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Our Experience on Topical Usage of Acetic Acid in Pediatric Major Burns

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ABSTRACT

OBJECTIVES: **We discuss the topical usage of acetic acid in pediatric patients with major burns and wound infections caused by multidrug-resistant bacteria.**

PATIENTS AND METHODS: **Patients were 5 boys; mean age was 11 years (range, 4-16 years), and mean total body surface burn area was 45.2% (range, 15%-74%). Two patients had high-voltage electrical injuries (with 1 patient having concomitant flame burns), 2 patients had flame burns, and 1 patient had scald injuries. Systemic treatment with topical 3% acetic acid application was started as soon as the septic conditions due to isolated bacteria were identified.**

RESULTS: **Mean length of elimination period was 12 ± 5.1 days for multidrug-resistant *Acinetobacter baumannii.* For 2 patients who had concomitant *Pseudomonas aeruginosa* isolation, colonization of *Pseudomonas aeruginosa* continued during a longer period, although infectious findings regressed. Septic conditions regressed, and burn wounds totally healed after surgical debridement, split-thickness grafting, and amputation plus flap surgeries during mean length of hospital stay of 59.8 days (range, 35-90 days).**

CONCLUSIONS: **Topical acetic acid (3%) administration is feasible for clearance of multidrug-resistant *Acinetobacter baumannii* and for reduction of *Pseudomonas aeruginosa* quantity in the burn wounds.**

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INTRODUCTION

Local wound infections and burn wound sepsis are unwanted but one of the most probable complications in burn care. Bacterial flora isolated in burn speciality centers is one of the sources of these infections. Although prevalence varies in different regions, *Pseudomonas aeruginosa, Acinetobacter baumannii, Staphylococcus aureus, Enterococcus faecalis, Escherichia coli, Klebsiella pneumoniae*, and *Enterobacter* species are the most common ones.[1,2] Antibiotic resistance of these bacteria remains an increasing problem globally, and high-dose systemic antibiotics with various topical antimicrobial agents are needed for treatment, for biofilms, and for subsequent infectious formations in the burn wounds. Modern technology has provided novel commercial products, including topical agents, for this purpose. Similar to those used around the world, these novel products are also currently in use at our burn center in Turkey. However, some of these topical antiseptic and antimicrobial solutions are hard to access, especially in low-income countries.

Regarding this perspective, acetic acid (AA), one of the predecessors of topical antimicrobial therapies, may be a cost-effective and easily accessible topical antimicrobial solution. In low concentrations (1%-5%), AA causes a bactericidal effect against many Gram-positive and Gram-negative microorganisms located in the biofilm of the wounds, hence contributing the prevention of the biofilm formation and reducing multiple resistant bacteria-induced infections and sepsis. This agent also may contribute to treatment when these conditions occur.[3-5]

Here, we present our experience on use of topical AA in burn wound infections and sepsis caused by multidrug-resistant *A baumannii and* multidrug resistant *P aeruginosa*.

PATIENTS AND METHODS

Patients

We reviewed findings in 5 children; all were male, with mean ± SD age of 11 ± 4.4 years (range, 4-16 years) and mean ± SD total body surface area (TBSA) burned of 45.2 ± 26.9% (range, 15%-74%). Two of the 5 patients had high-voltage electrical injuries, 2 had flame burns, and 1 had scald injuries.

Case 1 was a 12-year-old boy with high-voltage electrical injury associated with arc flame burns (74% TBSA) (Figure 1). Case 2 was a 16-year-old boy with electrical trauma and 15% TBSA and severe tissue defects with full-thickness burns to both upper extremities and both lower extremities, including hand and feet (Figure 2). Case 3 was a 14-year-old boy with flame burns (72% TBSA) (Figure 3). Case 4 was 4-year-old boy with flame burns (40% TBSA) (Figure 4), and case 5 was a 9-year-old boy with 25% TBSA scalds at upper and lower extremities. Case 1, case 3, and case 5 were brought to our burn center in the initial 3 days after burn trauma. Case 2 and case 4 were referred from other medical centers (at 38 days and 14 days after the injury, respectively).

Clinical signs and symptoms of infections occurred in case 1, case 3, and case 5 during their hospital stays, whereas case 2 and case 4 had infections at admission.

FIGURE 1. Case 1: 12-Year-Old Boy With High-Voltage Electrical Injury and Concomitant Flame Burns (74% Total Body Surface Area)

FIGURE 2. Case 2: Severe Electrical Trauma With Infective Necrosis, Severe Tissue Defects and Full-Thickness Burns to Upper Extremities and Lower Extremities, Including Hand and Feet

Multidrug-resistant *A baumannii* was isolated in the wounds of all patients. In case 2 and case 5, isolation of *A baumannii* was associated with concomitant isolation of multidrug-resistant *P aeruginosa*.

Acetic acid application

As soon as septic conditions were suspected and observed, intensive medical support was added to our other standard treatment modalities for major burns. Further surgical debridement sessions were required as ongoing surgical approaches. The number of daily wound dressing changes was also increased. As soon as *A baumannii* and *P aeruginosa* were isolated in the wounds, AA (3%) was added to topical treatments of the colonized/infected sites. The solution was prepared fresh by our hospital chemist's every day. In the morning sessions under sedoanalgesia, the dressings were opened, wounds were washed with povidone iodine solution (7.5%) and then followed by cleansing with hydrogen peroxide solution, with wounds again washed with 0.9% NaCl. Sponges soaked in AA were applied after this procedure. Exposure period was 10 to 15 minutes, and then wounds were washed with 0.9% NaCl. Silver sulfadiazine was applied to dried wounds before the dressings were closed. If needed, the dressing changes were repeated twice per day, but with no sedoanalgesia and no AA application for the second ones. Only tender washing with 0.9% NaCl and silver sulfadiazine were used in these sessions. Swab culture investigations were repeated twice per week over the course of the follow-up period.

FIGURE 3. Case 3: 14-Year-Old Boy With Flame Burns (72% Total Body Surface Area)

FIGURE 4. Case 4: 4-Year-Old Boy With Flame Burns (40% Total Body Surface Area)

RESULTS

Multidrug-resistant *A baumannii* was eliminated from the wounds within 14 days in case 1 and case 2. The microorganism was eliminated in 7 days in the first bacterial invasion with wound infection during sepsis, with removal in 20 days in the second invasion of colonization for case 3. Colonized burn wounds of case 4 showed elimination of bacteria at the end of 10 days, and the elimination period for multidrug resistant *A baumannii* was 9 days for case 5 (mean length of elimination period of 12 ± 5.1 days).

Patients demonstrated no adverse effects, such as metabolic acidosis, itching, and refractory pain within and after the AA application sessions. Although *P aeruginosa* colonization continued in both case 2 and case 5 for 2 to 3 weeks, clinical signs and symptoms of septic conditions regressed in 3 to 4 days. Burn wounds subsequently completely healed with our standard surgical approaches, including multiple surgical debridement and split-thickness skin grafting, with uneventful course in case 1, case 3, case 4, and case 5. In case 2, split-thickness skin grafts, local flap surgery, and amputation surgery were performed with successful attempts to limit the extent of the procedure, with amputation below the ankle for his left foot and below the elbow for the left upper extremity.

Case 1 was discharged on day 90 after his admission, case 2 was discharged on day 37 after admission, case 3 was discharged on day 83, and case 4 was discharged on day 54 after his admission. Case 5 was discharged on day 35 after admission. The mean length of hospital stay was 59.8 ± 25.6 days (range, 35-90 days). No adverse effects were observed during treatment (Figure 5, Figure 6, Figure 7, and Figure 8).

FIGURE 5. Burn Wounds of Case 1 Completely Healed on Day 90 After Admission

FIGURE 6. Limited Transmetatarsal Amputation Performed for Right Foot and Forearm Amputation Protecting the Left Elbow

Stump was closed with local lateral fasciocutaneous flap in the left foot.

DISCUSSION

For the past 6000 years, AA as vinegar has been a well-known traditional antiseptic and antimicrobial agent. However, the mechanisms of its antimicrobial activity are not clear.[6] Previous studies suggested that AA reduces the toxicity of bacterial end products, such as ammonia. It enhances the destruction of abnormal collagen in the wound bed, the promotion of angiogenesis, macrophage, and fibroblast activity, and the control of enzyme activity, with positive effects on protease activities in both the wound and for bacteria by providing low pH levels in the wounds.[7] These effects are not only produced by the low pH environment: AA is more effective than strong acids such as hydrochloric acid in the same pH conditions because its nonionized form can freely diffuse across hydrophobic membranes in contrast with strong acids. As a weak acid solution, AA is able to penetrate easily into the bacterial membrane, producing a collapse among the proton gradients that are necessary for ATP synthesis in the bacteria.[5]

Earlier studies demonstrated that application of AA at concentrations of 0.16% to 5% up to twice per day could be used for wound cleansing with no adverse effects, whereas higher concentrations could result in severe pain and

FIGURE 7. Burn Wounds of Case 3 Completely Healed on Day 83 After Admission

FIGURE 8. Burn Wounds of Case 4 Completely Healed on Day 54 After Admission

itching.[5,6,8] Confirming this information, usage of AA at a concentration of 3% brought benefits to the burn wounds of the present septic cases in our study, and no adverse effects were observed. Use of AA was safe for these children of different ages. Very low concentrations, such as 0.10% to 0.16%, have been reported to have less adverse effects; however, dilute concentrations in those studies were able to eliminate *P aeruginosa* but not others in a number of infected samples. For the cases in our present study, we selected 3% for elimination of the biofilms, which probably were containing a broader spectrum, including the isolated microorganisms *A baumannii* and *P aeruginosa*. Usage of bed-side sedoanalgesia provided an excellent maneuverability for cleansing procedures and for pain control during and after the procedure. Meticulous efforts for not overwhelming the AA solution to the healthy skin was the other approach that contributed to pain control. We believe that this approach also prevented itching, which could be triggered by AA in healthy skin.

Duration of exposure is another factor for effective topical bactericidal benefits. A recent study by Sloss and associates[6] demonstrated that the numbers and spectrum of bacteria that were eliminated from the wound were broader if the exposure period was longer than 30 minutes. We preferred a shorter period (10-15 minutes) in our patients, as prolonged wound dressing sessions in major burns might result in severe hypothermia and uncontrolled fluid loss. Even with this short exposure time, elimination of *A baumannii* was achieved in acceptable periods. Regression of clinical signs and symptoms of septic conditions due to *P aeruginosa* seems to be achieved with the preferred exposure time and AA concentration. However, the continuation of *P aeruginosa* colonization in the wounds after elimination of *A baumannii* may be because of our short exposure time preference and because a higher concentration of AA might be more effective on multidrug-resistant *P aeruginosa* isolated in our patients. Thus, we suggest that the AA concentrations and exposure times may be arranged according to the spectrum and nature of the bacteria located in the wounds and according to the peculiar clinical conditions of the patients.

CONCLUSIONS

Acetic acid in low concentrations can be used safely and cost-effectively in burn wounds, even in children. In the absence or with nonresponse of novel products, AA may be a cost-effective option for controlling multidrug-resistant bacterial colonizations or infections at burn centers. A further understanding of the frontiers and margins of AA usage on wound morphology, pathophysiology, and wound healing process in major burns is required.

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