the achieved results justify the position that the method of choice for primary stabilisation of bone fragments in war wounds is external fixator.

Having worked with a great number of fixators,

I have realised that the best external fixator is the one closest to W. Roux's maximum-minimum law and Wolff's law of transformation. Translated to the external fixator, this would mean that the best external fixator is the one that provides maximum functions (combinations) with minimum material and enables, through healing stages and by transforming the outer frame, the stabilisation of bone defects with and without bone fragments, bone distraction, biocompression, and elastic fixation.

A war fixator should be easy to manufacture and user-friendly for doctors who have never done external fixation. ✦

REFERENCES

1. Grubor Predrag: Tretman koštanih defekata , Glas srpski, Banja Luka 1999.
2. Popović dr Zoran: Rigidna osteosinteza AO pločom I spongioplastica po Phemistru u sekundarnom liječenju dijafizarnih strelnih preloma, Doktorska disertacija, Begrad 1996.
3. Piščević s. Nova oružja I osobenosti njihovog dejstva na organizam , Novi Sad 1976, Acta hirurgica, Yugoslavica 19-23.
4. Popović D: Ratna rana, sekcija za ortopedsku hirurgiju SLD-a, Beograd 1991.
5. Stojanović V.K., Hirurška obrada ratne rane, cta hirurgica Jugoslavica, Novi sad 1976, 43-47
6. Belokurov N.J.: Dinamika krovosnabženija nižnih konečnostej pri perelomah kostej, Ortop.Traumat. Protez. 2, 33-37, 1962.
7. Paradis G.R., Kelly P.J.: Blood flow and mineral deposition in canine tibial fractures, J.Bone Joint Surg., 57 A, 220-226, 1975.
8. Rand J.A., Chao E.Y.S., Kelly P.J.: A comparasion of the effect of open intramedullary nailing and compresion plate fixation on fracture-site blood flow and fracture union. J.Bone Joint Surg., 63A, 427-442, 1981.
9. Wray J.B. and Lynch C.J.:The vascular response the fracture of the tibia in the rat, J.Bone Joint Surg., 41A, 1143-1148, 1959.
10. Wray J.B. and Goodman H.O.: Post -fracture vascular phenomen and long bone overgrowth in immature skeleton of the rat, J.Bone Joint Surg., 43A, 1047-1055, 1961.
11. Wray J.B.: Acute changes in femoral arterial blood flow after slosed tibial fracture in dogs, J.Bone Joint Surg., 46A, 1262-1268, 1964.
12. Janković Ž. i Popović S.: Anatomija domaćih životinja, Beograd, 1988.
13. Mc Kelvey D., Hollingshead W.K.: Small animal anesthesia, Mosley-Year Book, Inc, St. Lous, 1994.
14. Witschi T., Omer G., ;The treatment of open tibial shaft fractures from Wietnam war, jurnal of trauma, Vol 10, N02, 105-111, 1970.
15. Mitković M., S. Cvetanović: Naša iskustva u liječenju hroničnog osteomijelitisa, Zbornik Radova, XVI Ortopedski i Traumatološki dani Jugoslavije, Priština 1986,63-65.
16. Ivankovski A., Miljković I., Roje J., Stojkovski K., FridrhS., : Liječenje kroničnog fistuloznog posttraumatskog osteomijelitisa primjenom različitih metoda, Zbornik Radova, XVI Ortopedski i Traumatološki dani Jugoslavije, Priština 1986,87-89.
17. Gustillo R., Mendoza R., Williams D.: Problems in the management of type III open fracturea; A eew clasification of type III open fracture, J. Of Trauma, Vol.24-8: 742, 1984.
18. Charles M. Court-Brown, Margaret M. McQueen, Awf A. Quaba: Menagement of Open Fractures, Martin Dunitz ltd 1996, Frst published in the United Kingdom in 1996.
19. Grubor P., Uloga spoljnje fiksacije u zbrinjavanju ratne rane, Glas srpski, Banja Luka 1996.
20. Papo I: Ratna hirurgija, vojnomedicinski zavod, Beograd, 1980.
21. Baščarević Lj.: Osteomijelitis, Medicinska knjiga, Beograd-Zagreb 1981.
22. Kraljević Lj.: Značaj morfoloških karakteristika strelnih rana nanesenih projektilima velike početne brzine na primarnu hirušku obradu, Acta chirurgica Jugoslavica, Novi sad 1976, 120-24.
23. Gustillo R. Mendosa R. Williams D. Problems in the management of type III open fractures:A new classification of type III fractures. J of trauma, 1984 Vol. 24-8: 742.
24. Grubor P. Mitković M. Application of external fixator Mitkovic in the treatment of war wounds of anatomic and surgical humeral neck, XII International congrees of emergency surgery and intensive care, Oslo 1995, 73-4.
25. Grubor P. Manual of external fixation in management of war wounds, Glas Srpski, Banja Luka 1996.

CORRESPONDING AUTHOR
Luigi Meccariello, MD
University Hospital "Santa Maria alle Scotte"
Viale Bracci 1, 53100 Siena, Italy
drlordmec@gmail.com
mobile +39 329 9419574