Coll. Antropol. **37** (2013) Suppl. 1: 265–269
Professional paper

Gunshot Injury of the Foot: Treatment and Procedures – A Role of Negative Pressure Wound Therapy

Marin Marinović[1], Endi Radović[1], Bore Bakota[2], Marijan Mikačević[3], Nikola Gržalja[1], Darko Ekl and Ivica Cepić

[1] Clinical Hospital Rijeka, Rijeka, Croatia
[2] General Hospital Karlovac, Karlovac, Croatia
[3] Clinic for Orthopedics Lovran, Lovran, Croatia

A B S T R A C T

Civilian gunshot injuries of the foot are not so common in Croatia. They are related with accidents in hunting or weapon cleaning. Gunshot injuries represent a special challenge for surgeon because of specific anatomical relations and biomechanical function of the foot. We have decided to present a patient with a complex foot injury caused by hunting firearm in self-inflicted accident. A 45-year-old male presented with 12-gauge shotgun wound to his left foot. We found a complicated fracture with bone defect of 3rd, 4th and 5th metatarsals and wide soft tissue injury with skin and subcutaneous defect of the dorsal and lateral side of the foot. The wound was contaminated with numerous metal fragments, particles of rocks and ground. Surgical treatment was performed three hours after trauma and included extensive debridement of damaged soft tissue, removing of the non-viable bone and metal fragments, rocks and other foreign bodies. Negative Pressure Wound Therapy (NPWT) was applicated in the operating table. The starting therapy was continuously –125 mm Hg of vacuum. We continued with intermittent therapy of –100 mm Hg and change NPWT dressing every fourth day. After four weeks of NPWT the defect was filled with granulation tissue and split thickness skin graft was applied. Skin graft was additionally fixed with NPWT using continuous therapy at –100 mm Hg for a period of four days. Forthy days after injury there was a complete healing of all soft tissue. Control X-ray showed good bone healing process.

***Key words**: gunshot injury, foot injury, Negative Pressure Wound Therapy, NPWT*

Introduction

The incidence of gunshot injuries is increasing in Europe and in USA. Consequence of that unfortunate trend is that surgeons in trauma centers are more frequently confronted with this type of injury[1]. Civilian gunshot injuries of the foot are not so common in Croatia. They are related with accidents in hunting or weapon cleaning and presented as an isolated injury. Multiple gunshot injuries associated with foot injury are related with criminal violence and often result with lethal epilogue. Fortunately, they are very rare in Croatia.

Gunshot injuries represent a special challenge for surgeon because of specific anatomical relations and biomechanical function of the foot. These wounds often require debridement in the operating room and usually are associated with wide tissue damage and bacterial contamination.

The extend of tissue damage caused by bullet depends of numerous factors. These factors include bullet characteristics such as velocity and weight, which are the most significant determinations of tissue damage. Bullet size, shape and tumbling also have an important role in tissue destruction. Moreover, characteristics of the tissue damaged by bullet and abundance of specific structures such as nerves, vascular structures and tendons determines extension and seriousness of injury[2]. Gunshot wounds to the foot and ankle can be very devastating[3]. On the other side, the unique problem of filling and covering a tissue defect is present, particular in cases of through-and-through gunshot wounds, also called »Fearless Fosdick« injury[4]. Sophisticated reconstructive strategies are often necessary because it remains a challenging problem to achieve reliable soft tissue coverage while at the same time optimizing foot contour and weight bearing function[5].

Received for publication October 15, 2012

Gunshot injuries associated with fractures are potentially infected. Protocols for antibiotic prophylaxis in the treatment of gunshot injuries associated with fractures have not been delineated clearly[6]. There are differences between wounds caused by weapons with high velocity, low velocity and shotguns. In wounds with fractures caused by shotguns, thorough wound debridement and administration of intravenous antibiotics within a minimum of 24 to 48 hours is necessary[6].

In the past few years, Negative Pressure Wound Therapy (NPWT) has become an accepted option and important factor in managing and treating lots of trauma patients with wide diapason of wounds. It is widely used in treatment of large soft-tissue injuries with compromised microcirculation. It is also used in treatment for gunshot injuries. Using NPWT with comprehensive surgical assessment and debridement procedure, terms for wound closure is achieved.

Case Report

A 45-year-old white male was presented to the emergency department after he shot himself through the left foot in self-inflicted accident. He had a close range gunshot wound caused by 12-gauge »Brenneke« cartridge (Figure 1). It was RWS – Rottweil ammunition characterized with weight of 31.5 g, initial bullet speed of 430 m/s (1411 ft/sec) and impact energy of 2912 Joules. The wound measured 11 x 6 cm (Figure 2). The defect of skin and subcutaneous tissue with laesion of extensor tendons of fourth and fifth toe was presented. The extensor tendon of third toe was exposed. The patient also sustained multifragmental fractures of third, fourth and fifth metatarsal with exposed bone tissue. A standard X-ray of the foot demonstrated spiral fracture of diaphyses and proximal metaphyses of the third metatarsal bone, multifragmental fracture of diaphyses of the fourth metatarsal bone with minimal angulation of fragments and multifragmental fracture of diaphyses of the fifth metatarsal bone with small shift. In soft tissue it was viewable contaminated wound area with pieces of rocks and numerous metal pieces of bullet inside the wound area (Figure 3).

Fig. 1. 12-gauge »Brenneke« cartridge..

Fig. 2. The wound measured 11 x 6 cm.

Fig. 3. contaminated wound are with ametal pieces.

The patient presented to the emergency room two hours after the injury. He was conscious (Glasgow Coma Scale 15), blood pressure was 125/85 mm Hg, pulse rate 92/min, respiration rate 15/min and oxygen saturation of 99%. The main neurovascular structures of the foot were intact. During the examination and preoperative preparation in the emergency room, the patient was cardiorespiratory stable. He was taking no medications and had no comorbidities. He reported no allergies. After performing a clinical exam, we found no other injuries.

After admittance, pacient received antitetanus protection, 1.2 g of amoxicillin/clavulonic acid intravenous, 160 mg of gentamicin and 500 mg of metronidazol. He was taken urgently to the operating room and placed on operating table in supine position. Spinal anesthesia was used. Surgical treatment was performed three hours after trauma and included excision of the wound edges and extensive debridement of damaged soft tissue. All avital bone tissue, metal fragments, rocks and other foreign bodies were removed and wound was irrigated. Samples for microbiological exam was taken. A negative pressure wound therapy device was applied. We used black polyurethane (PU) foam. The initial therapy was continuously with value of –125 mm of mercury (Hg). Imobilisation was aplied. Patient also was treated with daily 40

mg enoxaparin by subcutaneous injections and analgetics periodically by intramuscular injections. Antibiotic therapy was continued; amoxicillin/clavulonic acid 1.2 g every 8 hours, gentamicin 160 mg once daily and metronidazol 500 mg every 8 hours.

This initial care was followed by a second debridement and irrigation after 48 hours. Small areas of necrotic tissue were demarcated. Additional debridement and irrigation were performed. Negative pressure wound therapy (NPWT) was continued with the same negative pressure value, –125 mm of mercury, but in intermittent mode of work (5 minutes ON, 2 minutes OFF). Laboratory exam results were in range of normal with no clinical signs of infection.

The patient remained hospitalized for twelve days for continued antibiotic therapy and pain control. He was brought to the operating room every four days for replacing NPWT dressing. Any further anesthesia was not necessary. The procedure of placing Negative Pressure Wound Therapy (NPWT) resulted in significant granulation and bone healing.

After the first change, the formation of new granulation and retraction of the edges of the wound was observed. Necrotic area was not observed. Exposed metatarsal bones were vital (Figure 4). The edges of the skin were without maceration. Microbiologically *Pseudomonas aeruginosa* was detected. The control sample was taken for MBD. Antibiotic therapy was continued. Further changes of NPWT showed progression in wound retraction and filling of the defect with granulation tissue and covering exposed bone and tendon (Figures 5 and 6). MBD control test was negative. The patient was discharged from hospital on the 12th day and NPWT changes continued in ambulatory conditions.

After four weeks of NPWT the entire defect was filled with grit and surface of MT bones and fextensor tendons were completely covered. The transplantation of skin graft by Blair was performed. The graft thickness was 0.4 mm. The graft was attached by skin stapler. Further the NPWT was applied continuously at –100 mm Hg for 4 days. For the protection of the graft we used vaseline gauze. After 4 days, we removed NPWT. Graft was almost completely accepted, except for a small region in the depth of the wound (Figures 7 and 8). We found no signs of infection.

Fig. 4. Vital exposed metatarsal bones.

Fig. 5. Progression in wound retraction.

Fig. 6. Filling of the defect with granulation tissue.

During the early postoperative period, the patient was instructed to perform leg elevation to decrease foot swelling. He also avoided full weight-bearing for 12 weeks. Imobilisation was removed after 5 weeks.

After 6 months of treatment, the patient returned to work. The wound had healed completely. The patient reported no pain and minimal swelling after all day standing. He had good motoric and sensory function and he walked with full weight-bearing. After one year of follow-up, patient reported good function of the foot with no pain or swelling. He walked without crutch and he needed no orthopedic shoes or tools. Local status was cosmetically satisfactory (Figure 9). X-ray presented full bone healing (Figure 10).

Fig. 7. Almost completely accepted greft.

Fig. 9. Cosmetically satisfactory local status.

Fig. 8. Completely accepted greft.

Fig. 10. Full bone healing.

Discussion

Gunshot injuries of the foot represent a special challenge for surgeons because of specific anatomical relations and biomechanical function. Soft tissue loss associated with bone fracture that occurs after severe trauma caused by gunshot injury demand a clever management of the skilled surgeon. If there is a massive loss of bone and soft tissue, that will compromise the function of walking, reconstructive procedure must be done. In that case, reconstruction with free or local muscular flaps and bone grafts are used. Free tissue transfer has been useful in managing different defects of the foot. Banerjee et al described a technique using iliac crest bone graft and soft tissue coverage with an abductor hallucis rotational flap[7]. Fibular composite grafts[8] and the radial forearm flap, also called Chinese flap[9], can be a very good choice of treatment for this kind of injuries. Operative treatment of these injuries can be difficult because of the limited autogenous resources and possible donor site complication. Advent of Negative Pressure Wound Therapy (NPWT) significantly improved the management of large soft tissue and skin defects in the past twenty years. These advance resulted with salvage of many limbs that would likely have resulted with some kind of amputation otherwise[10].

However, surgical exploration and debridement in combination with irrigation is the first and most important step in treatment of gunshot injuries. All necrotic tissue must be debrided, all foreign bodies and non-viable bone particles without adequate blood supply must be removed from the wound and hemostasis obtained. This procedure is necessary to prevent infection[11]. Since necrosis can evolve over 48 hours, redebridement is indicated. Once the wound is free of contamination, coverage can be considered[12–18].

Negative Pressure Wound Therapy has become widely accepted in the treatment of large soft tissue injuries with compromised microcirculation, even more in potentially contaminated or contaminated wound and hematomas. It is also very helpful in treating degloving injuries and mangled extremity[19]. Using NPWT technique, open wound is converted into controlled and temporarily closed environment. Under these conditions, blood flow is optimizes and neoangiogenesis is stimulated and local edema is reduced. NPWT also reduces bacteria level and removes excess fluid[20]. All these resulted with formation of granulation tissue and preparing wound bed for definitive wound closure.

In our case with gunshot wound with bone fracture of metatarsals, but without indication for bone grafting and soft tissue transfer such as free or local muscular flap, NPWT was a very good solution for preparing wound bed for skin grafting as a final treatment procedure and wound closure.

Conclusion

Treatment of the presented patient with gunshot injury of the foot using Negative Pressure Wound Therapy has shown as very good decision. Gunshot wound treated with this procedure was easier to manage, both in the hospital and at home, in the opposite to standard known procedures of wound treatment. Inside the wound area, good conditions for acceptance of the skin graft were achieved. Treating our patient with these procedures had very good functional and esthetic final result.

REFERENCES

1. KOBBE P, FRINK M, OBERBECK R, TARKIN IS, TZIOUPIS C, NAST-KOLB D, PAPE HC, REILMANN H, Unfallchirurg, 111 (2008) 247. — 2. HOPKINS DAW, MARSHALL TK, British J Surg, 54 (1967) 344. — 3. SERGI AR, ACELLO AN, Clin Podiatr Med Surg, 12 (1995) 689. — 4. VERHEYDEN CN, MCLAUGHLIN B, LAW C, GALLEGO K, KETCH L, WHITE RR, Ann Plast Surg, 55 (2005) 474. — 5. PU LL, MEDALIE DA, LAWRENCE SJ, VASCONEZ HZ, Ann Plast Surg, 50 (2003) 286. — 6. SIMPSON BM, WILSON RH, GRANT RE, Clin Ortop Relat Res, 408 (2003) 82. — 7. BANERJEE R, WATERMAN B, NELSON J, ABDELFATTAH A, J Foot Ankle Surg, 49 (2010) 301. — 8. TAN O, ATIK B, ERGEN D, J Reconstr Microsurg, 24 (2008) 53. — 9. BOWERS KW, EDMONDS JL, GIROD DA, JAYARAMAN G, CHUA CP, TOBY EB, J Bone Joint Surg Am, 82 (2000) 694. — 10. CLEMENTS JR, MIERISCH C, BRAVO CJ, J Foot Ankle Surg, 51 (2012) 118. — 11. GEISSLER W, TEASEDALL R, TOMASIN J, HUGHES J, J Ortop Trauma, 4 (1990) 39. — 12. BOUCREE JJ, GABRIEL R, LEZINE-HANNA J, Ortop Clin NA, 26 (1995) 191. — 13. HOEKSTRA S, BENDER J, LEVISON M, J Trauma, 30 (1990) 1489. — 14. O'SULIVAN S, O'SHAUGHNESSY M, O'CONNOR T, Injury, 27 (1996) 63. — 15. SWIONTOWSKI M, Clin Ortop 243 (1989) 20. — 16. GUSTILO R, ANDERSON J, J Bone Joint Surg, 58A (1976) 453. — 17. GUSTILLO R, MERKOW R, TEMPLEMAN D, J Bone Joint Surg, 72A (1990) 299. — 18. PATZAKIS M, WILKINS J, Clin Ortop, 243 (1989) 36. — 19. BAKOTA B, KOPLJAR M, JURJEVIĆ Z, STAREŠINIĆ M, CVJETKO I, DOBRIĆ I, DE FAOITE D, Coll Antrop, 36 (2012) 1419. — 20. ARGENTA LC, MORYKWAS MJ, Ann Plast Surg, 38 (1997) 335.

M. Marinović

University of Rijeka, Rijeka University Hospital Center, Department of Traumatology, T. Strižića 3, 51000 Rijeka, Croatia
marin.marinovic2@gmail.com

OZLJEDA STOPALA SAČMARICOM: LIJEČENJE I POSTUPCI – ULOGA TERAPIJE NEGATIVNIM TLAKOM

SAŽETAK

Ozljede stopala sačmaricom kod civila nisu tako česte u Hrvatskoj. Povezane su s nesrećama u lovu te pri čišćenju oružja. Ozljede sačmaricom predstavljaju poseban izazov za kirurge zbog specifičnih anatomskih odnosa i biomehaničke funkcije stopala. Odlučili smo prikazati pacijenta sa kompleksnom ozljedom stopala uzrokovanu puškom u nesreći u lovu. Prezentiran je 45-godišnjak sa ranom lijevog stopala. Nađene su komplicirane frakture sa defektom treće, četvrte i pete metatarzalne kosti i široka povreda mekog tkiva sa defektom kože i podkožnog tkiva dorzalne i lateralne strane stopala. Rana je bila kontaminirana sa brojnim metalnih tijelima, komadićima kamena i zemlje. Kirurški postupak je proveden tri sata nakon traume i uključio je ekstenzivni debridman oštećenog mekog tkiva, uklanjanje avitalne kosti i metalnih tijela, kamenja i ostalih stranih tijela. Terapija negativnim tlakom je postavljena na operacijskom stolu. Početna je bila kontinuirana terapija od –125 mm Hg. Nastavili smo s intermitentnom terapijom od –100 mm Hg i promjenom seta za negativni tlak svaki četvrti dan. Poslije četiri tjedna terapije negativnim tlakom, defekt je ispunjen granulacijskim tkivom i transplantat djelomične debljine kože je apliciran. Kožni graft je dodatno fiksiran sa negativnom tlakom uz kontinuiranu terapiju od –100 mm Hg naredna četiri dana. Četrdeset dana poslije ozljede nađe se kompletno zaliječenje svih mekih česti. Kontrolni RTG pokazao je dobro cijeljenje kosti.