

Wound Infections in Tsunami Survivors: A Commentary

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Abstract

Survivors of the December 2004 Indian Ocean tsunami sustained a variety of wound infections, ranging from common pathogens to rarely seen organisms. This article discusses the likely microbiology potentially seen in wound infections with exposure to freshwater, seawater, soil, faecal or other contamination, and attempts to provide an organising framework for choosing empiric antibiotics for such infections. Therapy for less frequently encountered clinical entities is also discussed, including tetanus, cutaneous and septicaemic melioidosis, post-traumatic mucormycosis, *Vibrio vulnificus* and *Aeromonas hydrophila*.

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Introduction

The Indian Ocean tsunami on 26 December 2004 killed over 225,000 people,¹ but it had an impact on far more than the 12 countries directly affected. Indonesia sustained the heaviest toll with over 100,000 dead, but the Scandinavian nations also lost hundreds of citizens travelling in the regions struck by the tsunami.²

Amongst these travellers as well as the affected local populations, traumatic injuries sustained during this catastrophic event were complicated in many instances by infection. Wound infections such as melioidosis, not commonly seen outside the tropics, have been reported in returning tsunami victims.³ Claims in the lay media highlighted dramatic reports of tetanus, an infection rarely seen since routine immunisation programmes were introduced.

Apart from isolated case reports, the medical literature has yielded sparse data on this subject. This article is an attempt to look at the aetiology and management of wound infections in tsunami survivors with regard to the likely pathogens acquired from exposure during that disaster, with special emphasis on unusual or virulent pathogens less frequently encountered in non-disaster settings.

Overview

During the tsunami, many persons were injured by debris, causing both sharp and blunt trauma. These injuries included deep lacerations caused by dislodged corrugated iron

roofing, puncture wounds and superficial abrasions. Many of these wounds became grossly contaminated with soil, seawater or sewage in the immediate aftermath of the tsunami. One survey of 33 patients hospitalised in Phuket Province demonstrated polymicrobial infections in two-thirds of the cases.¹

A relatively high incidence of wound infections¹ was to be expected, given the disruption of clean water supplies and sanitation systems. In some locations, access to health care was unavailable for several days due to the destruction of medical facilities and transportation infrastructure. In other anecdotal instances, victims delayed seeking medical attention while they searched for missing family members.

Wound Management

Initial wound management requires adequate cleansing and irrigation of the wound, as well as examination for foreign bodies which may be deeply embedded. If sterile saline is unavailable, bottled water is an acceptable substitute. Irrigation should be carried out with a large bore needle and syringe.⁴ Thorough evaluation may require surgical debridement of devitalised or infected tissue, or orthopaedic attention for open fractures, depending on the wound, and the availability of appropriate medical personnel and supplies.

Contaminated wounds should not be sutured for primary closure because of the high risk of infection. The wound should be dressed, or packed with saline-soaked

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gauze in the case of deeper wounds. Delayed primary or secondary closure may be considered after at least 4 days, if medical staff can perform closure under sterile conditions.⁵

All patients with wounds, even superficial or minor abrasions, should receive tetanus prophylaxis. This consists of a tetanus booster (Td), unless the patient has received one within the past 5 years. If available, tetanus immunoglobulin (TIG) is recommended for patients who have never received their primary tetanus vaccine series.

Post-exposure rabies prophylaxis is recommended for animal bite wounds. The risk of rabies is present in many of the tsunami-hit countries, including the Indian subcontinent, Indonesia and Thailand.

Appropriate antibiotics should be given to wounds at high risk for infection, including bites, extensive or grossly contaminated wounds. If facilities are available, wound swabs for microscopy, culture, and sensitivity of the appropriate pathogens should be sent *prior* to initiating or changing antimicrobial coverage. Given the wide array of pathogens potentially involved, including melioidosis and fungi, microbiological results are necessary for guiding antibiotic therapy, especially when severe or refractory infections develop.

Microbiology of Wound Infections

In tsunami-associated wound infections, it may be helpful

to group the likely pathogens involved by type of exposure (Table 1). The purpose here is not to make an exhaustive list of all the conceivable pathogens that could be involved, but to focus our discussion on major entities as well as certain unusual infections encountered in tsunami survivors.

In a disaster setting, significant difficulties include establishing diagnoses in resource-limited situations where basic laboratory services may be unavailable. Empiric use of antibiotics should be targeted to the narrowest spectrum possible. However, if the survivor is able to continue medical treatment in a higher-resource setting, then further therapy should be guided by appropriate investigations.

In any given disaster-affected area, only a limited range of antibiotics may be available. The table lists a wide range of antibiotics to provide flexibility for front-line healthcare workers who may face different clinical scenarios, or have different drugs available based on donated supplies or national formularies. This table does not include broad-spectrum agents such as carbapenems because it would be inappropriate to use these on an empiric basis in most cases.

Skin Pathogens

Whenever skin integrity is breached, the normal flora colonising the skin can become a source of infection. These include staphylococcal and streptococcal species, with aggressive infections typically caused by *Staphylococcus*

Table 1. Pathogens and Useful Antibiotics

Type of exposure	Type of organism	Organisms	Useful antibiotics
Skin	Gram-positive cocci	<i>Staphylococcus</i>	Cloxacillin, first-generation cephalosporins, clindamycin, macrolides, cotrimoxazole
		<i>Streptococcus</i>	Penicillin, cephalosporin, macrolides, clindamycin
Freshwater	Gram-negative bacilli	<i>Pseudomonas</i> <i>Aeromonas</i> , <i>Plesiomonas</i>	Ciprofloxacin, ceftazidime, aminoglycosides, aztreonam Ciprofloxacin, cotrimoxazole, tetracycline
	Mycobacteria	<i>M. marinum</i> rapid-growers	Clarithromycin, doxycycline, cotrimoxazole, rifampin
Seawater	Gram-negative bacilli	<i>Vibrio vulnificus</i>	Ceftazidime + doxycycline, quinolones
Soil or environmental	Gram-positive bacilli	<i>Clostridium perfringens</i>	Penicillin, clindamycin, chloramphenicol
		<i>C. tetani</i>	Penicillin, metronidazole, cephalosporin, macrolides
	Gram-negative bacilli	<i>Burkholderia pseudomallei</i>	Ceftazidime, amoxicillin/clavulanate, doxycycline, cotrimoxazole
	Fungi	Mucormycosis	Amphotericin B
	Anaerobes	Miscellaneous species	Metronidazole, clindamycin, penicillin
Sewage or faecal material	Gram-negative bacilli	<i>Escherichia coli</i> , <i>Proteus</i> , <i>Klebsiella</i>	Third-generation cephalosporins, quinolones, aminoglycosides, aztreonam
Animal	Dog bite	Rabies <i>Pasteurella multocida</i>	RIG and rabies vaccine post-exposure prophylaxis Amoxicillin/clavulanate, penicillin, cefuroxime, cotrimoxazole, doxycycline
	Rat bite	<i>Spirillum minus</i> <i>S. moniliformis</i>	Amoxicillin/clavulanate Doxycycline

RIG: rabies immune globulin

aureus and *Streptococcus pyogenes* (Group A streptococcus). In certain virulent, toxin-producing strains, invasive infections including necrotising fasciitis may develop, requiring urgent surgical debridement or even amputation.

Antibiotics should be selected for anti-staphylococcal and anti-streptococcal activity. These typically include cloxacillin and penicillin, or first-generation cephalosporins such as cephalexin. In the penicillin-allergic patient, clindamycin, macrolides or parenteral vancomycin are also possible options, depending on other pathogens that may be involved, the severity of infection, and the medical setting.

Freshwater Pathogens

Bacteria classically associated with freshwater exposure are gram-negative bacilli such as *Aeromonas*,^{4,6} *Plesiomonas*⁷ and *Pseudomonas*. *Aeromonas* and *Plesiomonas* typically respond to quinolones, cotrimoxazole or doxycycline. However, even in freshwater exposure, the most common pathogens involved are still staphylococci and streptococci. Empiric antimicrobial coverage should therefore always include agents with activity against these organisms.

Atypical mycobacteria may also be seen in wounds with freshwater exposure. *Mycobacterium marinum* or occasionally, other “rapid-growers”, may form granulomatous infections with a sporotrichoid pattern. Diagnosis ideally requires biopsy for culture and speciation. Non-tuberculous mycobacterial infections can be indolent, poorly responsive to anti-tuberculosis therapy, and may require surgical excision.

Seawater Pathogens

Vibrio species are among the bacteria able to survive the harsh milieu of seawater. *Vibrio vulnificus* can cause wound infections in patients whose wounds are exposed to seawater.^{8,9} In patients with severe liver disease or diabetes mellitus, *vibrio vulnificus* infection can lead to fulminant septicaemia and death. Other *Vibrio* species seen infrequently in connection with marine exposure are *V. alginolyticus*¹⁰ and *V. parahaemolyticus*. *Vibrio* infections should respond to quinolones, or ceftazidime plus doxycycline.

Soil and Environmental Pathogens

Anaerobes

Anaerobic bacteria are commonly encountered in wound infections contaminated by soil. Culturing these anaerobes can be technically challenging, and may not be reliable if samples are not collected appropriately. If the patient provides a history of probable soil exposure, the choice of antibiotics should include a drug with activity against

anaerobic bacteria. Metronidazole, penicillin, or clindamycin provide excellent anaerobic coverage.

Additionally, metronidazole and clindamycin possess the added virtue of excellent oral bio-availability. In post-disaster settings with limited medical supplies, like the tsunami-affected areas, this allows oral therapy to be virtually equivalent to parenteral treatment, as long as patients are not vomiting and can absorb medications orally.

Tetanus

Several dozen cases of wound tetanus occurred in Aceh, Indonesia. Skin abrasions, even superficial cuts, can provide potential portals of entry for *Clostridium tetani*, the gram-positive rod which causes “lockjaw”. Generalised tetanus may present with trismus, the classic “risus sardonicus”, tetanic spasms, autonomic instability, and airway obstruction. Tetanus carries a high mortality rate of more than 50%.

The management of tetanus consists of wound cleansing, TIG 500 to 3000 IU,¹¹ initiating active immunisation with tetanus vaccine, and supportive care. Oral metronidazole therapy may be superior to intramuscular penicillin; other antibiotics with activity against *C. tetani* include cephalosporins, macrolides and imipenem.

Benzodiazepines remain the mainstay of treatment for tetanic spasms. Autonomic instability may require alpha- as well as beta-blockade. Magnesium sulphate appears promising for the control of spasms as well as hypertension due to autonomic dysfunction. Other therapies which have been used include clonidine, dantrolene, baclofen, and morphine.^{12,13}

Melioidosis

Burkholderia pseudomallei is a soil-associated organism endemic in Southeast Asia. Cutaneous injuries resulting from inoculation of the pathogen can lead to cutaneous melioidosis as well as septicaemic melioidosis,^{14,15} as reported in 3 Finnish travellers who were injured during the tsunami.³

The treatment of melioidosis has been reviewed extensively elsewhere.¹⁶ The initial treatment of melioidosis should include several weeks of parenteral ceftazidime or a carbapenem. Doxycycline may be added to the initial regimen. Thereafter, combination oral antibiotic therapy, with amoxicillin/clavulanate, cotrimoxazole or doxycycline, depending on susceptibility testing, should be used. In severe cases of melioidosis, 20 weeks of treatment is advised, and may nevertheless result in 10% relapse.¹⁶

Mucormycosis

Mucormycosis has previously been reported in wound

infections from trauma,¹⁷ and natural disasters such as volcanic eruptions.¹⁸ The report of post-traumatic cutaneous mucormycosis in an Australian traveller who was injured in Sri Lanka during the tsunami is consistent with likely soil contamination of his wounds.¹⁹ Diagnosis was made on histopathology showing tissue invasion, and fungal culture subsequently grew *Apophysomyces elegans*. Treatment in his case consisted of surgical debridement, amphotericin B (liposomal) and adjunctive hyperbaric oxygen therapy.¹⁹

Sewage and Faecal Pathogens

As a result of the disruption in sewage and sanitation systems, contamination of wounds by faecal material should also be considered. The pathogens associated with this scenario typically include gram-negative coliforms, such as *Escherichia coli*, and *Proteus* and *Klebsiella* species.

Third-generation cephalosporins or quinolones may be used empirically until susceptibility testing is available.

Animal Bite Pathogens

Animal bites were not commonly reported after the tsunami, but when these occur, the most common pathogens involved need to be considered in choosing empiric antibiotic therapy. For example, *Staphylococcus* and *Streptococcus* species as well as oral anaerobes need to be considered first in an infected dog bite wound, in addition to less common organisms such as *Pasteurella multocida*.

The possibility of rabies exposure should be considered in any bite wound sustained in the tsunami-affected areas where rabies remains endemic. Post-exposure rabies prophylaxis consisting of various WHO-approved regimens should be promptly instituted, and appropriate wound care for the bite wound, and a tetanus booster should be given as necessary.

Rat bites, although uncommon, may pose a problem in some areas. These injuries are a risk for rare organisms such as *Spirillum minus* and *Streptobacillus moniliformis*, which has been described to cause fulminant illness even in healthy persons.²⁰ Antibiotic treatment includes amoxicillin/clavulanate or doxycycline.

Conclusion

The assessment of wound infections in tsunami survivors requires a careful history detailing the circumstances in which the injury occurred. However, it must be taken into consideration that immediate wound care may have occurred under suboptimal conditions. Subsequent wound care may require further surgical debridement and appropriate antibiotics should be selected based on up-to-date microbiological data.

Antibiotics need to be selected appropriately, and where

possible, the narrowest spectrum agent should be used. The hope is that, with adequate care, these tsunami survivors will continue their recovery from this devastating catastrophe.

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