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TREATMENT OF THE CHRONIC WAR TIBIAL OSTEOMYELITIS, GUSTILIO TYPE IIIB AND CIERNY MADER IIIB, USING VARIOUS METHODS. A RETROSPECTIVE STUDY

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SUMMARY

Introduction: War osteomyelitis is an inflammation of all the bone elements at the place of bone fracture resulting from a war wound.

Method of work: During the Bosnian (1992-1995), 2,195 wounded people underwent primary surgical treatment for their wounded extremities. Tibia wounds were dominant in 695 (31.66%) of the cases, and 59 (8.48%) of which developed chronic osteomyelitis. The Gustilo's Classification score was IIIB and the Cierny-Mader's Classification score was IIIB. The average age of the patients was 38.2 years, sex representation: 57 (97%) males and 2 (3%) females. Cause of fracture: bullets 18 (31%), shell pieces 39 (66%), and combined 2 (3%), with polytrauma in 31 (52.54%). The most dominant infective agent was Staphylococcus aureus 31 (52%). We used 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%). We used the instantaneous vacuum for 36 (61%) patients. The aim of this work is to evaluate some perceptions in the therapy of the chronic fistulous war osteomyelitis tibia in a decade-long work. The study is retrospective and analyzes the use of surgical methods in the treatment of chronic osteomyelitis tibia caused by the high kinetic energy projectiles.

Results: Each of the 59 patients had an average of three surgical treatments. In spite of the above-mentioned treatments, 9 (15.25%) out of the 59 patients had chronic fistulous osteomyelitis. The average length of treatment was 36 days, and the duration of the exacerbation was 7 months. Transfusion was used for 23 (40%) patients. In the group of patients, the microbiological finding after operation was negative in 44 (75%). In 13 (22%) patients, infection manifested very early (i.e. during the first hospitalization).

Conclusion: Primary treatment of the war wound with sterilization is a crucial factor of acute (i.e. chronic osteomyelitis) prevention and sterilization is a general result of treatment. The optimal approach is to treat within 2 hours from the moment of injury. A multidisciplinary approach to treatment, highly sophisticated equipment in the diagnosis of injury, and the use of highly potent antibiotics of the newer generation, enable the achievement of full restitution of the wounded patient.

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Introduction

War osteomyelitis is an inflammation of all the bone elements at the place of the bone fracture as the consequence of the war wound. This distinguishes it from the haematogenous osteomyelitis, which renders the problem more complex. Haematogenous osteomyelitis is characterized by the typical localization in meta- and epiphyses, and very often penetrates and affects the adjacent joint. In 80% - 90% of cases, Haematogenous osteomyelitis is caused by Staphylococcus aureus. War osteomyelitis is often caused by mixed bacterial flora, while the association of mixed bacterial flora with chronic osteomyelitis is very rare. There are widened Havers' channels in the flora, which cause a condition of fragmented osteoporosis. With progression, the bone fragments that remain without vascularization or that are deperiosted break free and swim in pus [1,2]. Therefore, free segregates of bone originate and behave as free bodies. Those that remain connected with the periosteum, become construction material and serve as a defense against infection. Chronic war osteomyelitis can occur as the consequence of undiagnosed or inadequately treated acute war osteomyelitis. It may appear without previous acute infection, as a deceptive, slow, progressive infection without striking clinical manifestations. If the patient is not cured within the first eight weeks from the initial appearance of acute osteomyelitis symptoms, then the illness passes into its chronic form, which often worsens. Local symptoms of chronic osteomyelitis (such as pain, functional limitation, etc.) are very diverse and pronounced [3]. In 2011, Cierny described chronic osteomyelitis as, "A biofilm infection wherein only a small fraction of the microorganisms are free-swimming, available, and sensitive to systemic agents." Instead, the overwhelming majority of pathogens are sessile-based, resiliently attached (to dead bone, implants, or foreign bodies) and embedded within a microbial-based slime as biofilm. Once in the sessile state, the organisms are invulnerable to both the host's defenses and circulating concentrations of antibiotics. Over time, microbial toxins and caustic by-products of the host's cellular defenses accumulate to cause a profound local and systemic compromise: sepsis, tissue loss, and chronic edema. It is this pathophysiology that mandates a multidisciplinary approach to treatment: complete surgical removal of the biofilm burden (debridement), medical optimization of host defenses, and administration of antimicrobial agents at concentrations to kill pathogen phenotypes within the wound following debridement. Over the last three decades, treatment strategies to counter mechanisms of surface colonization by potential pathogens have set the foundation for today's limb salvage protocols. Innovative technologies introduced versatile fixation devices, methods of tissue regeneration, antimicrobial agents and isolation strategies, local antibiotic delivery systems, negative pressure applications, and function-sparing ways to transfer living tissues site to site. With the ability to convert dirty wounds to clean wounds and restore both form and function, the treatment of musculoskeletal sepsis entered a new era wherein the prospects of a successful reconstruction derailed the "fear of failure" that had been blocking surgeons from initiating treatment at all. The treatment of osteomyelitis is a very complex, long process that requires a great persistence where a basic surgical treatment needs to be supplemented with antibiotic therapy on the basis of antibiogram, and the means to improve immunological capacity of the body [4]. In order to appropriately perform this treatment, it is important in war scenarios to have a properly formed multidisciplinary team for the treatment of war trauma [5]. The cure with spontaneous reabsorption is extremely rare. Necrosis with burrowing potentially lasts from a couple of weeks to the patient's whole life. Exitus letalis under appearance of septicemia is possible but is a rarity in the era of antibiotics [6].

Material and methods

During the war (1992 – 1995) in KBC (Clinic-hospital center) Banja Luka, 2,195 wounded people received primary surgical treatment for wounded extremities. The most prevalent injuries were wounds of the tibia, in which 695 people (31.66%) were treated. From 1995 to June 1, 2005, 59 (8.48%) tibias were treated for chronic war osteomyelitis at the Clinic of Orthopedics and Traumatology.

This study is retrospective and comprised of 59 patients (**see Table 1**) who have chronic osteomyelitis as the consequence of wounding in the above mentioned war. Chronic osteomyelitis tibia is represented according to the age of the patients: 21-30 years old 2 (4%), 31-40 years old, 35 years old (60%), 41-50 years old, 16 years old (26%), 51 years old, and 6 years old (10%).

The Gustilo's Classification score was IIIB and the Cierny-Mader's Classification score IIIB. In our analysis, we used the details of the history of illness and the selected treated patients. All patients were treated with modular external fixation [7], and received anti-tetanus protection and four doses of 5MIU crystal penicillin intravenously, and two 80mg doses of Gentamicine. The shortest time span between the operation and the control examination was 1 month with the patients undergoing regular controls. The longest time between the operation and control examination was 1 year. These patients were treated by the orthopedist of the competent Health Insurance Fund. When the exacerbation of the process and fistula appeared, they were sent to the surgeon without inquiry into the treatment in the previous period. The

	n=59 (%)
Gender (M; F)	57 (97); 2 (3)
Average age of patients (range) in years	38.2 (28-60)
Age class of Patients at the moment of trauma	
– 21–30 years	2 (4)
– 31–40 years	35 (60)
– 41–50 years	16 (26)
– 51–60 years	6 (10)
Number of Patients suffered of tibial fracture by Bullets	18 (31)
Number of Patients suffered of tibial fracture by Shells	39 (66)
Number of Patients suffered of tibial fracture by Bullets + Shells	2 (3)
Number of Polytraumas	31(52.5)
Grade Gustilo's Classification	IIIB
Grade of Cierny– Mader's Classification	IIIB
Number of Patients treated	
– with Papineuo Method	5 (8.5)
– with Sequestration Method	28 (47.5)
– with Fenestration, Sequestration the infected area Method	17 (29)
– with Only Forage of Tibia Method	3 (5%)
– with Decortication and Resection Method	6 (10)

Table 1: Socio-demographic, clinical and surgical description of population in study.

average time of exacerbation of the process and fistula was 12.3 months (ranging from 5 weeks to 65.6 months). Clinical diagnosis supported by laboratory testing and radiographic examinations performed in our center immediately diagnosed tibial chronic osteomyelitis. The average age of the patients was 38.2 years (the youngest at 28 years and the oldest at 60 years of age). According to sex, 57 (97%) males and 2 (3%) females were represented. Objects which caused the fracture of tibia of the patients were: bullets 18 (31%), shell fragments 39 (66%) and mixed 2 (3%). 31 (52.54%) patients were polytraumatized: abdomen 19 (32.20%), thorax 15 (24.42%), thigh 5 (8.47%), arms 12 (20.33%), soft tissue wounds of another leg 27 (45.76%).

Up to the moment of wounding, 5 (9%) patients had suffered from chronic illness (cardiac and bone-joint problems) and 52 (91%) were healthy. At the time of their wounding, 5 (9%) patients had a university degree, 34 (57%) had a secondary school degree, and 20 (34%) had only a primary school education. Before the war 45 (76%) wounded people were employed and 15 (24%) were unemployed.

There were 43 (72%) smokers and 16 (28%) non-smokers. It is interesting to note that 48 (81%) patients had cavities in one or more teeth during the treatment of osteomyelitis.

The presence of the foreign body (shell fragments) was found in 43 (73%) patients treated with chronic osteomyelitis and was not found in 16 (27%). On the basis of the antibiogram taken from the fistulous channel, the representation of infection was (**Figure 1**): 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 pyocineus 1 (2%), Klebsiella spp 1 (2%). Mixed infections were represented in 5 patients (9%): Pseudomonas aeruginosa + Enterobacter, Staphylococcus aureus + Enterobacter, Pseudomonas aeruginosa + Klebsiella spp.

Out of the examined sample, 9 (15%) patients were initially bandaged, immobilized with the Kramer's rail, and transported to hospital for the purpose of delayed treatment. Primary surgical treatment was carried out within the first 6 hours. In 42 (71%) patients, primary surgical treatment was carried out at the Surgical Station within 4 hours after wounding. Immobilization with a cast and hospital treatment continued, on average, 24 hours after treatment. Out of the 42 patients, 19 (20%)

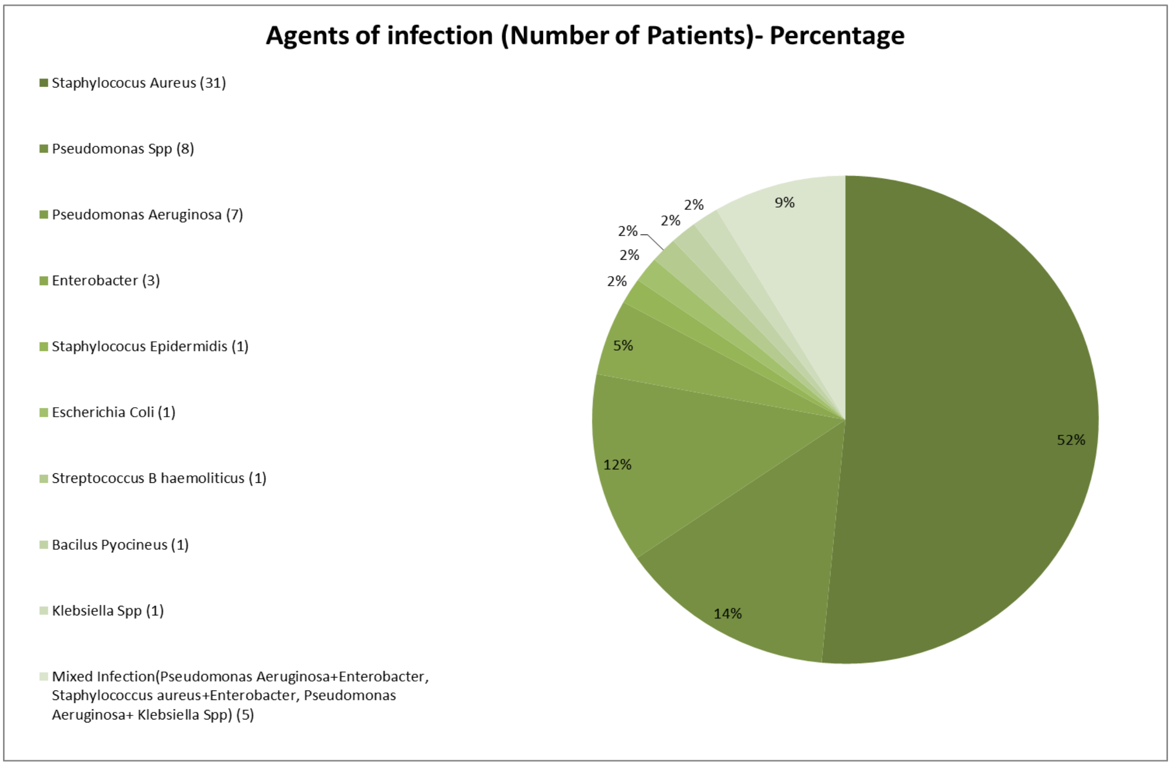

Figure 1: Infective agents and their percentages. Staphylococcus Aureus was the most dominant agent of infection with 31 (52%) infected patients.

were treated with a definitive cast and 23 patients were treated with an external fixator. After primary surgical treatment in 8 (13%) patients, the fracture was stabilized with an external fixator, which was a definitive treatment. Out of 59 patients, 42 (71%) were primarily managed in KBC Banja Luka and 17 (29%) patients were managed in other institutions. Upon arrival at our Clinic, 14 (24%) patients had already been surgically and medically treated for chronic osteomyelitis by other institutions.
Diagnosis of the chronic osteomyelitis was established on the basis of history and clinical examination (continuous secretion of the wound, fistula), laboratory hematological search (increased SE, alkaline phosphatase, fibrinogen, increased C reactive protein, creatine-phosphokinesy) and bacteriology searches. Radiological diagnosis was used in all the patients (X-Ray in two projections, fistulography and, if necessary, tomography), and scintigraphy-radioisotopic search with 99mTc in 16 (27%) patients, used to show the infected area (bone) for the purpose of the resection of the same. We used CT and MRI in 11 (18%) patients. Upon admission to the Clinic, an antibiogram from the fistula was taken and antibiotics were administered by the antibiogram (three days before the surgical treatment at latest). After the diagnosis, the plan of treatment was performed. We preferred to treat all the patients with surgical and specific perioperative antibiotic prophylaxis. We did not try to treat chronic tibial osteomyelitis with only specific antibiotic therapy. The decision to use one surgical technique over another was not determined by the type of germ found, but rather was determined according to the characteristics of osteomyelitis as its extension in the bone, the size of the fistula, and the involvement of the soft tissues. An adequate (preserved) venous route was recoded in 47 (80%) patients and in 12 (20%) was not preserved. The reason for an inadequate venous route was the frequent use of the same in the surgical treatment of the injury caused by the war trauma. The use of the local antibiotics in combination with the adequate surgical treatment is a valid method in the treatment of the chronic osteomyelitis. However, a radical debridement, curettage, forage, perfusion drainage, and sequesterotomy, currently are not sufficient or efficient methods of treatment of chronic osteomyelitis caused by the high kinetic energy projectile.
On the operating table before the surgical incision, the swab from the fistula was taken, fistula channel washing was performed by polifen, and methylene blue staining through the fistula was applied under pressure, enabling tracking of the fistula branching. In all the patients, we noticed minor defects of sclerotic, thin, insufficient skin, which were frequently strained fistulous openings. We did not have a single metaplasia of the fistula or occurrence of carcinoma. We did not use Disulphin blue to mark necrotic tissue. Radical debridement into the healthy skin and complete removal of the fistulous channel and the scar tissue in the wound were performed in all the patients. Radical debridement into the healthy skin caused a skin defect at the tibia that caused a delayed skin covering in all 26 patients. When the infection calmed down, we started solving the skin problem. Plastic and reconstructive surgeons used rotation flaps of the head gastrocnemius 18, fasciocutanium 8, and covered the skin defect using a Thiersch transplant. A soft tissue cover is very important in definitive treatment of the chronic bone infections because it improves the local circulation up to the quality of the mechanical cover, and for bone protection against new invasions of microorganisms. Papineau's method is based on the well-known biological rules: granular tissue has a bacteriologic effect and capacity for metaplasia, with the sponge graft resistant against infection. We used Papineau's method in 5 (8.50%) cases (**Table 1**). In 3 patients the external fixation M20, according to Mitkovic, was used while for the others, osteomyelitic process was presented by a joint cavity where, after sequestration or curettage, biomechanical stability was not violated. We filled a new cavity with a vaseline gauze. After granulation appeared, the cavity was filled with Ringer and was bandaged 2-3 times a day. Cancellous bone autotransplant was pressed into the granular tissue.
Sequestration was performed in 28 (47.50%) patients (**Table 1**), and curettage of the concentration of osteomyelitis on all of the patients. Removal of segregates at the chronic osteomyelitis on our material

did not confirm the previous understanding "conditio sine qua non," which means successful treatment has been done.

Instantaneous vacuum drainage was used in 36 (61%) patients, even though there were limited opinions for local use of antibiotics in practical irrigation. After infected bone was identified, the removals of all potential sequesters of the new cavity were opened, curettage was performed, and the medullary channel was opened. Then, drains were inserted (ca. 4 mm in diameter) for the purpose of instantaneous vacuum drainage. The drains were inserted so that they lay at the level of the infected bone with the afferent drain set above the efferent drain. The wound was shut in layers. The afferent drain was connected to a bottle containing saline solution or a Ringer with the antibiotic defined by the antibiogram from the fistula, which was done upon admission to the hospital. The swab from the efferent drain was taken once a week and the antibiotic was administered or switched with a saline solution through the system. This system was continued until a sterile finding from the efferent drain was obtained, or it was discontinued if the system was not functioning. On average, the duration of the drainage was 18 days.

The fenestration and sequestration of the infected bone was performed in 17 (29%) patients **(Table 1)**. Samples of bacteria in all of the cases were identified before the operative intervention, and all of them were sensitive to gentamicine. The forage of the tibia was only performed in 3 (5%) patients (**Table 1**) who exhibited previous good curettage of the osteomyelitis concentration. We were convinced that by foraging, we would be able to obtain revascularization of the bone and by introducing gentamicine beads into the treatment, we could expect healing. The long-lasting cavum gentamicine beads were implanted into the obtained space in 9 patients who had a stable bone segment, and remained until extraction of the same swab of beads was negative. The swab of the wound after extraction of the beads was positive in one patient. In 3 patients, where we estimated that a pathologic fracture could appear, the obtained space was filled with bone cement with antibiotic (Refobacin-Palakos^{R}) with the addition of 0.5g of gentamicine. We filled the defect of the tibia with Refobacin-Palakos^{R} while it was in the state of paste. This is useful for temperatures up to 80˚C, which appear during the polymerization of the bone cement from the powder, and convert the paste into a solid shape. As a result of this high temperature, there is an additional "sterilization" of the infected bone up to ca. 0.5 mm where it has a contact with bone cement.

Due to chronic osteomyelitis, we performed decortication and resection of the dead tibia bone in 6 (10%) patients (**Table 1**). This was indicated based upon the radiology, scintigraphy and clinical intraoperative findings. Bone resection was done up to the healthy bone, with the appearance of bleeding from the bone cortex. The cure was continued by compressing the resected fragments of tibia, utilizing Ilizarov's apparatus, with the previous osteotomized, resected fibula. In two patients, corticotomy was performed after two weeks in order to achieve the length of extremities by successive distraction.

We did not use sympathectomy: cutting the fibers of symphaticus in the lumbar region, in the region of aorta abdominalis, or ganglia symphaticus in the region arteria femoralis, as a form of surgical treatment of the chronic osteomyelitis. 22 patients used immunotherapy (blood, gamma globulins, gamma veninis).

Antibiotics were administered intravenously specific to each cause of infection, which was isolated from the deep bone tissue during curettage, fenestration or resection. Antibiotics were administered in the optimal dose during hospitalization when the cause of infection was identified (biogram) in the clinic, as well as in the follow-up treatment at home, which totaled 4 and 6 weeks.

The aim of this work is to evaluate some perceptions in the therapy of the chronic fistulous war osteomyelitis tibia in a decade-long work. It involved the analysis of the applied surgical methods of work in the treatment of chronic osteomyelitis tibia caused by the high kinetic energy projectiles in our institution. The study is retrospective. Patients were treated according to the Helsinki Declaration's ethical standards, and all patients were required to be able to read and understand the patient information sheet and sign the informed consent form. The author has no financial interest to declare in relation to the content of this article.

Results

Since chronic osteomyelitis was surgically treated in each of the 59 patients an average of three times, 179 total surgeries were performed. In addition to the abovementioned treatments, 9 (15.25%) out of 59 patients have chronic fistulous osteomyelitis, which presents a poor outcome of treatment in comparison with developed countries. The average length of treatment is 36 days and the length of exacerbation is 7 months. Transfusion was used in 23 (40%) patients. In the group of patients, microbiological findings after operation was negative in 44 (75%), while polymicrobe infection was dominant in 90%. The early appearance of infection (during the first hospitalization) was recorded in 13 (22%).

Out of the 5 (8.50%) patients treated by Papineau's method, 3 were healed. Exacerbation appeared in one patient after 8 months. He then underwent surgery an additional two times with Papineau's method, but there was no recovery. Today he is suffering from chronic osteomyelitis. Another patient, who demonstrated exacerbation of the chronic osteomyelitis eleven months after surgical treatment, did not accept the suggested treatment, which was most likely continued in another institution.

28 (47.50%) patients were treated with sequestration method. Relapses did not occur in 24 patients. Complications appeared in 5 patients in the form of redness, swelling, increased temperature, and increased findings of inflammatory syndrome, which calmed down after the 15-day antibiotic therapy. Exacerbation appeared in 7 patients after the abovementioned surgical treatment; seventh months at the earliest and eighteenth months at the latest. In two patients, the second intervention involved tibia resection and compression of fragments according to Ilizarov [5]. One patient was healed, while another patient suffered exacerbation at the beginning of summer in the form of fistula, which calmed down after twenty days of antibiotic therapy according to swab results. (**Figures 2, 3**) This has lasted for the past 8 years and the patient has not accepted a different form of treatment. Five patients were surgically treated another five times with the combination of: Papineau's method, fenestration, vacuum drainage, and gentamicine beads. One patient was healed, while four patients still have chronic fistulous osteomyelitis.

The number of patients treated with Fenestration, Sequestration was 17 (29%), the number of patients treated with only forage of tibia was 3 (5%), and the number of patients treated with decortication and resection method was 6 (10%). The average time of treatment of the three groups men-

Figure 2: Skin of Tibia in a patient with healed tibia and chronic osteomyelitis.

Figure 3: X-Ray in Anterior posterior and Latero-Lateral of Tibia in a patient with healed tibia and chronic osteomyelitis.

tioned above was 23 months after the intervention, when antibiotic was implanted in the cavum of the bone modified by osteitis. Six cases were clinically healed. Redness and swelling appeared during hospitalization and they continued treatment in another institution. Exacerbation appeared in 4 cases on average after one year. Follow-up interventions were performed three times. Three patients still have chronic osteomyelitis, and one patient's tibia has been amputated due to a defect on bones and skin that could not be solved by plastic surgery and because the pain was unbearable.

Due to the chronic osteomyelitis, we performed decortication and resection of the dead tibia bone in 6 patients. An Ilizarov's external fixator performed stabilization. In 5 patients osteomyelitis was healed, and one patient still has chronic osteomyelitis and healed tibia **(Figures 2, 3)**.

Five patients were treated in a hyperbaric chamber. This form of treatment only delayed surgical treatment. After this experience we no longer insisted on treatment in the hyperbaric chamber.

We applied the method of instantaneous vacuum drainage in 36 (61%) patients.

Rehabilitation of patients suffering from the bone infection is essential because it prepares the patient for independent functioning. We started the early rehabilitation on the second postoperative day: kinesis therapy, occupational therapy, and verticalization work to restore the function of the locomotor apparatus, which was damaged by this illness in 90% of cases. This is the most important way towards successful healing of the patients. The task of the orthopedist, as well as the physiatrist, social worker, and psychologist, is to get the patient back to work or direct him to the sort of work which will not aggravate his illness.

Discussion

Complexity and originality of each case, as well as the specificity of chronic war osteomyelitis, require expertise, experience, attention and study.

Billroth, between the years1860 and 1887, had to perform 28 amputations and 93 open fractures of tibia, and lost 36 wounded people. Böhler cited in his book published in 1929 that open fractures of bones were absolutely fatal injuries [8]. Open fracture types I and type II react well to the treatment, while wound type–III is a great problem with infection occurring in up to 24%. A primary concern is prevention of infection at open fractures, especially with wound type–III, which is why this category is divided into three subtypes. According to Gustillo, the infection of these three subtypes was: for the subtype IIIa 4%, for the subtype IIIb 52%, for the subtype IIIc 42%, and amputations were as follows: for IIIa 0%, III b 16%, IIIc 62% of cases [6,9].

Gunshot wounds were 70% localized on the extremities, out of which ca. 40% of these wounds were followed by the fracture. Speed of transport from the place of wounding to the surgical station is very important. In Vietnam, the transport of wounded people by helicopter to the aircraft carrier that contained an extremely well equipped surgical station was available, so that wounded people were being managed within 1 to 1.5 hours after injury. Chronic osteomyelitis was represented in 8.3% [10]. In the examined materials, primary surgical treatment was performed in the surgical station in 42 (71%) of the patients, within 4 hours after injury. A similar way of transport with the lowest infection rate (1.5-5%) was in 1973 during the Izraeli – Egypt war. This war marked the first time a frequent use of external fixation was introduced in managing the open wounds of extremities.

The Army of Great Britain in the Falkland's war of 1982 reported good results regarding a minor number of infections. A vertical transport was used, while the presence of chronic infection was reported in 9.7% cases [11].

In Chad, as well as in the war in Angola, then in West Africa (Polisario), an extremely large number of infections were recorded, over 20%. In the Russia – Afghanistan war, there was bad transport (on horseback) and inadequate timely surgical help [10], which resulted mainly in amputations in hospitals.

Chronic osteomyelitis in open fractures at traffic trauma occured in 5.2% - 20.6% of all the open fractures in Gustilo's study from 1971. Chronic osteomyelitis occured in 5.25% of open fractures of the tibia; which were treated by traction and cast,

and by metal plates in operative treatment of 20.6% [12].
According to Gustilo's research in 1987, chronic osteomyelitis in open fractures of tibia occurred in 7.1% of III degree fractures treated with an external fixator.
In the Whittle study of 1999, chronic osteomyelitis at open fractures of the III degree that were treated by an external fixator occurred in 8% of cases, according to Gustilo, and those who were treated by an internal fixation represented 12% of all the wounded people [6,10].
In 2011, Cierny GIII describes in his article [13]: type I and type II components of osteomyelitis are often concomitant in type III lesions, and debridement commonly leads to a composite, hard, and soft -tissue deficit. If the excision will be of such a magnitude as to threaten the mechanical stability of the remaining bony segment, the limb may be prophylactically stabilized with the use of an osseous transfer [14-16], an external fixator [17], or stabilized in situ following debridement with an antibiotic depot (antibiotic-coated implant/spacers, antibiotic rods, and so on). Soft-tissue defects are addressed as discussed for type II lesions. If osseous reconstruction is indicated or a significant dead space exists following debridement, reconstruction will usually follow a course of local antibiotic therapy [13].
There is an AAOS statement (American Academy of orthopedic surgery) citing the cause of the bone infection: Staphylococus aureus 84.2%, Escherichia Coli 3.2%, Klebsilla 2.9%, Streptococus B hemoliticus 2.3%, Pseudomonaes aeruginosa 2.0%, and all the others make-up 5%. The details are interesting, which I. Gavrankapetanović et al. [26] cites in a local report of Sarajevo trauma center during the war, which reports that 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 a fatal Enterococcus fecalis in 3% of cases. Based upon antibiograms taken from the fistulous channel, the representation of infection in our patients was: Staphylococus aureus 31 (51.4%), Pseudomonas spp. 8 (13.8%), Pseudomonas aeruginosa 7 (12.5%), Enterobacter 3 (5.5%), the others 5 (8.45%) (Staphyloccocus epidermalis, Escheerichia Coli, Streptococcus B haemoliticus, Bacilus pyocineus, Klebsill spp). Mixed infection was represented in 5 (8.4%) patients: Pseudomonas aeruginosa+Enterobacter, Staphylococcus aureus+Enterobacter, and Pseudomonas aeruginosa+Klebsiella spp [18]. 4 Level I trials studying antibiotic prophylaxis in open fractures [19-22] highlighted a prevalence of Staphylococcus aureus as the number one cause of surgical site infection, and one trial [22] reported the rate of methicillin-resistant S aureus (MRSA) as being nearly one-third of the total staphylococcal infections. With increasing use of antibiotics in the general population, we are faced with a new concern that was probably not present in clinical trials from prior decades: the changing epidemiology of the colonizing organisms. In 2000, Patzakis et al. [28] observed in his randomized, double-blind study that only 18% of the infections were caused by the same isolated micro-organism in the perioperative cultures. Patzakis et al. also [18,28] demonstrated that the empiric use of first generation Cephalosporin reduced the incidence of the infection in the treatment of open fractures.
In 2005 Beals et al. [24] reported: the treatment of 30 consecutive adult patients with chronic draining osteomyelitis of the tibia was reviewed. There were four treatment patterns. Eight patients had local debridement with or without soft tissue coverage procedures or bone graft. Three patients had radical debridement and bone transport using a circular frame. Eight patients were treated by the Papineau's grafting technique after debridement. Eleven patients had debridement and circular frame fixation to correct associated nonunion, not perfect union or shortening. All patients received long-term antibiotic therapy. At an average of 6 years follow-up (minimum 2 years), two patients had persistent drainage and one patient had an aseptic nonunion. This experience affirms the value of the circular frame, of the Papineau's graft, of bone transport, and of long-term antibiotics for treatment of chronic osteomyelitis of the tibia. There was successful limb salvage in all of the patients and successful treatment (fracture healing without drainage) in 27 of 30 patients.
In 1976 Böhm and Könn described morphological changes in chronic posttraumatic osteomyelitis based on 760

cases of exogenous osteomyelitis. They described chronic aggressive osteomyelitis with a characteristic histology, which shows a purulent inflammation surrounded by a fibrin wall and a granular tissue. It also shows a chronic persistent osteomyelitis characterized by a connective tissue rich in cells and capillaries and infiltration of cells in the sense of bone construction [6,8]. They divide the latter in two subgroups: in so-called "very active," there are signs of creating the new trabecular bone, and another so-called "less active," which is chronic and persistently poor in cells and did not exhibit the signs of destruction of trabecular bone or creating the bone trabecular. The characteristic of this chronic inactive osteomyelitis is creating the abundant amount of healing that contains embedded leucocyte abscesses. The question is whether these abscesses are important for the exacerbation of illness in the secondary chronic osteomyelitis. Ideal coverage would deliver an agent exhibiting a 1:1 kL ratio between its mean inhibitory concentration and mean bactericidal concentration for a particular pathogen and capable safe serum concentrations at least six times the organism's mean bactericidal concentration [17].

According Hou Z et al. [26], they treated 32 Gustilo type IIIB open tibia fractures with Vacuum-assisted closure (VAC) therapy. The mean Injury Severity Score was 17.3 +/- 2.0. All wounds were closed after being treated with the primary VAC closure. The mean interval between the initial injury and definitive intervention was 10.9 days +/- 0.3 days. 20 of the 27 patients (74%) underwent rotational muscle flaps; four received free muscle flaps and three only with split-thickness skin grafts for definitive wound coverage. Nine out of 32 patients (28%) underwent below knee amputation, five without flap coverage after several VAC sessions and four after definitive flap coverage. The average time to union was 10.0 months +/- 2.0 months. Eight patients (25%) developed nonunion and 11 patients (34%) developed infections. The rate of infection was significantly increased in patients who had an interval of more than 7 days from the time of injury to flap coverage. The VAC therapy may help to reduce the flap size and need for a flap transfer for type IIIB open tibial fractures. However, prolonged periods of VAC usage, greater than 7 days, should be avoided to reduce higher infection and amputation risks.

In 2010, Hutson et al. [27], treated 19 Gustilo grade III B tibial fractures with circular tensioned wire fixation and distraction histogenesis with flap reconstruction. Flaps were applied on average of 34 days after initial injury, with 13 free flaps and 6 rotation flaps applied. Two free flaps failed and experienced a second successful application. Flap survival was achieved in 17 of 19 cases. Complications included: one partial necrosis and one flap hematoma but no complication from delayed elevation and spacer removal. Average tibial bone defect was 9.4 cm. Reconstruction time was 26.5 months. Reconstruction resulted in union and no deep infection or osteomyelitis in 18 of 19 fractures. Hypertrophic nonunion occurred in one noncompliant patient. The use of antibiotic spacers and flaps to construct a soft tissue tunnel combined with distraction histogenesis is an effective technique to salvage complex Gustilo III B tibia fractures with segmental bone loss.

In 2011, Papakostidis et al. [28] described in their meta-analysis: Open tibial fractures (N = 3060 fractures in 32 studies). Reamed tibial nails (RTNs) were associated with significantly higher odds of early union compared with unreamed tibial nails (UTNs) in IIIB open fractures (odds ratio (OR) = 12; 95% CI, 2.4-61) Comparing RTN and UTN modes of treatment, no significant differences were documented per grade of open fractures with respect to both delayed and late union rates. Nonunion rates in IIIB open fractures treated with either RTNs or UTNs were lower than IIIA or II open fractures (P = ns). Significantly increased deep infection rates of IIIB open fractures compared with all other grades were documented for both modes of treatment. Lower deep infection rates for IIIA open fractures treated with RTNs were recorded compared with grades I and II. Grade II open tibial fractures, treated with UTN, presented significantly greater odds for developing compartment syndrome than when treated with RTNs. Our cumulative analysis, providing for each grade of open injury and each particular method of treatment, gives a summarized estimate of the most important outcome measures of open tibial fractures, and constitutes a useful tool of the practicing surgeon for optimal decision making when operative treatment of such fractures is contemplated.

According to data in the United States, an infection costs between 6,000 and 9,000 dollars on average. Ca. 14,000,000 recorded infections on a yearly basis cost the United States 9.8 billion dollars. According to data from Germany in 1976, a chronic osteomyelitis femur costs 50,000 Deutsch mark, and an osteomyelitis tibia ca. 35,000 DM. It is clear from this short synopsis how one infection largely caused by negligence in work can be extremely costly [8]. Therefore, the imperative question arises of how, when, and on what conditions a bone system should be operated. The cost of treating the patients with chronic bone infection is unusually high, and prevention measures, which are expensive, are nevertheless far simpler and cheaper for society than curing the infections.

Conclusion

Chronic bone infection, as the consequence of war trauma, is one of the most difficult complications of wounds. War wound is characterized by abundant destruction, primary contamination of polymorphic bacterial flora, and altered reactivity of the organism. The tibia is the most frequent place of development of chronic bone infection and the most frequent cause is Staphylococcus aureus.

Primary treatment of the war wound is “sterilization,“ which is a crucial factor in prevention and curing of acute or chronic osteomyelitis. The best outcomes result from treatment performed within two hours after the moment of injury. A multidisciplinary approach to treatment, highly sophisticated equipment in diagnosing the wound, and the use of highly potent antibiotics of the newer generation, enable achievement of the full restitution of the wounded people. Our retrospective study on the treatment of tibial chronic osteomyelitis during the war in Bosnia utilized various methods and demonstrated that in the light of new findings reported in the literature after our modern conflicts, our treatments were parallel.

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