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Research Article

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The use of Negative Pressure Wound Therapy in the Treatment of Military Blast Wounds/High-Velocity GSW Wounds of the Extremities

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ABSTRACT

Background: Since the beginning of the full-scale Russian-Ukrainian war, a large number of soldiers and civilians have received blast wounds/GSW wounds to their extremities, which required long-term treatment. Most of these patients required staged debridement of these wounds and implementing negative pressure wound therapy.

Purpose: Due to the high intensity of modern war hospitals are faced by many challenges - huge numbers of patients with open fractures with soft and bone tissue defects, personnel shortage, long evacuation hours, patients with tourniquet syndrome. The purpose of this study was to point out the effectiveness of the use of negative pressure wound therapy in the treatment of war wounds in the front line hospital.

Methods: This is a retrospective case series study, which was conducted among war injured patients. Treatment strategy is the usage of multiple debridements in combination with NPWT. The pressure of the VAC systems ranged from 90 to 130 mm Hg, 120 mm Hg being the average. Wound VACs were changed every 3-5 days. Treatment goals were staged wound closure or wound preparation for complex reconstructive surgery. During this study we used several criteria to evaluate successful treatment – WBC, soft tissue conditions, wound closure with no inflammation signs.

Results

1. Debridement in combination with NPWT gives great results in staged wound closure.
2. NPWT eliminates daily dressing changes which allows a large number of doctors to participate in urgent care of the wounded and reduces the load on medical staff.
3. NPWT provides active wound care during evacuation stages.
4. NPWT is extremely important in tourniquet syndrome management (helps to differentiate between viable/non-viable tissues).

Conclusions: NPWT is of great importance during war time. NPWT makes it possible to perform multiple life and limb saving surgeries despite medical staff shortage and huge admission rates.

Level of Evidence: Level IV, Therapeutic Study, case series.

Introduction

Cases

Since the beginning of the full-scale Russian-Ukrainian war, a significant number of soldiers and civilians have received blast wounds/GSW to their extremities, required long-term treatment. During the first month and a half of the war, the Regional Clinical Hospital named after Ilya Mechnikov, which is one of the largest medical institutions in Ukraine and which is located two hundred kilometers from the active combat zone, received 1000 wounded soldiers and civilians, among them 521 (52,1%) had

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a combination of high-velocity gunshot wounds and explosive blast wounds of the extremties [1]. From the beginning of the full-scale Russian-Ukrainian war more than 42000 patients were treated in Mechnikov hospital. Most of these patients required staged debridement of mine-blast wounds/GSW and implementing of negative pressure wound therapy.

Rationale. Due to the high intensity of modern war hospitals are faced by many challenges - open fractures with soft and bone tissue defects, personnel shortage, long evacuation hours, tourniquet syndrome. The purpose of this study was to point out the effectiveness of negative pressure wound therapy in the treatment of war wounds in the front line hospital.

Methods

Study Design and Setting. This is a retrospective case series study, which was conducted in the Regional Clinical Hospital named after Ilya Mechnikov, Ukraine, Dnipro.

Participants. Inclusion criteria: patients with mine-blast, high-velocity gunshot wounds.

Description of Treatment. Upon admission to the hospital, all wounded patients initially are taken to the emergency department, where, with the support of the anesthesia service, an initial examination of patients is performed, and a decision is made on further management of the patient. Considering the massive numbers of admissions, the constant workload of operating rooms and anesthesiology services, primary treatment of wounds with antiseptic solutions and stabilization of fractures with external fixation devices can be provided in the intensive care unit. In case of contaminated untreated wounds, traumatic amputations, presence of blast wounds with defects of soft tissues and bone structures, patients are taken to the operating room, where they undergo wound debridement, stabilization of fractures, and placement of a VAC system. The severity of the general condition of patients, the complexity and unpredictability of blast wounds, necessitates the management of patients using damage control strategy [1]. Patients with isolated or multiple traumatic injuries, with stable vital functions, are hospitalized in the orthopedic surgery department. Patients with polytrauma, unstable vital functions, massive defects of soft tissues and bone structures, are hospitalized in the ICU. All dressing changes in the ICU are performed under intravenous sedation. Taking into account the large influx of patients (from the beginning of the full-scale Russian-Ukrainian war more than 42000 patients were admitted to Mechnikov hospital) injured, after stabilizing their general condition and fulfilling surgical interventions using damage control strategy, are evacuated to the next stage of medical care. The primary goals for the front line hospital are stabilization of fractures, debridement, life and limb preserving surgeries. Before using negative pressure therapy, the wounds are repeatedly washed with isotonic solution until the rinses are clean. After washing with isotonic solution, wound debridement is performed - non-viable tissue is excised, free bone fragments are removed, and thorough hemostasis is performed. The use of negative pressure therapy is possible only after thr adequate treatment of the wound surface. To install the NPWT system, the foam pad is cut to the size of the wound and placed on the base. To prevent skin contraction and better fixation of the foam pad, the edges of the skin are pulled together by skin sutures (without excessive tension). The pressure of the VAC system ranges from 90 to 130 mm Hg, 120 mm Hg being the average. Subsequently, dismantling or reinstallation of the VAC system is applied every 3-5 days. If there are necrotic tissues and pathological secretions in the wound, repeated debridement is performed with reinstallation of the VAC system.

Patients are evacuated by train, and NPWT continues at this stage of evacuation - the trains are equipped with VAC systems. Patients are evacuated from the hospital only with clean wounds. During this study we used several criteria to evaluate successful treatment – WBC, soft tissue conditions, wound closure with no inflammation signs.

Cases

Case 1

Diagnosis: Mine-blast injury. Traumatic amputation of the first metatarsal bone. Open medial malleolus and talus fractures.

During the evacuation stages, tension band fixation and K-wires placement were performed.

The patient was delivered to Mechnikov hospital on the second day after the injury.

Upon Admission

NPWT (5 Days After the Admission)

Repeated Debridement and NPWT (7 Days After the Admission)

VAC System Removal (12 Days After the Admission)

Debridement (18 days After the Admission)

After a series of NPWT and staged debridement, the foot wound was cleared and granulation tissue appeared.

	After the injury	After debridement and antibiotics administration	After multiple debridements and NPWT
WBC	**14,3**	**10,6**	7,76

The patient was transferred to the next stage of care.

Case 2

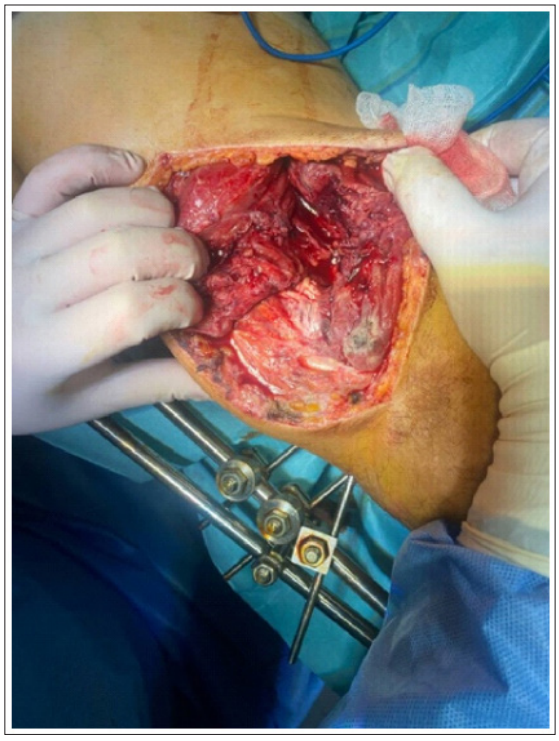
Diagnosis: Mine-blast injury. Open right femur fracture with femoral vein injury. Right arm and forearm wounds. Post-traumatic radial nerve palsy.

During the evacuation stages, debridement of the right arm wound, revision of the right femoral neurovascular bundle, ligation of the right femoral vein, and dermatofasciotomy of the right leg were performed.

The patient was deliverd to Mechnikov hospital on the 1st day after the injury.

Upon admission

Right Shin Fasciotomy Wounds



Application of a non-adhesive dressing on the vessel (Prevents the ingrowth of granulation tissue into the vessel and reduces the risk of erosive bleeding. The risk of bleeding is the highest during a sponge removal).

Debridement in Combination with NPWT, Leg Wounds Closure (3 Days After the Admission)

Wounds reveision with major vessels demonstration

NPWT

Fasciotomy Wounds Closure

NPWT Removal, Wound Closure (3 Days After the Admission)

After one round of NPWT and debridement, the mine-blast wounds of the thigh and elbow joint were cleared and granulation tissue appeared. Non-adhesive dressings on the vessels prevented the growth of granulation tissue in them, and successful removal of the VAC system was performed. The wounds to the thigh and shin were closed. The patient was evacuated to the next stage of care.

Case 3

Diagnosis: Gunshot tibia and fibula fractures with massive soft tissue defect.

The patient was delivered to Mechnikov hospital on the 3rd day after the injury

Upon Admission

Huge volume of non-viable tissues is visualized.

The Patient Underwent Debridement and Installation of the VAC System (5 days After the Admission).

NPWT Removal, Repeated Debridement, Application of a Non-Adhesive Dressing on the Vessel (8 days After the Admission).

Reinstallation of the VAC system

NPWT Removal, Wound Closure (13 days After the Admission)

	Upon admission	After antibiotics administration	After starting NPWT	After reinstalling	Removing VAC dressings, closing the wound
WBC	13,3	13,0	**16,1**	11,62	7,26

The patient was evacuated to the next stage of care.

Case 4

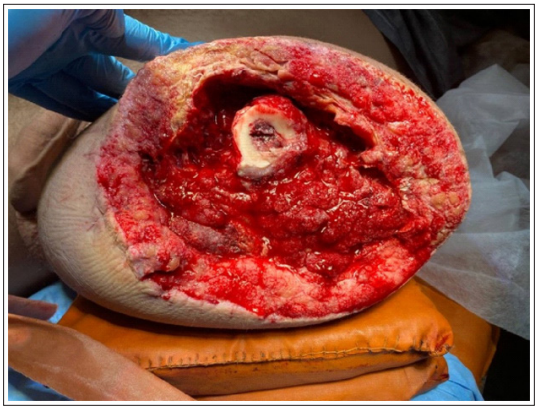
Diagnosis: Mine-blast injury. Traumatic below knee amputation. Acute lower extremity ischemia, tourniquet syndrome (the tourniquet was applied for 24 hours).

During the evacuation stages, abow knee amputation was performed.

The patient was delivered to Mechnikov hospital on the 2nd day after the injury.

Debridement in Combination with NPWT (5 Days After the Admission).

Removal of the VAC System, Repeated Debridement, Closure of the Wound - The Wound is Clean, with a Large Amount of Granulation Tissue (9 days After the Admission).



4 Days After Stump Closure

The suture line is calm, without signs of inflammation.

	One day after the injury	Upon admission	One day after the beginning NPWT	4 days after the closure
WBC	12,9	13,0	11,88	8,87

The patient was successfully transferred to the next stage of care.

Case 5

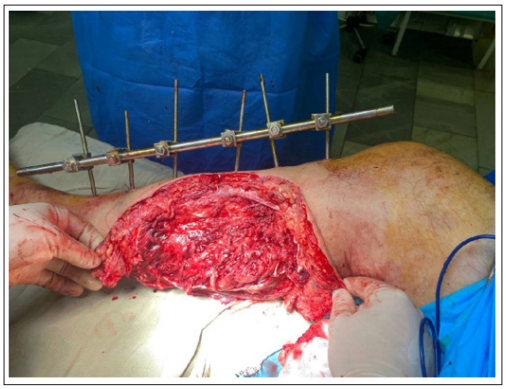
Diagnosis: Mine-blast injury. Open tibia fracture with soft tissue defect. Arm mine-blast wounds.

During the evacuation stages, debridement, ex fix placement, ldeep brahial artery ligation were performed.

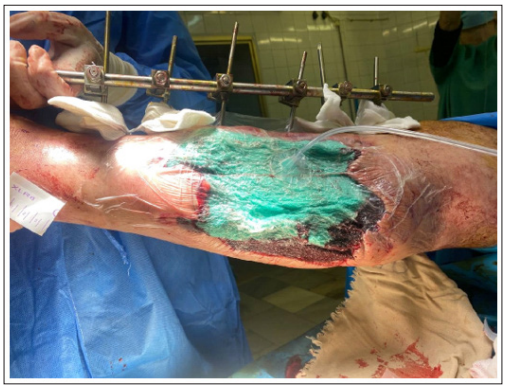
The patient was delivered to Mechnikov hospital 1 day after the injury

Upon Admission

Debridement in Combination with NPWT (1 Day After the Admission)

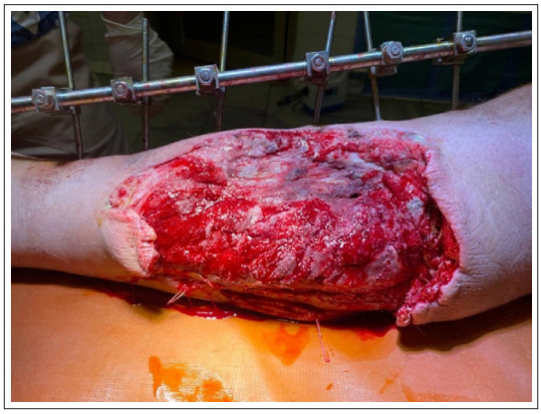


NPWT



NPWT Removal, Repeated Debridement, NPWT, Ex Fix Correction, Arm Wound Closure (6 Days After the Ddmission).

Despite the excision of all non-viable muscles during the first debridement and the installation of the VAC system, there were areas with necrotic muscles. The repeated debridement in combination with VAC system placement were done



The arm wound was closed.

	Upon admission	After starting NPWT	5 days after the admission
Leukocytes	15,4	9,02	9,1

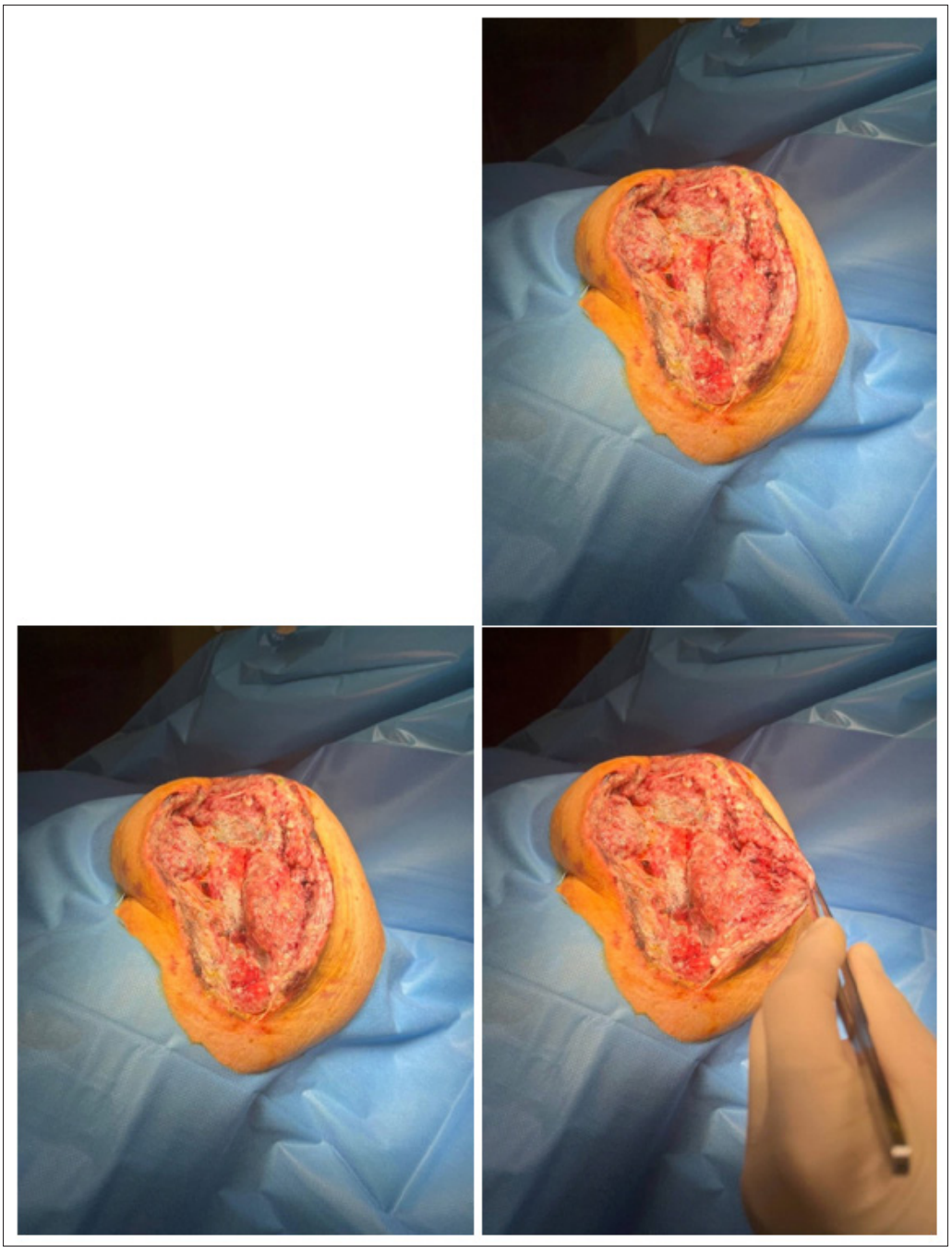
The high kinetic energy of bullets and missles leads to the fact that the zone of molecular concussion is located much deeper and wider than the zone of the wound channel itself. For this reason, it is often impossible to estimate the volume of damaged tissues in the first few days after injury, what is happened with our patient - despite extensive excision of non-viable tissues during the first debridement, after removal of the VAC system, area of necrotic tissues was discovered. After repeated debridement with VAC system reinstallation the wound was cleaned and closed. The patient was evacuated to the next stage of care.

Case 6

Diagnosis: mine-blast injury. Open scapula fracture with soft tissue defect. During the evacuation stages (1 day after the injury), debridement was performed.

The patient was delivered to Mechnikov hospital on the 2nd day after the injury.

Revision of the Wound, Debridement, Installation of the VAC System (1 Day After the Admission).



NPWT

NPWT Removal, Repeated Debridement, NPWT Placement, Guiding Sutures (3 Days After the Admission).

After the sponge removal, areas of both granulating tissue and areas of necrosis are visualized.

Repeated debridement (non-viable muscles are removed).

Guiding sutures.

NPWT

NPWT Removal, Wound Closure (8 Days After the Admission).

The wound was clean.

Wound closure

The Wound 8 Days After Closure.

Any inflammation signs.

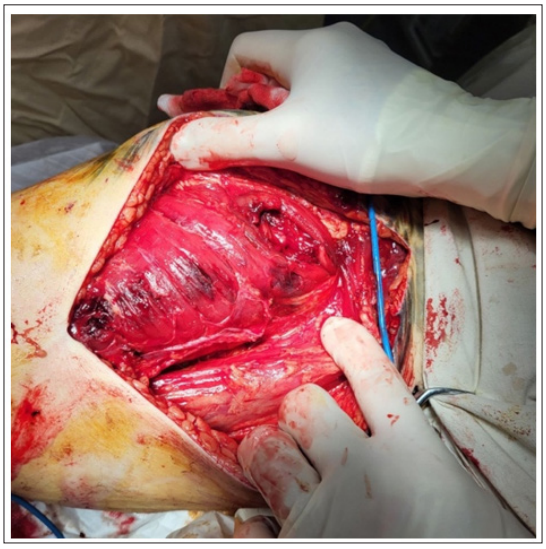
	Upon admission.	After NPWT was started.
WBC	15,21	9,02

This case perfectly illustrates the high effectiveness of negative wound pressure therapy as a method of stage-by-stage preparation for wound closure.

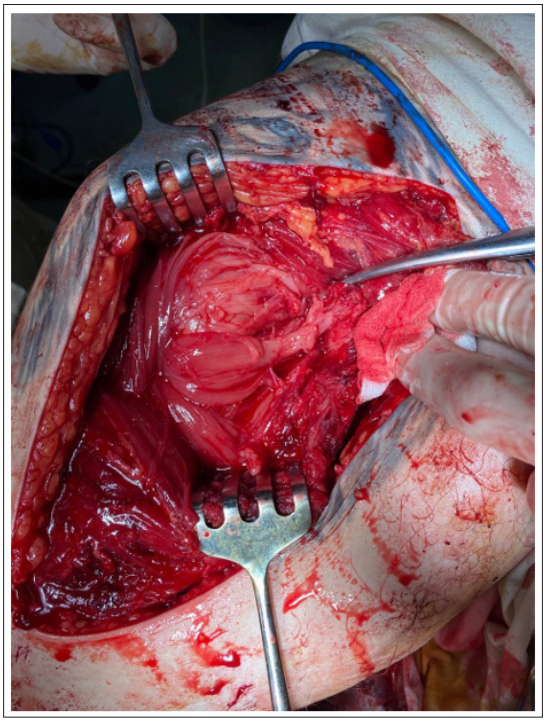
Case 7

Diagnosis: traumatic below knee amputation with mid-thigh tourniquet syndrome for 6 hours.

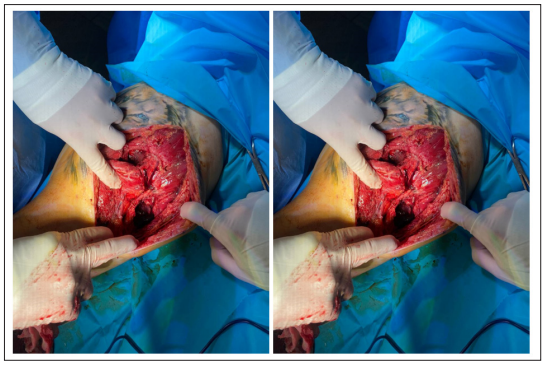
Fasciotomy



Muscles Revision

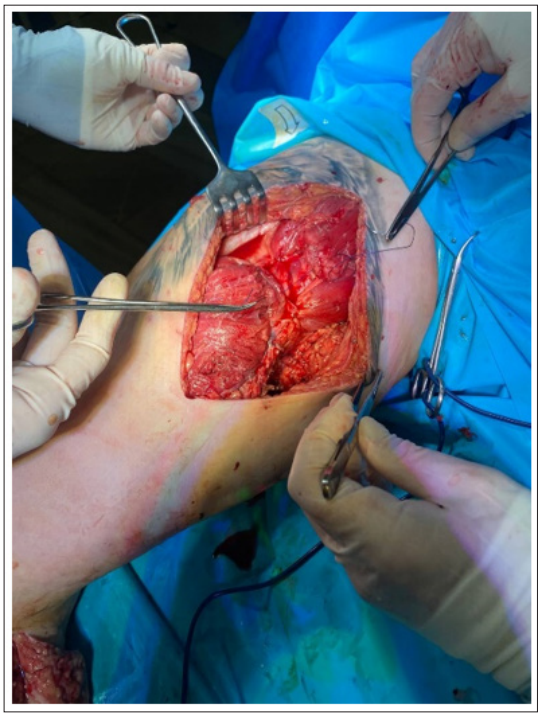


Circular Excision of Non-Viable Muscles



NPWT, Second Look, Redebridement, NPWT, Second Look...

Approximating Sutures on Muscles



Wound Closure

As a result we preserves kidney function, limb length, knee joint and restored function.

Results

1). Large soft and bone tissues defects, as well as diverse wounds 'flora, make primary wound closure impossible. Thorough debridement in combination with NPWT are the most effective methods in staged wound closure.

2). The huge number of wounded is many times greater than the number of medical personnel, which makes it almost impossible to perform daily dressings. NPWT eliminates the need for daily dressing changes which reduces the workload on medical staff and allows a large number of medical personnel to participate in urgent care of wounded.

3). Patients after treatment in front line hospital (for example, Mechnikov Hospital) must be evacuated to the next stage of care. The evacuation could take many hours. VAC therapy provides active wound care during the evacuation stages

4). Fourthly, VAC therapy is of great importance in the tourniquet syndrome treatment. Main reasons to use VAC therapy for this condition:
   - Absorption of necrosis products
   - Reduction of edema
   - Formation of granulation tissue, which allows to distinguish between viable and non-viable muscles.

Discussion

Background and Rationale

Since the beginning of the full-scale Russian-Ukrainian war, a large number of soldiers and civilians have received blast wounds/GSW wounds to their extremities, which required long-term treatment. Orthopedic surgeons in Ukrainian hospitals were faced with several difficult problems - huge numbers of patients with open fractures with soft and bone tissue defects, personnel shortage, long evacuation hours, patients with tourniquet syndrome. The purpose of this study was to point out the effectiveness of the use of negative pressure wound therapy in the treatment of war wounds in the front line hospital. Mechnikov hospital is an excellent example of the huge facility located close to the war zone. A lot of injured civilians and soldiers were treated in Mechnikov hospital – from the beginning of the full-scale Russian-Ukrainian war more than 42000 people were treated in Mechnikov hospital and we believe that our experience could help many hospitals and orthopedic surgeons in other countries to manage high patients flow from war zone.

Limitations

This study had a number limitations. First, we do not have patients follow up after evacuation from Mechnikov hospital. Second, due to huge amounts of admissions our main priority is stabilization care using damage control orthopedic strategy, which makes it difficult to evaluate effectiveness of our treatment regarding reconstructive surgeries. Military blast wounds and high-velocity gunshot wounds of the limbs are severe injuries that are characterized by massive damage to the skin, muscles, bone structures, blood vessels and nerves and are far more extensive than traditional gunshot wounds (GSW). Modern high-energy weapons and high intensity of combat operations lead to the formation of contaminated wounds with massive soft tissue defects that cannot be closed either primarily or due to secondary tension which forces orthopedic surgeons to pursue different methods of staged wound closure or wound preparation for difficult reconstruction surgeries. One of these methods – NPWT use. The first data on the systematic use of negative pressure therapy for patients with combat trauma were provided by Balad's Air Force Theater Hospital, Iraq in September 2004 [2,3].

In our experience, the combination of staged debridement with the use of VAC therapy is an effective method of managing patients with blast wounds. Same findings are seen during the war in Iraq - the use of negative pressure therapy for 77 patients with 88 blast wounds resulted in no infectious complications, decreased hospital stay, and easier patient care [4].

Conclusion

NPWT is of great importance during war time. NPWT makes it possible to perform multiple life and limb saving surgeries despite medical staff shortage and huge admission rates.

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