THE EFFECTS OF LOW VOLTAGE CURRENT ON HEALING OF THERMAL THIRD DEGREE WOUNDS

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ABSTRACT Bilateral third degree burns were created on the flanks of eight miniature swine. Each animal had one side treated daily with low intensity direct (LIDC) of 400 microamperes (μA) by contact electrode for 2 hours morning and afternoon until healing occurred.

The polarity of the electrode was negative in 4 pigs and positive in 4 pigs. One group of 4 pigs had the eschar surgically removed 24 hours post burn. Weekly biopsies and cultures were taken of treated and control wounds.

Results indicated: local treatment of 400 μA LIDC did not hasten or delay healing of thermal third degree burns; escharectomy hastened wound healing by 10 days, and superficial proteus infection occurred in 80% of all wounds.

KEY WORDS: BURNS, ELECTROTHERAPY, ESCHARECTOMY, THIRD DEGREE BURNS, SKIN

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IN THE last 10-15 years there has been a surge of medical interest in the field of piezoelectricity. Tissues have been shown to respond to electrotherapy in various ways (1,2,3,8). Reports on the use of low voltage current on decubital sores (5,7) stimulated interest in the use of such current on burn wounds.

The purpose of the experiment was to create uniform third degree burns, use routine type treatment (antibiotics and topical enzyme) plus 400 microamperes (μA) low intensity direct current (LIDC) and observe the effects on healing in the treated and control burn wound.

The experiment was run in two phases:

Phase 1: Comparison of LIDC versus control using antibiotics and enzyme treatment on the eschar.

Phase 2: Comparison of LIDC versus control using antibiotics and enzyme treatment on the wound after early eschar removal.

MATERIALS AND METHODS

The experiment was performed on two groups of ovariectomized miniature pigs. The first group was composed of four miniature pigs from the same litter, six months of age and weighing between 9-10.90 kg. The second group was composed of four miniature pigs from the same litter, eight months of age and weighing 27-34 kg.

Rechargeable LIDC unit (Rechargeable LIDC unit, Ritter-Sybron Corporation, Rochester, New York) producing 400 μA with buzzer alarm generators were used for the experiment. The generators were checked daily for any malfunction. To record and evaluate the progression of healing, close-up photographs were taken daily or every other day using a fixed focus camera (Instatech Kodak Camera, Eastman-Kodak Corporation, Rochester, New York).

The pigs were premedicated for general anesthesia with 0.04 mg/Kg atropine intramuscularly, induced with methoxyfluorane inhalation anesthesia administered by mask. The hair was clipped on the lateral sides of the trunk. A branding iron of 7.5 cm. diameter was heated to 260° C as recorded by a dial thermometer and Tempil disc (Tempil disc, Taylor Instruments Consumer Products Division of Sybron Corporation, Arden, North Carolina 28704). Bilateral flank burns were produced in all pigs by application of the hot iron for one minute per site (Fig. 1). Color photographs were taken one minute after the thermal injury and daily thereafter. Ph

of the wound was taken twice daily. Penicillin G 400,000 units and dihydrostreptomycin 500 mg. were given daily by intramuscular injection for 4 days. Tetanus antitoxin 500 units was given prophylactically (Tetanus antitoxin, Fort Dodge, Lincoln, Nebraska). Fibrinolysin and desoxyribonuclease

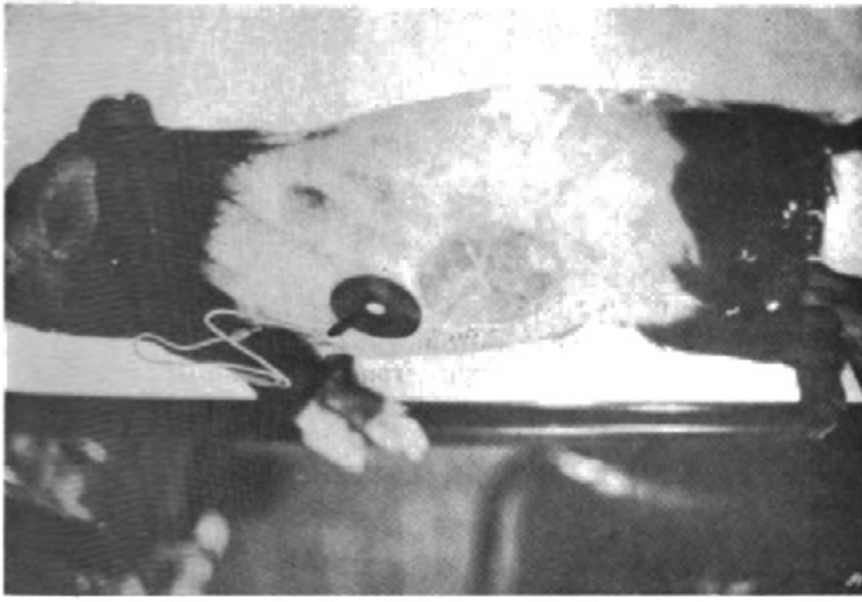


Fig. 1. 2.5 cm. diameter third degree flank burn and nonreactive rubber carbon electrode used to deliver current.

combined (bovine) (Elase with chloramphenicol, Parke Davis, Detroit, Michigan) was applied to burned areas twice daily to aid in enzymatic debridement of the eschar and to act as a bacteriostat. Treatment consisted of placing a nonreactive rubber carbon electrode (Fig. 1) between two saline moistened gauze pads, positioned on each of the defects and covered with a plastic film (Saran Wrap, Dow Chemical Company, Indianapolis, Indiana) to retain moisture. The right flank lesion was the treated side in each animal, while the identical lesion on the left side received no current through the electrode.

The #1 and #2 pigs had the positive electrode on the lesion and the negative electrode on normal skin. On #3 and

#4 pigs, the negative electrode was on the lesion (Table 1). Each day the current was administered with the generators providing for 2 hours twice a day with a 3 hour break in between, for a total treatment time of 4 hours daily, 7 days per week (Fig. 2). At weekly intervals, biopsies of the

Table 1. Phase 1 (eschar)

Pig #	Polarity of Treated Side
1	+
2	+
3	-
4	-
	Phase 2 (eschar removed).
5	+
6	+
7	-
8	-

wounds were taken under general anesthesia with a biopsy punch. The weekly biopsy samples taken from control and treated wounds were submitted unlabeled to a pathologist for examination. Cultures were taken of the wounds to evaluate infection.

The second group of pigs were treated the same as the first group (Table 1) with one exception. The eschar was debrided surgically 24 hours after the initial injury.

RESULTS

In Phase 1 (Figs. 3a, 3b and 3c), no macroscopic difference in healing was seen between the control side and the treated side in all 4 pigs regardless of polarity used. On histologic examination, regeneration of epithelium was comparable in both wounds at almost the same rate of time. Marked dermal fibrosis was seen in equivocal amounts on both sides. Large amounts of collagen were formed and surface infection was observed in both wounds. Large vacuoles of fat were also seen in each of the wounds. In all the wounds, a gradual progression in healing took place after removing the eschar on the 14th to 16th day with healing completed by the 30th to 40th day (Fig. 4). Photographs and histologic specimens of the wound correlated well in evaluation of wound healing. The pH of all wounds were generally the same

throughout the experiment. They ranged from 6.6 to 7.4 with occasional readings as high as 8.0. Neither side showed significant difference from the other side.

In Phase 2 (Figs. 3d, 3e and 3f), no significant differences were seen between the control and treated sides. The

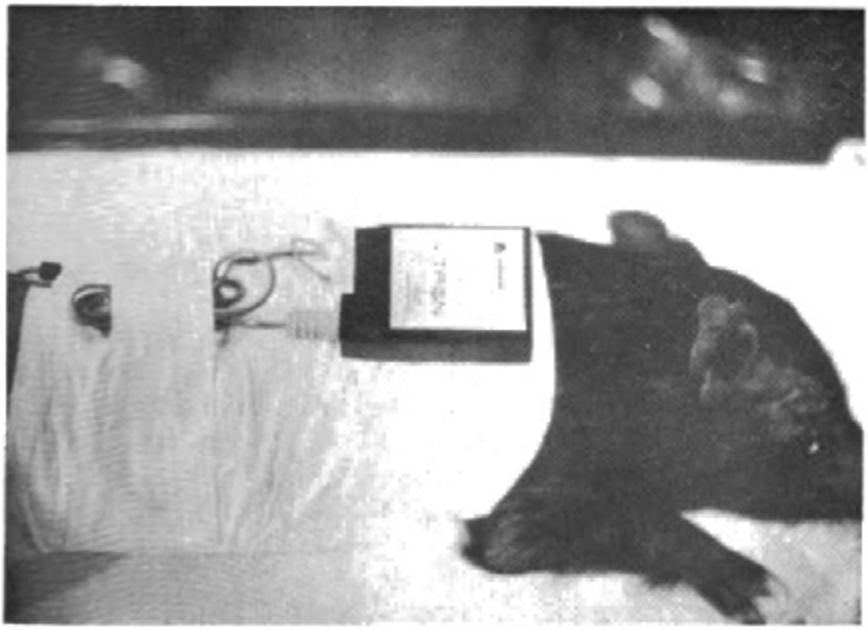
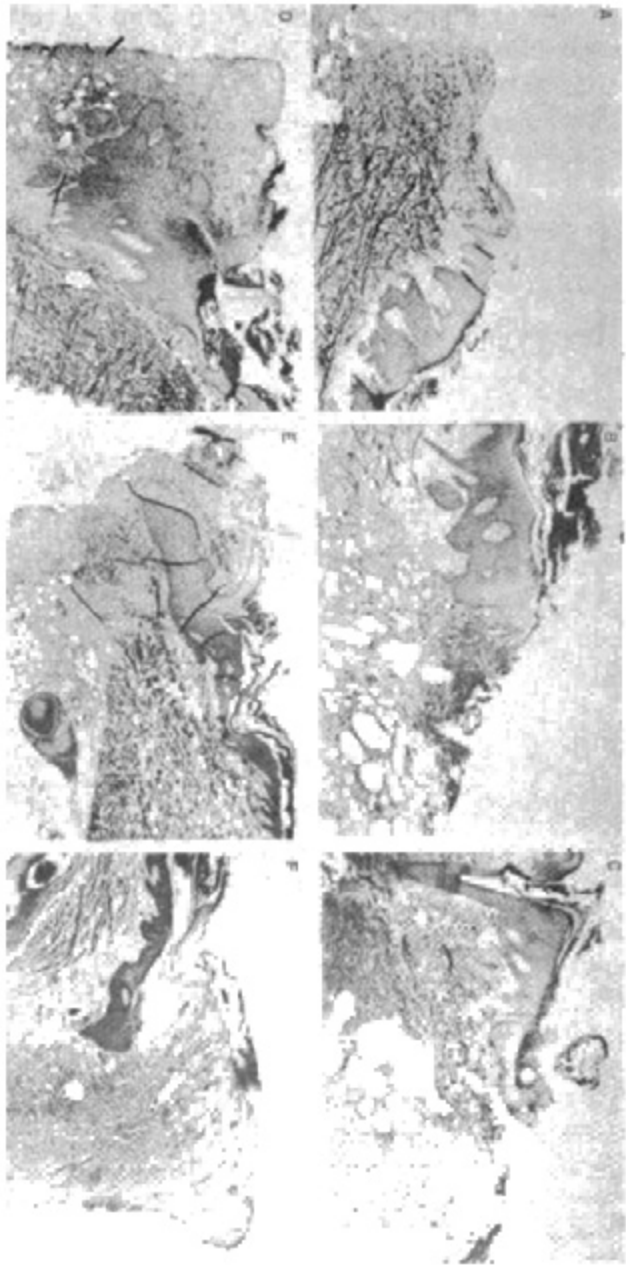


Fig. 2. Rechargeable Low Intensity Direct Current generator shown in position for daily 4 hour treatment.

photographs of the wounds showed complete granulation of the wound within one week, which was verified by the microscopic examination of the biopsy specimens. The histologic examination showed granulation down through the dermis and marked proliferation of stratified squamous epithelium deep in the granulation tissue. As healing progressed over the weeks epithelium regenerated and covered the wound within 21 days (Fig. 5). Again, the pH of the wounds did not vary significantly and ranged from 6.6 to 7.8.

In both phases of the experiment, cultures were taken of each of the wounds. In 80% of the wounds, proteus was isolated as a superficial infection. *Aerobacter*, *Staphylococcus*



and *Flavobacterium* were also isolated. No deep infection was seen in any of the wounds.

DISCUSSION

This experiment differed from others (7) in that microamperage and polarity were maintained until healing oc-

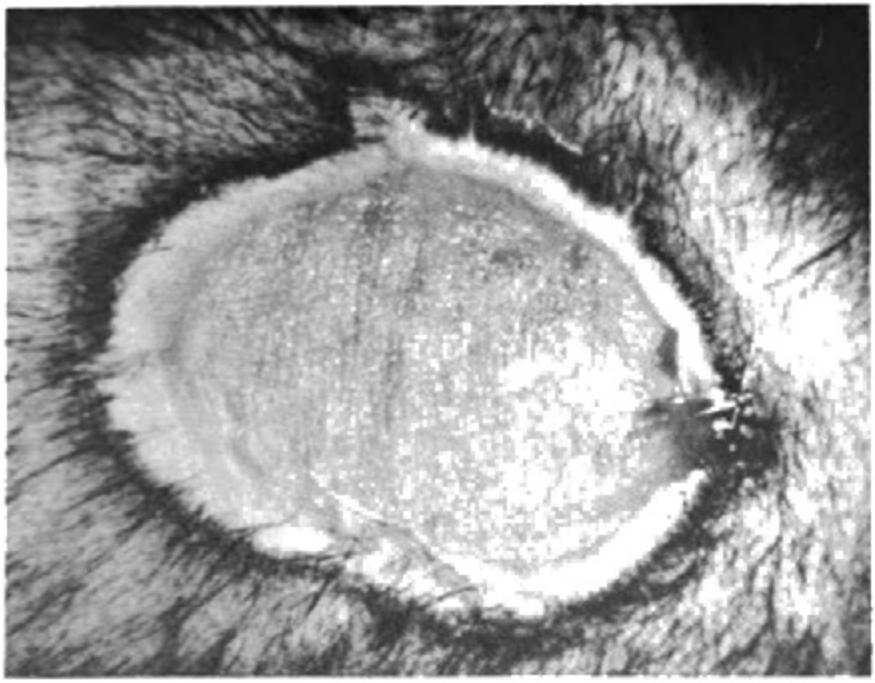


Fig. 4. Typical healing 21 days post burn — eschar not removed.

curred, rather than changing each during the course of treatment. This was done to avoid variables, however, it is possible that another current level or alternating polarity may have given a different response.

Fig. 3. Photomicrographs of typical normal-skin boundary biopsies taken two weeks post burn. (25X, Hematoxylin & Eosin Stain)

a. Eschar group — positive treatment. b. Eschar group — control. c. Eschar group — negative treatment. d. Escharectomy group — positive treatment. e. Escharectomy group — control.

The failure of bioelectric therapy to hasten normal rates of healing has been observed by others (4). To accelerate healing beyond an optimum rate may be unattainable, as compared to stimulating an ischemic, refractory lesion as seen in decubitii. Conversely, LIDC did not delay the normal heal-

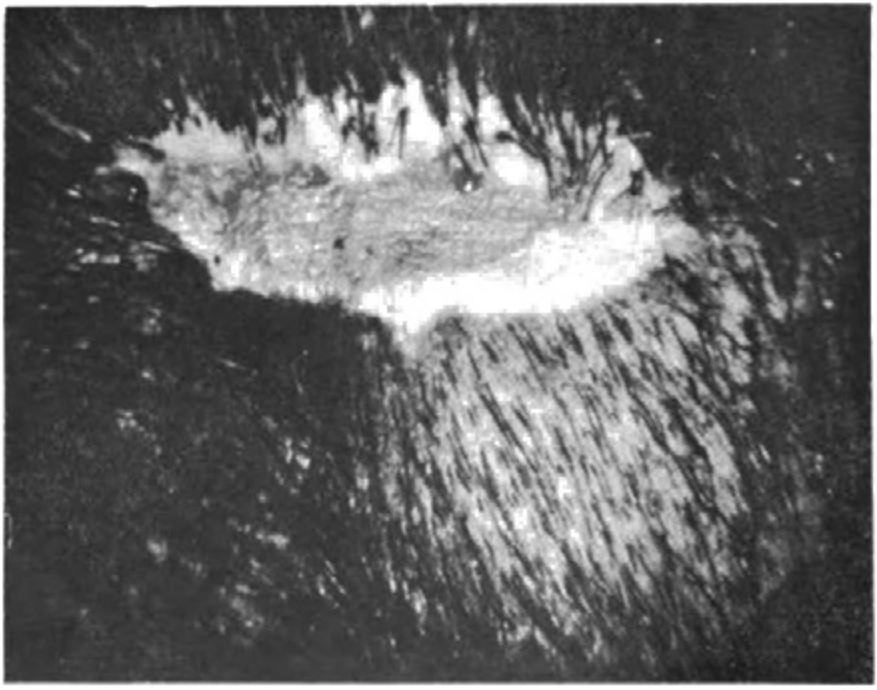


Fig. 5. Typical healing 21 days post burn — eschar removed 24 hours post burn.

ing process. Bioelectric therapy may hold promise in the control of wound infections (6).

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