

Microbial Spectrum and Pathogenesis of Infections in Crush Syndrome Patients

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Abstract— Crush syndrome, even not directly affecting vital organs and involving only extremity injuries, can be also life threatening as infectious complications of the trapped limbs are consequential and is the most common infectious complication in crush syndrome patients. Despite several advances in appropriate treatment methods, mainly focusing on renal failure, infections remain one of the utmost important factors in mortality of crush syndrome patients. *Acinetobacter baumannii* and *Pseudomonas aeruginosa* are the major bacterial isolates of wound infections. Proper wound management – early detection of wound infection and timely administered treatment of infections can decrease the risk of infection generalization, sepsis development and therefore may decrease the morbidity and mortality rate in crush syndrome patients.

Keywords— Crush syndrome, pathogenesis of infection, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, sepsis.

I. INTRODUCTION

Crush syndrome is generalized manifestation of muscle cell breakdown (rhabdomyolysis) with release of necrotized contents (autointoxication) into the circulation. Rhabdomyolysis clinically manifests soon after the skeletal muscle is released from pressure leading to severe metabolic disturbances, cardiac arrhythmias, acute renal failure and traumatic shock [8, 24].

Clinical signs of crush syndrome such as myalgia, loss of muscular power and dark urine appeared in German literature in 1910, after the Sicily earthquake [24]. Though as broadly known, in 1941 after battle of London by the term “crush syndrome” was first time used by Waters and Beall and some pathogenetic mechanisms were also delineated. They described the cases in soldiers who were pulled from the rubble. The soldiers initially appeared to be unharmed, but then developed progressive limb swelling and shock and died of renal failure a few days after. Autopsy had revealed pigmented – red granular casts of erythrocytes obstructing the renal tubules [20]. Later, studies showed that it was broadly known myoglobin, released due to rhabdomyolysis. Myoglobinemia and myoglobinuria resulted in consequent tubular obstruction, as kidney is able to filter myoglobin, though it is trapped in the tubules by special proteins – tamm-horsfall proteins (uromodulin).

Historically, in addition to manmade catastrophes, crush syndrome occurs in several types of natural disasters such as earthquakes, landslides, etc., but in everyday life it is more commonly found in patients after motor-vehicle accidents, especially with prolonged extractions [10, 16].

Also, there are described some cases when crush syndrome occurring in patients who had self compressed a part of their own body due to a stroke, intoxication, or mental illness [9]. Prolonged immobility in any condition (e.g. operating table), can also result in a crush injury [1,19].

Generally, management of crush syndrome in critical patients is associated with difficulties.

Rapid surgical operation and hemodialysis were major treatment options in the series of 10 crush syndrome cases, occurred mainly due to trapping in vehicle accident. Severe infection and rhabdomyolysis was the reason of amputation in 50% (5) of patients. Infection development affects the prognosis of crush syndrome, blood, urine and tracheal microbial cultures were analyzed in these patients and appropriate antimicrobial treatment was administered. [13].

For crush and fracture related injury, more examination is necessary to avoid overtreatment. Special attention should be paid to medical history and determination of etiology and mechanism of traumatic injury is the key for the treatment of patients [23].

Despite the different vital organs damage (especially – cardiac, renal, respiratory distress syndrome, disseminated intravascular coagulation), patients with crush syndrome are at risk for subsequent infections, especially, those, who required fasciotomies and long term hospitalization. Both – fasciotomy and prolonged hospitalization are of prognostic and predictive values of possible infectious complications [1, 5,12].

In turn, one of the complications of the infections and later, reason of death, is sepsis. In a study conducted after the Wenchuan earthquake, sepsis was developed in almost half cases of renal impairment and open fasciotomies [3,5]. Bacteriological results of the patients from the Wenchuan earthquake suggest that most infections are nosocomial [11]. Wound contamination with microorganisms was the most common source of infection, with prevalence of pseudomonas and acinetobacter organisms [3, 14]. *Acinetobacter* spp. and *P. aeruginosa* were major bacterial isolates from wound infections, since Gram-negative organisms are mainly found in hospital environments, can colonize easily and are resistant to carbapenems [14].

Especially, open wounds resulting from initial injuries, as well as the frequent need for subsequent fasciotomy, can promote contamination with either exogenous microorganisms or the patient’s own microflora [7,11]. Open wounds result in

serious infections and subsequent loss of protein-rich fluids, also, the of intra-compartmental pressure and radical debridement of dead muscle play role because of the danger of necrosis due to poor perfusion, palsies due to nerve entrapments and severe infection [18, 27].

The treatment of injured limbs is especially important since any fasciotomy carries the risk of two main complications; bleeding from the fasciotomy site and infection [18]. Both of these problems can prolong hospitalization and result in increased morbidity and mortality. Some studies suggest, only a few days after admission to unit, fasciotomy sites became the main source of infection. Wound infection at the crush injury site are reported as result of aerobic and opportunistic anaerobic bacteria [4,2].

There were analysed 10 crush syndrome cases occurred in Turkey. According to authors, if not adequately treated by surgical and medical intervention, the risk of subsequent complications, especially sepsis, is high and the outcome is poor [13]. Transportation of numerous patients, inadequate wound treatment, incorrect usage of antibiotics, invasive procedures, and longterm hospitalization provide favorable conditions for contamination and proliferation of microorganisms, thus potentially contribute to raising the rate of hospital-acquired infections [15, 17, 21].

Patients with central venous catheters (such as those used during hemodialysis) have a higher risk of infection [15, 25]. Also, several data report, that specific procedures such as urinary catheters and prolonged treatment may increase cases of nosocomial infections in crush syndrome patients [7, 11].

According to Turkish specialists' experience, despite the wide application of dialysis, mortality from acute renal failure is still high, infection is a major complication contributing to death during the loss of kidney function [13, 26]. The overall outcome of acute renal injury is significantly influenced by infectious complications [22]. In the obtained study results, 75.7% patients had infectious complications, in which, wound infection, pulmonary infection, and sepsis were most common [11].

Study results indicate that bacterial agents of wound infections vary depending on the stage of hospitalization: in the initial stage of hospitalization, *Staphylococcus aureus*, *Escherichia coli*, *Enterococcus faecalis*, and *Enterobacter cloacae* were dominant organisms; in the middle stages of hospitalization *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* (which was multidrug resistant) were isolated [5,11].

According to another study, although staphylococci and streptococci are the usual pathogens in wound infections, they were not detected in wound cultures [14].

There was revealed that different types of infections (septicemia, pulmonary infections, catheter infections, and urinary infections) caused by Gram-negative bacteria, gradually increased also.

Long-term hemodialysis may also be one of the reasons for the increased risk of infection [11].

Non-fermenting Gram-negative bacilli, Gram-positive cocci, *Enterobacteriaceae* and yeast-like fungi were isolated in 67, 17, 12 and 4% of the wound samples, respectively [14].

In conclusion, after analyzing the above data, we can suggest that in parallel with vital organs treatment, wound management is crucial. Regular wound inspection, identification of changes in the bacteria spectrum and blood bacterial cultures analyses are important to follow up the sequence of the process. *A. Baumannii* and *P. aeruginosa* are the major bacterial isolates of wound infections. Careful wound debridement, appropriate management of the wounds limits appearance of necrosis of deep muscles, wound hemorrhage, and exacerbation of systemic toxicity. Urinary and venous catheters should be removed in crush syndrome patients as soon as possible in order to avoid furthermore complications and lethal outcome due to sepsis.

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