

Wound Complications from the Tsunami Disaster: A Reminder of Indications for Delayed Closure

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Abstract

Objectives: To illustrate the character, clinical course and late complications of wounds caused by high energy with severe contamination during a natural disaster, as a basis for designing principles for primary treatment under these conditions.

Patients and Methods: This paper presents case reports from complicated wounds treated at a specialized unit for wound management in a hospital receiving patients after transfer from primary to definitive treatment.

Results: Of the Swedish citizens evacuated from the disaster zone in Thailand after the tsunami disaster in 2004, 174 of those arriving at Stockholm Airport were referred to the Karolinska Hospital for treatment, of whom 75 were admitted. Forty of the patients admitted were seen by the surgeons at the Department of Plastic and Reconstructive Surgery because of complicated wounds requiring special treatment. Fifteen of these could be treated as ambulatory patients and 25 required hospitalization for a mean time of 10.5 days (range 1–48). The majority had multiple injuries, 93% on the lower limbs and 47% on the upper limbs. The majority had been primarily closed at primary treatment. Treatment strategies included removal of all sutures, wound excision, secondary healing (38/40, 95%), delayed primary closure (40/40, 100%), vacuum-assisted closure (VAC) (3/40, 8%), split-thickness skin grafts (23/40, 58%), pedicled perforator flap (1/40, 2%) and free flap (1/40, 2%). Amputation was requested in two cases. Aside from long-lasting psychological sequelae and varying degrees of physical disability, unusual late infections occurred with pro-

gressing and migrating abscesses. Cultures and skin biopsies from these revealed both mycobacteria and pigmented fungal hyphae.

Conclusions: The patterns of injury and clinical courses in these patients illustrate the risk of complications in wounds caused by high energy, with severe contamination and which arrive late for primary treatment by staff who are not fully aware of the risk of secondary complications under these conditions. Recommendations for primary treatment should include extensive cleaning, excision of dead tissue and delayed primary closure, according to the well-established principles of management of war wounds, where the conditions are similar.

Key Words

Trauma · Plastic and reconstructive surgery · Skin graft · Flap · Mycobacteria

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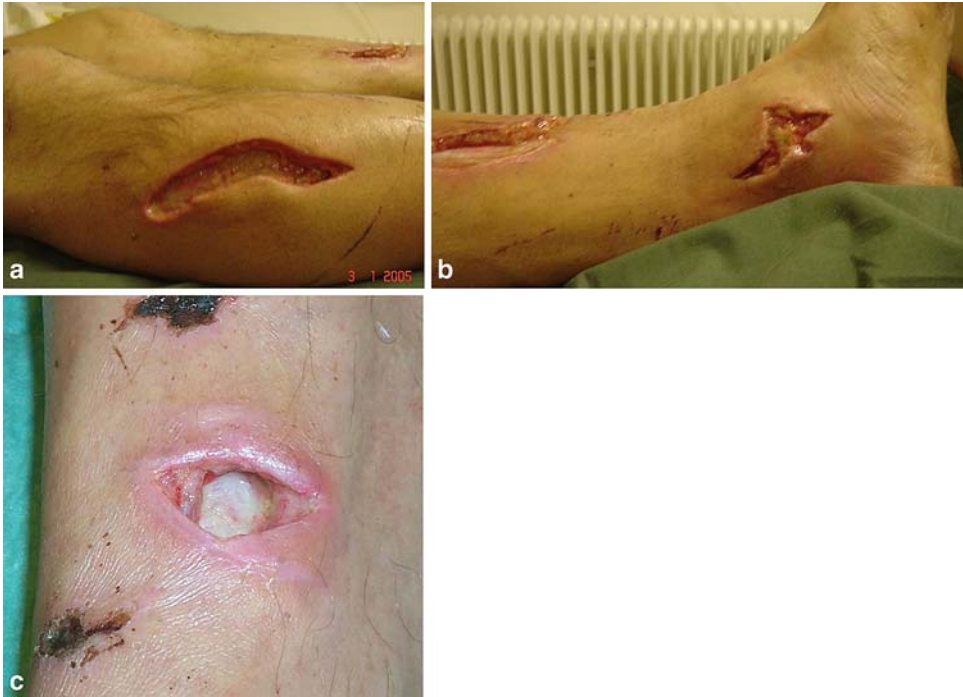
Introduction

A devastating tsunami wave, triggered by an earthquake, struck in the Indian Ocean on 26 December 2004. The wave hit the shores of the surrounding countries, causing an estimated 310,000 deaths in eight countries on two continents. In Thailand, six provinces were impacted, including several tourist destinations. This part of the world is very popular among Swedish tourists around Christmas. About 35,000 Swedes were on holiday in Thailand, of which around 20,000 were

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Figures 1a to 1c. A 52-year-old man with multiple wounds on the lower extremities. Some of his wounds were these deep wounds on the right leg (a), left medial malleolus (b) and left ankle (c).



on the eastern coast of Thailand [1]. To date, there are 528 confirmed casualties and 15 people still missing [2]; Sweden is among the European countries worst hit by the disaster [1]. Collectively, the hospitals in the Phang Nga, Phuket and Krabi provinces received more than 11,000 injured people during the first three days, with 3,000 admitted as inpatients. Swedish citizens constituted the largest group of injured foreign nationals in all hospitals. The total number of Swedes injured has been estimated at 1,500 [1].

The aim of the present report is to illustrate the wound panorama, clinical course and late complications of wounds caused by a natural disaster such as the tsunami in 2004. This is a report of the experience and lessons learnt at the largest receiving hospital in Sweden. This article will mainly concentrate on the plastic surgical aspects.

Patients and Methods

Of the approximately 35,000 Swedes in the country, around 20,000 spent their holiday on the eastern coast of Thailand at the time of the tsunami [1]. Approximately 14,000 passengers from the tsunami areas were evacuated via Stockholm Airport, all of whom were seen by medical teams at the airport. Around 50% of the passengers were identified as having injuries mainly located on the lower part of

the body and psychosocial injuries (personal communication, Lennart Malmström, head of Emergency Medical Services and Disaster Medicine, Karolinska University Hospital). Patients with mild injuries were transferred and treated by the primary care centres and if possible transferred to the hospital in their home community. In all, 174 passengers came to the emergency room at the Karolinska University Hospital in Solna. Most of the patients were treated on an outpatient basis, whereas 75 patients were admitted and 40 patients had sustained injuries requiring attention from plastic surgeons.

Table 1. Examples of the results from the wound cultures at admission.

<i>Acinetobacter</i>
<i>Aeromonas hydrophila</i>
Allescheriasis (<i>Scedosporium apiospermum</i>)
<i>Bergeyella zoohelcum</i>
<i>Candida</i> (<i>Candida tropicalis</i>)
<i>Chryseobacterium meningosepticum</i>
<i>Escherichia coli</i>
<i>Enterobacter faecium</i> / <i>Enterobacter cloacae</i>
Coagulase-negative staphylococci
<i>Microsporium gypseum</i> (dermatophytes)
<i>Pseudomonas</i>
Zygomycosis (<i>Saksenaea vasiformis</i>)

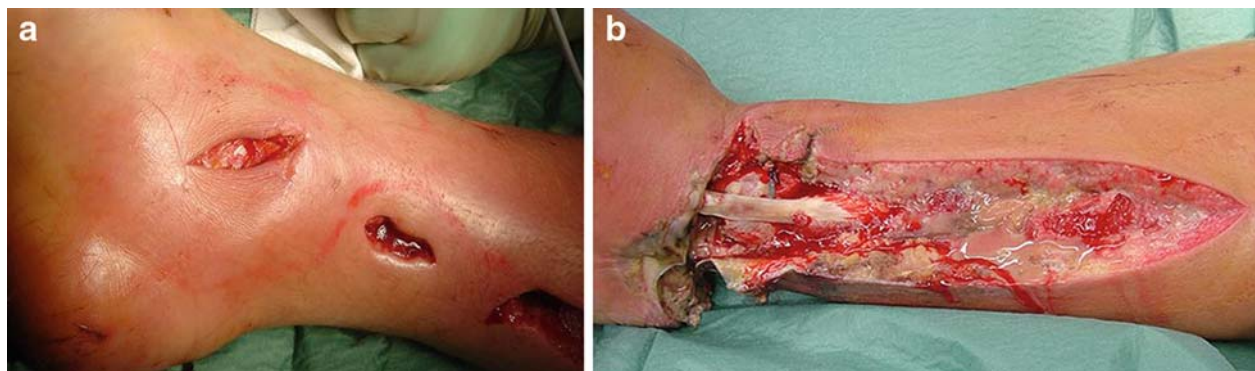
Results

Patient Population and Initial Assessment

The mean age of the patients requiring attention from plastic surgeons was 35 years (range 8–66).

Two wards were opened exclusively for patients from the tsunami area to avoid spreading multiresistant bacteria. They were dehydrated upon arrival at the hospital and in a state of catabolism. We avoided

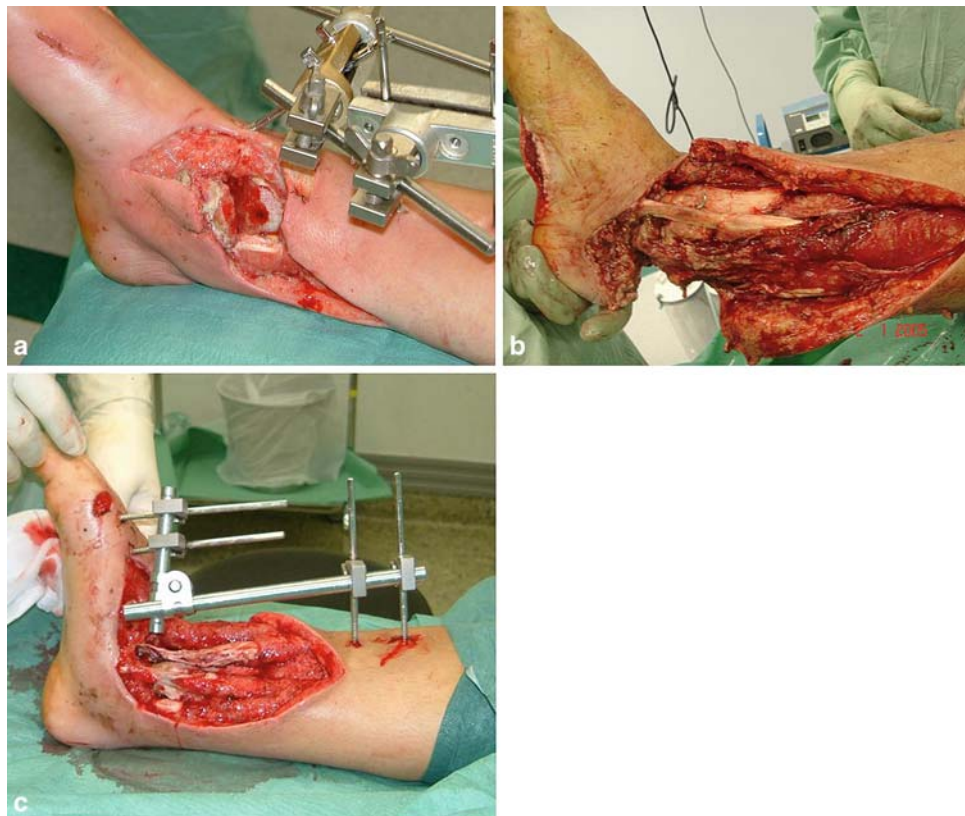
splitting up families, as an overwhelming majority of our patients had lost one or two close relatives. After an initial assessment, 15 of the 40 patients needing plastic surgical attention were converted into outpatients, whereas 25 needed to be transferred to our ward at the Department for Reconstructive Plastic Surgery. Mean treatment time as inpatients was 10.5 days (range 1–48 days).



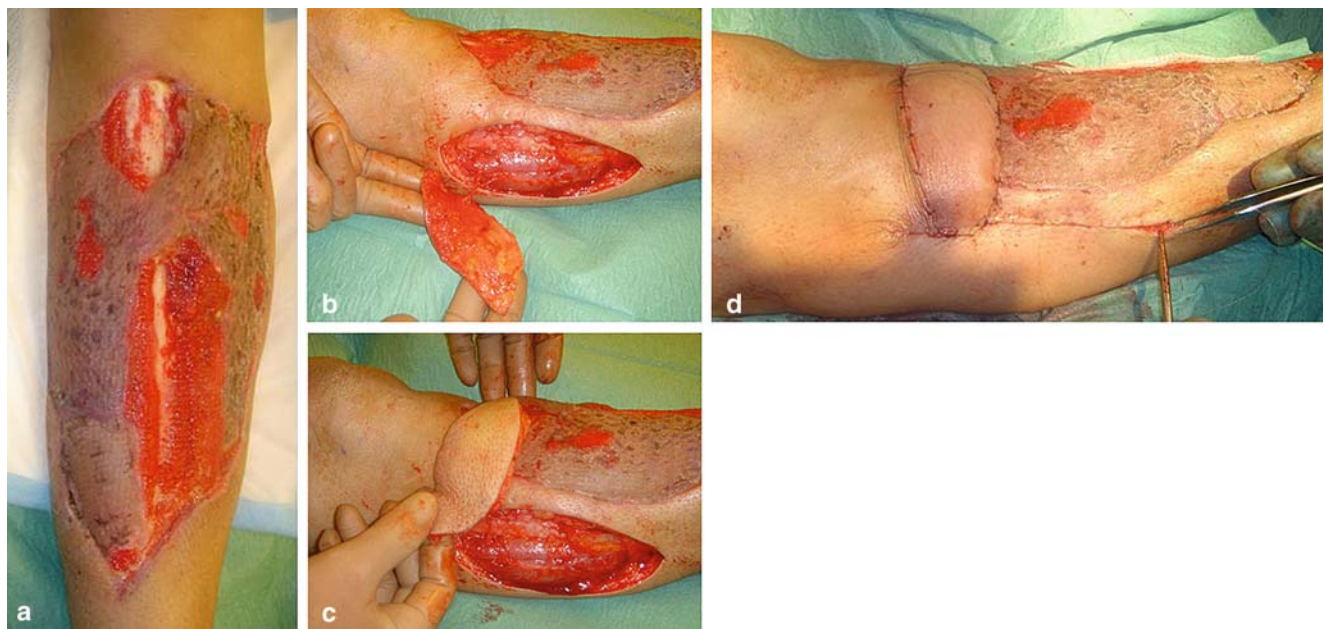
Figures 2a and 2b. The wounds were heavily infected at admission and displayed all signs of inflammation: tumor, rubor, calor and dolor around several wounds on the right foot and ankle (a), and functio laesa and pus in a deep complex wound with an open fracture and torn tendons (b).



Figures 3a to 3e. Examples of large and complex defects. a) A 28-year-old woman with an almost circumferential skin and soft tissue defect on her left leg. b) A 60-year-old man with exposed tendons on his right ankle. c) A 50-year-old woman with a combination of skin, soft tissue and partial muscle defects on both legs. d) A 32-year-old man with wounds on the back of his left thigh and left knee region medially. e) A 28-year-old woman with a wound anteriorly on her right thigh after surgical revision.



Figures 4a to 4c. a) An open fracture in a 28-year old woman, also seen in Figure 10. b) A 27-year-old woman with a severely damaged right leg/ ankle who shortly thereafter had an amputation of her lower leg. c) A 28-year-old woman with a complex defect and open fracture, which was treated with external fixation and multiple surgical revisions and later a free latissimus dorsi flap.



Figures 5a to 5d. A 56-year-old woman previously operated with a medial gastrocnemius flap in Thailand to cover the exposed bone. Part of it was revised and later covered with a pedicled perforator flap (a). Perforators from the fibularis vessel were used (b), and the perforator flap was easily transposed onto the exposed bone and covered it (c). The donor site was closed primarily (d).



Figures 6a and 6b. A 41-year-old man with wounds on his right leg covered with a split-thickness skin graft. He presented with these abscesses a few weeks after his wound had healed completely. The progressing abscesses are located outside the transplanted area and marked with a pen (a). Skin biopsies were taken from the affected area (b).

Injury Spectrum

The majority of patients had multiple wounds and complicated infection spectra. The injuries were mainly (93%) located on the lower part of the body,

and less than half (47%) on the upper extremity. Most patients had multiple injuries (Figures 1a–1c).

The wounds were heavily infected (Figures 2a and 2b) after walking around in sewer- and blood-contaminated water. This was reflected in the infection spectrum, which included a variety of unusual microorganisms (Table 1).

The patients in need of reconstructive plastic surgery mainly had large defects (Figures 3a–3e) with exposed bone and tendons, and some had open fractures (Figures 4a–4c). Our strategies included daily changes of the dressings, which required full sedation for many patients, partly because of psychological trauma. All sutures and other attempts to close the wounds performed before arrival at the Karolinska University Hospital were removed to reveal any hidden infection. Additional multiple surgical revisions were required in most cases. Most reconstructive attempts before arrival at the Karolinska University Hospital had a bad take rate because of infection.

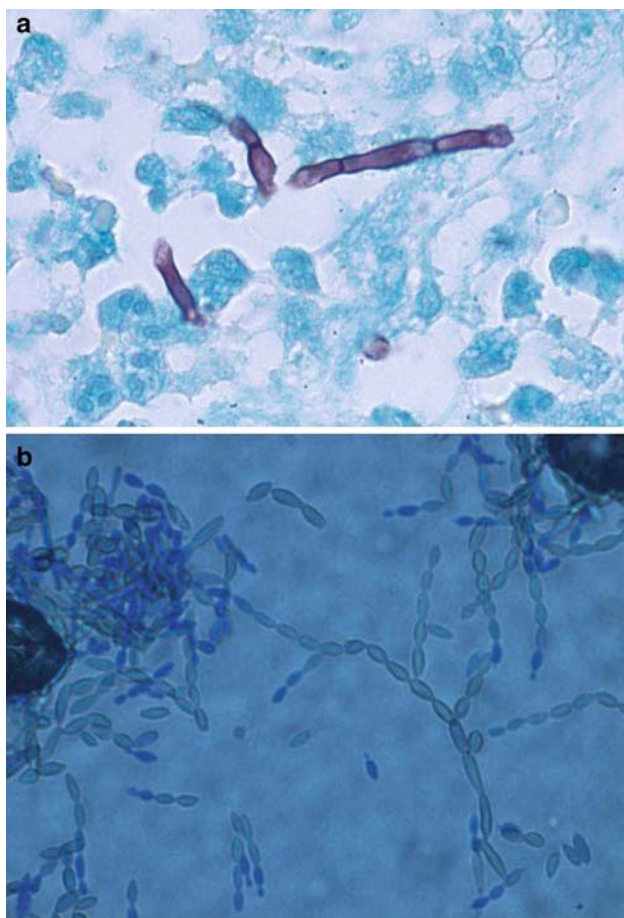
Treatment Strategies

The treatment of the 40 patients needing reconstructive plastic surgery consisted of secondary healing (38/40, 95%), delayed primary closure (40/40, 100%), vacuum-assisted closure (VAC) (3/40, 8%), split-skin graft (23/40, 58%), pedicled perforator flap (1/40, 2%) (Figures 5a–5d) and free flap (1/40, 2%).

The long-lasting sequelae for these patients are of a psychological nature [3], and also comprise varying degrees of physical disability. Unusual late infections have also occurred. At between 6 and 12 weeks after the trauma, seven patients presented with progressing and migrating abscesses in the nontraumatized, virtually intact skin outside the resection margins (Figures 6a, 6b). Cultures revealed *Mycobacterium abscessus*, and antimycobacterial treatment was given to treat the recovered microorganism. We did not see any correlations with the extent of injury.



Figures 7a to 7d. This 50-year-old woman, whose initial wounds can be seen in Figure 3c, also presented with migrating abscesses (a); (b) shows a close-up after the split-thickness skin grafts had healed completely. The abscesses were drained (c and d), but the skin biopsies also revealed pigmented fungal hyphae.



Figures 8a and 8b. The potentially dangerous pathogen black fungus, *Cladophialophora bantiana*, as seen in direct microscopy (a) and from clean culture (b).

In two patients, as well as the presence of *M. abscessus*, skin biopsies also revealed granulomatous reaction and pigmented fungal hyphae (Figures 7a–7d). This potentially dangerous pathogenic black fungus, *Cladophialophora bantiana* (Figures 8a, 8b), was eliminated with antifungal treatment for one month [4].

Case Presentation

The following narrative describes the most badly injured patient treated at the Karolinska University Hospital. A 28-year-old woman was spending Christmas on Phi-Phi Island with her boyfriend. The wave hit their bungalow and she was hit by a pole of reinforced concrete. She was rescued and brought to a local hospital and later moved to a hospital in Phuket. As her state of health deteriorated, she was transported to Sweden with an ambulance flight for 1.5 days. It was then 7.5 days since the wave had struck.

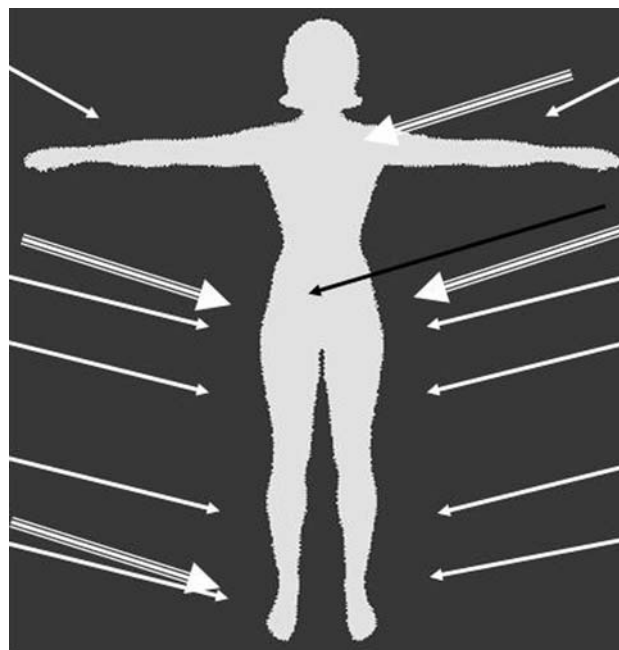


Figure 9. Schematic view of injuries described in the 28-year-old woman shown in Figure 10a–10e. White arrows indicate wounds, wide-striped arrows indicate fractures, and the black arrow indicates a decubitus ulcer.

On arrival she presented with wounds on her arms, buttocks, thighs, lower legs and feet. She had fractures on her right clavicle, first costal rib and sternum, multiple pelvic fractures, and an open fracture of the right ankle joint. She also had a sacral decubitus ulcer (Figures 9, 10a–10e). Initially she required intensive care with ventilator and hemodialysis. She also required multiple major surgical revisions. During her hospital stay she had 25 operations under general anesthesia and 52 treatments with hyperbaric oxygen (HBO), and was treated with VAC. Her defects were covered using split-thickness skin grafts on the legs and also on her ankle after the exposed bone was covered with granulation tissue. She was eventually transferred to another regional hospital. In addition to multiple scarring, her physical disability is now limited to a limited range of movement in her right ankle and decreased sensibility in her left foot.

Discussion

The tsunami wave generated by the earthquake affected the coastline unevenly. In some parts, the shallow coastal waters allowed the wave to rise to up to 15 m, and the flat landscape in that same area resulted in the wave reaching 4 km inland. People swept up by the wave were thrown against sharp and hard objects,



Figures 10a to 10e. A 28-year-old woman hit by a pole of reinforced concrete presented with the following wounds: multiple lacerations and defects of the skin and muscle on both legs and feet (a and c) and right and left thigh (b and d); she also had a decubitus ulcer (e) on arrival.

causing multiple soft tissue wounds and deep puncture injuries. In addition, the tsunami water was heavy contaminated due to broken sanitary systems, which in combination with the high ambient temperature, the high humidity, the related soft tissue destruction at the time of wounding, and the understandable delay observed in receiving first medical care, all predisposed to a high risk of wound infection [5].

Surviving victims from the tsunami disaster in December 2004 were evacuated to their home countries after various periods of time. The care and treatment of these patients have been reported previously [5–11]. No previous reports on the wound panorama from a plastic surgeon's point of view have been published. The wounds seen at our receiving hospital were mainly located on the lower extremities and were heavily infected, which is probably explained by victims walking around in sewer-contaminated water with debris. Victims with major injuries to the head or thorax probably did not survive.

Late unusual infections due to mycobacteria and pigmented fungae were seen; however, no cases of melioidosis have been seen among these patients, as have been reported from other centers [12–16].

A major problem associated with wound management was significant contamination, both at admission [12–14, 15–18] and later [4, 19], which should be a re-

minder for delayed closure. However, in some cases, sutures were necessary to keep the skin flaps in place during transportation.

Conclusion

The patterns of injury and clinical courses in these patients illustrate the risk of complications in wounds caused by high energy, which were severely contaminated and which arrived late for primary treatment by staff not fully aware of the risk of secondary complications under these conditions. Liberal indications to re-open already sutured wounds at the receiving hospital are therefore of importance.

Recommendations for primary treatment should include extensive cleaning, excision of dead tissue, and delayed primary closure, according to the well-established principles of management of war wounds, where the conditions are similar.

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