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CASE REPORT / ПРИКАЗ БОЛЕСНИКА

Effective local treatment of necrotizing fasciitis using a chlorine solution obtained by electrolysis

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SUMMARY

Introduction Severe surgical wound infection as necrotizing fasciitis is one of the leading causes of death in the postoperative period. Large wounds affecting the skin and soft tissues are a particular problem, as such wounds are difficult to heal, especially in immunocompromised patients. Local treatment is important, and different antiseptics are in clinical use.

Case outline A 45-year-old woman with terminal kidney failure, with hypothyroidism and iodine allergy was admitted to the hospital with multiple abscess formation in the abdominal wall. After the first surgery, necrotic fasciitis and sepsis were diagnosed. Complete parenteral therapy, including antibiotics, other supportive therapy, and hemodialysis was performed. Successive debridement and local treatment with chlorine solution obtained by electrolysis as irrigation solution and wet wound dressing used daily lead to complete healing. Delayed wound closure was performed. She was discharged in good general condition, and the wound was healed completely.

Conclusion The application of a chlorine solution obtained by electrolysis (Aqualor H 200, SIGMA DOO, Kula, Serbia) in a concentration of 0.2 mg/l is effective for local treatment of wounds by washing and applying wet dressing in the wound on skin and soft tissue, especially necrotizing fasciitis as wound with mixed bacterial infection.

Keywords: antiseptics; electrolysis; chlorine-based antiseptic; wound infection; necrotizing fasciitis

INTRODUCTION

Surgical wound infection is one of the leading causes of death in the postoperative period. In developed countries, surgical site infection occurs in 16% of patients receiving hospital treatment and 38% of all surgical patients [1]. The bacterial burden in the wound can lead to infection, subclinical, or clinically evident and this continuous process of the inflammation in the wound is divided into five stages:

1. Contamination
2. Colonization
3. Local infection
4. Spread of infection beyond 2 cm from the edge of the wound or to regional lymph nodes.
5. Systemic infection – sepsis [1–4].

The treatment of each wound must be individual (holistic), adequate, and continuous in order to ensure the goal of healing, in a clinical and economic point of view [5]. Hemodialysis patients belong to the group of immunocompromised patients. Infections in those patients could have a fatal course. Large wounds with necrotizing fasciitis are difficult to heal. Targeted antibiotic therapy is mandatory according to the findings of the wound swab, and local treatment of the wound has key importance. Various antiseptic solutions are used for wound washing as iodine solution or solution of boric acid 3%. Sodium hypochlorite solution has been used for wound treatment known as Dakin's solution used in the First World War [6].

An electrolytic solution of sodium chloride contains hypochlorite, which is formed when an aqueous solution of sodium chloride is subjected to the action of current. The concentration of chlorine oxidants in that solution is sufficient as an antiseptic and acts on a large number of microorganisms. Hypochlorite is identified as an endogenous substance in the human cells. It is produced by leukocytes in open wound on the skin [7]. There are a number of advantages of antiseptics based on chlorine oxidants:

1. Hypochlorous acid (HOCl) can be applied to the skin.
2. HOCl produced by leukocytes is the first line of defense against microorganisms in oxidative stress that converts O_2 into H_2O_2. and it reacts with the chlorine ion Cl^- from the cells to form HOCl.
3. 0.05% HOCl is used to treat atopic dermatitis.
4. HOCl is bactericidal for most microorganisms [8].

Active chlorine released by electrolysis from sodium chloride is molecular chlorine Cl_2. Molecular chlorine is rapidly hydrolyzed into a number of different chlorine compounds: hypochlorous acid (HOCl), chloride ions Cl^- and hypochlorite ion (OCl^-) (Figure 1) [8].

By contacting the electrolytic solution with the wound, the pH of the solution is lowered,

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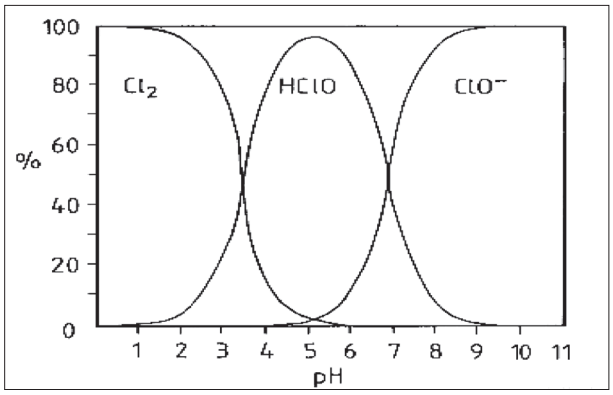

Figure 1. The ratio of hypochlorous acid and hypochlorous ion depending on the pH of the electrolytic sodium hypochlorite solution

releasing hypochlorous acid, NaClO, OCl- ion, which all have a bactericidal effect [9]. That highlight the special advantage of applying chlorine solution due to its low price [10]. Wound healing is a complex morphological and pathophysiological process that is influenced by a number of factors, such as the degree of tissue damage, the strains of bacteria present in the wound, the intensity of the inflammatory process, the capacity for tissue regeneration, the general state of health and the presence of accompanying diseases [3].

Chlorine solutions obtained by electrolysis have a high necrolytic activity, antimicrobial, and local immunomodulatory effect. It has an effect on gram-positive and gram-negative microorganisms, including muti-resistant microorganisms, and also exhibits fungicidal effects [11, 12]. For difficult-to-heal wounds with biofilm formation, hypochlorous acid is recommended [11, 13]. Hypochlorous acid solution has low cytotoxicity [13]. In the study conducted by Serena et al. [14], 82% of wounds that are difficult to heal were found to be contaminated with different microorganisms. Despite a series of proven facts about the effect of various antiseptics *in vitro* and in experiments, a more extensive clinical examination of the effectiveness of antiseptic solutions in clinical studies is necessary, especially for wounds that are difficult to heal [14]. One of such infections is necrotic fasciitis, which is presented in this paper. The aim of the work is to demonstrate the effectiveness of the chlorine solution obtained with electrolysis (Aqualor H200, SIGMA, DOO, Kula, Serbia) for the treatment of deep infected wounds.

This research was approved by the Ethical Committee of the University Clinic Center of Niš, Serbia, no. 39906/3 dated on December 22, 2023, and written consent form was obtained from the patient.

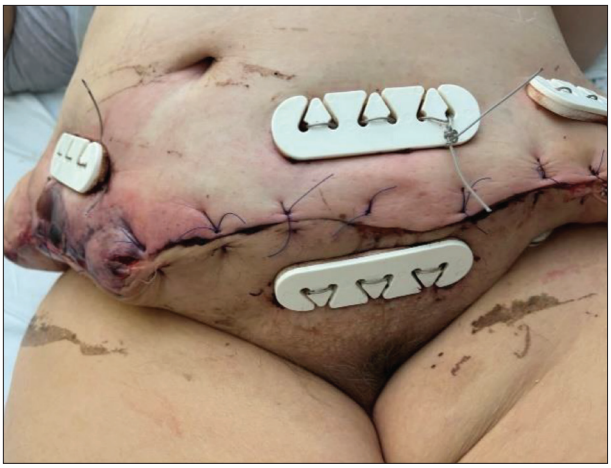

Figure 2. Wound condition after initial excision; the wound was opened and successive necrotomies were performed

Figure 3. Necrotizing fasciitis of the anterior abdominal wall after multiple necrectomies and placement of sutures

Figure 4. The wound is completely closed

CASE REPORT

A 45-year-old female patient has been on a hemodialysis program for five years due to end-stage renal failure. She suffers from hypothyroidism and is allergic to iodine.

She was admitted due to multiple subcutaneous abscesses of the abdominal wall. In the first surgery, excision of the skin and subcutaneous tissue was performed, and the wound was closed (Figure 2).

In the postoperative course, antibiotics were administered according to biogram. In the first swab, *Staphylococcus aureus* was isolated. Biochemical parameters were corrected in accordance with the laboratory results. Wound dehiscence occurs and necrotic fasciitis

Figure 5. Definitive result after removal of suture material

is noted on the anterior abdominal wall. *Staphylococcus aureus*, *Proteus mirabiliss*, *Pseudomonas aeruginosa* and *Enterococcus faecalis* were isolated in wound swabs. The patient was transferred to the intensive care unit with developed sepsis.

The wound extends transversely across the entire hypogastrium. Infection *with Proteus mirabilis*, *Pseudomonas aeruginosa* and *Enterococcus faecium* was recorded. Clinically, there is a biofilm and pyogenic membrane on the wound without signs of granulation tissue formation. Further, *Proteus mirabiliss*, *Corynebacterium* and *Pseudomonas aeruginosa* are proven in wound. The parameters of sepsis were elevated, reaching very high values (white blood cells 30×10^9/L, C-reactive protein 248.1 mg/L and procalcitonin 99 ng/L). The wound is treated daily, successive necrectomies are performed and generous washing with a chlorine solution obtained by electrolysis. Strips soaked in chlorine solution remain in the wound (moist dressing). The wound shows abundant purulent discharge and has an unpleasant odor. Signs of wound secretion are progressively reduced. After two weeks, granulations appeared on the walls of the wound. Additional necrectomy of devitalized tissue was performed. Temporary sutures were placed (Figure 3 and 4).

Wound was gradually sutured. The general condition has stabilized. Throughout the hospital stay, caloric intake was corrected after each dialysis, which significantly improved wound healing capacity.

On discharge, the wound was completely healed and the patient was discharged (Figure 5).

DISCUSSION

Treatment of severe infections of the skin and subcutaneous tissue is a great challenge even in the modern era. Necrotic fasciitis with mixed bacterial colonization was particularly notable [15]. The most common causative agents are *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* [16]. Colonization of *Staphylococcus aureus*, *Proteus mirabiliss*, *Pseudomonas aeruginosa* and *Enterococcus faecalis* was found in this patient. Adequate local treatment of that wound is particularly important. Although most antiseptics were introduced a long time ago, their importance is relevant nowadays, as iodine solution, hydrogen peroxide, boric-acid solution and chlorine antiseptics. The treatment of immunocompromised patients receiving hemodialysis, patients receiving chronic corticosteroid therapy, or diabetic patients is particularly specific. Wound healing is a very complex process. The phases of healing are hemostasis, inflammation, proliferation and the remodeling phase. Wound healing is also influenced by the systemic factors as the state of nutrition, hypoxia, infection, immunosuppression, chronic diseases, the age of the patient, and genetic factors [16]. The patient presented in this paper suffers from hypothyroidism and terminal renal failure and has a proven allergy to iodine. In the wound, active chlorine solution containing chlorine, hypochlorite ion and hypochlorous acid, disrupt cellular homeostasis by acting on the dissolution of the biofilm formed by *Pseudomonas*. Although some authors state that the effect of chlorine preparations on breaking biofilms in *in vivo* and clinical studies has not yet been clarified [16], in our patient, biofilm was present, without signs of granulation tissue formation and *Pseudomonas aeruginosa* infection present. During treatment with restricted debridement, washing the wound and applying wet bandages with chlorine, the biofilm was effectively removed.

The effectiveness of chlorine preparations for local wound treatment has been shown to be significant in reducing bacterial burden of the wound and accelerating the healing [16]. Chlorine produced by electrolysis has beneficial effects on the healing of infected wounds. The pH of the wound environment is of great importance in the control of wound healing by increasing antimicrobial activity, modulating the activities of proteases, of which matrix metalloproteases and tissue inhibitors of metalloproteases are significant, reducing the toxicity of bacterial products and accelerating epithelialization and angiogenesis [17]. Acidified electrolytic water is a synonym for chlorine solution obtained by electrolysis. It is effective in inactivating microorganisms, and Dunnill et al. [18] proved its effectiveness on *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The immune response and the response to oxidative stress in wound healing, which is shortened by the effect of acidified water, were also investigated. During wound healing, a certain amount of reactive oxygen species (ROS) is produced, which plays a significant role in normal wound healing by affecting phagocytosis processes or are secondary messengers in immune cells and regulate angiogenesis. [18]. Free radicals oxidize chemical groups containing nitrogen and sulfur on the surface of the bacterial cell and thus block membrane functions [19, 20, 21]. The chlorine solution obtained by electrolysis can be used as an antiseptic solution both for washing wounds and as a wet wound dressing. The price is very low, and its effectiveness is proven, so the price-efficiency ratio is extremely favorable. In several clinical studies, it has been proven that 0.05% sodium hypochlorite electrolytic solution shows safe effects in the treatment of infected skin wounds and can be recommended as the agent of first choice for wound treatment [12]. The application of a chlorine solution obtained

by electrolysis (Aqualor H 200, SIGMA DOO) in a concentration of 0.02 mg/dl is effective for local treatment of wounds (washing and wet dressing), especially for wound with mixed bacterial infection. Treatment with chlorine solution led to the complete healing of the wound, despite of severe sepsis and necrotizing fasciitis.

Conflict of interest: None declared.

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Ефикасан локални третман некротизирајућег фасциитиса раствором хлора добијеног електролизом

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САЖЕТАК

Увод Тешка инфекција хируршке ране, као што је некротизирајући фасциитис, један је од водећих узрока смртних исхода у постоперативном периоду. Опсежне ране које захватају кожу и мека ткива су значајан проблем, посебно ране које тешко зарастају код имунокомпромитованих болесника. Посебно је важан локални третман применом различитих антисептичних раствора у клиничкој пракси.

Приказ случаја Болесница стара 45 година која има терминалну бубрежну слабост, хипотироидизам и алергију на јод примљена је у болницу због мултиплих апсцеса у трбушном зиду. После прве операције дијагностиковани су некротизирајући фасциитис и сепса. Примењена је комплетна парентерална терапија укључујући антибиотике и другу супортивну терапију и рађене су хемодијализе. Свакодневно су рађени серија дебридмана и локални третман ране испирањем раствором хлора добијеним електролизом и применом влажног завоја са газама натопљеним овим антисептиком, све до потпуног зарастања ране. Рана је секундарно сутурирана. Болесница је отпуштена кући у добром општем стању, а рана је потпуно зарасла.

Закључак Примена раствора хлора добијеног електролизом (*Aqualor H* 200, СИГМА ДОО, Кула, Србија) у концентрацији 0,2 *mg/l* ефикасна је за локални третман рана испирањем и применом влажног завоја на рани на кожи и поткожном ткиву, посебно за некротизирајући фасциитис, као ране са мешовитом бактеријском инфекцијом.

Кључне речи: електролиза; хлорни антисептици; инфекција ране; некротични фасциитис