

RESEARCH ARTICLES

THE EFFECT OF ELECTRICAL DERMAL STIMULATION ON ISCHEMIC SKIN FLAP NECROSIS IN GUINEA PIGS

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SUMMARY :

Purpose : Reconstruction plays an important role in surgery. Ischemia is a troublesome point of flaps used in reconstruction. For preventing ischemia in skin flaps, we investigated the possible effects and technical details of electrical dermal stimulation. **Methods :** Sixty female guinea pigs were included in the study. A standard posterior neck myocutaneous flap (2 cm wide, 7 cm length) were prepared and sutured in same position in all groups. In group A, 20 animals served as control. There were 10 animals in Group B, and xylol was applied topically on the base of the flap for five days after surgery. In Group C, bipolar, high density (20 mA), high frequency electrical current was applied to 20 animals to the base of the flap for five days after surgery. In Group D, the electrical current was applied to the underside of the skin flaps in 10 animals for five days after surgery. **Results :** The percentage survival of the skin flaps in Group C was significantly better than the control and other groups ($p < 0.0001$). The mean percentages of viable flap surfaces of the groups were : Group A 37.8 %, Group B 33.4 %, Group C 65.1 %, Group D 50.2 %. **Conclusion :** Bipolar electrical stimulation of ischemic skin flaps increases the survival possibly by vasodilation and preventing the release of oxygen-free radicals.

Key Words: Ischemia, Skin Flap, Electrical Stimulation.

INTRODUCTION

Random skin flaps play an important role in reconstructive surgery, but flap necrosis limits their application. Ischemia due to vasoconstriction and oxygen-free radicals causes necrosis in skin flaps (1-3). For increasing the survival of the ischemic skin flaps, direct electrical stimulation, vasodilator agents, and oxygen-free radical scavengers have been used in animal models. TENS (Transcutaneous electrical nerve stimulation) increases survival in the dorsal musculocutaneous flaps in rats. It was suggested that TENS activates larger diameter sensory nerve fibers which may inhibit activity in

sympathetic vasoconstrictor neurons, and activates small to medium size sensory neurons to release vasodilator neurotransmitters (2). There is another suggestion about flap necrosis that oxygen-free radicals are the immediate cause of cell death by initiating a chain reaction (3). Depending upon the suggestion that external application of electrical current causes a decrease in tissue oxygen tension and production of oxygen-free radicals, electrical current was applied to ischemic skin flaps, and it was shown that there was an improved survival in flaps (1). Direct electrical current was used to improve the viability of ischemic musculocutaneous flaps in

guinea pigs in this study.

MATERIALS AND METHODS

At least three months old, female guinea pigs were used in the study. The mean weight was 490 g (410-540) for 60 animals. The guinea pigs were anaesthetized with ketamine hydrochloride (50 mg/kg im) and xylazine (0.2 mg/kg im). After shaving the back of the animal, a standard flap (2 cm wide and 7 cm long) was raised including underlying muscles, superficial fascia, subcutaneous tissue, and skin. The flap was then sutured in its original position. In the control group (Group A), 20 animals were observed for five days after surgery (Table 1). For Group B, 10 animals were treated with topical xylol application. Xylol was used for its local effect of vasodilation. After an hour from surgery, xylol was applied to the base of the skin flap for a period of 1 hour. This application was repeated every day for five days. In Group C, direct electrical current applied. The application was started after an hour from surgery and repeated for five days at the base of the flap for an hour. Twenty guinea pigs received bipolar, square wave pulses of 0.2 ms duration in a high intensity (20mA) and high frequency (80Hz) electrical current. The electrical current source could create direct electric stimulation in different intensity and frequency. Also, the shape and the duration of pulses could be controlled. Electric wires which had diameters smaller than 0.5 mm were used for stimulation, and these wires were implanted to base of the flaps with the help of adhesive bands. In Group D, there were 10 animals who received electrical current as Group C. But the current was applied to the underside of the skin flap by wires that were implanted under the base of flap in the operation. In all applications, animals were anaesthetized for an hour. The percentage survival of the flaps was measured in a blinded manner after five days from surgery. For

Group A :	Control
Group B :	Xylol was applied to the base of the skin flap for a period of 1 hour for five days
Group C :	Direct electric current was applied to the base of the skin flap for an hour for five days (0.2msec, 20mA, 80Hz)
Group D :	Direct electric current were applied to the underside of skin flap for an hour for five days (0.2msec, 20mA, 80Hz)

Table - 1 : The study groups.

statistical analyses of flap survival between groups, chi-square test used.

RESULTS

In the control group, the percentage of viable flap area ranged between 16.4 % to 74.1 %. The mean percentage was 37.8 % (Fig. 1). In Group B, the flap survival percentages were between 12.8 % and 49.2 % with a mean of 33.4 %. In Group C, the survival percentages ranged between 37.8 % to 97.1 %. The mean percentage was 65.1. For Group D, the percentages of viable flap area were between 12.8 % - 87.8 %, with a mean of 50.2. Statistical analyses with chi-square test revealed that there is a significant difference between Group C and the control group ($p < 0.001$). Other applications failed to create significant differences in flap survival.

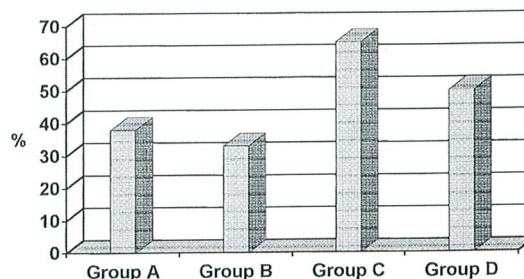


Fig. 1 : The mean percentage of viable skin flaps in groups.

DISCUSSION

In several clinical studies, it has been shown that electrical stimulation and different modes of peripheral stimulation may increase peripheral blood flow. Therefore, electrical stimulation was used to increase the flap viability of ischemic skin flaps in animal studies. Kjartansson and colleagues found a significant difference between ischemic flaps non-treated or treated with electrical stimulation in rats (2). They used high intensity and high frequency electrical currents in their study. Their suggestion was that TENS inhibits the sympathetic activity and causes the release vasodilatory neurotransmitters. This suggestion depended on the effect of electrical current in peripheral nerve fibers. This is not the

only effect of electrical stimulation on skin; galvanotaxic effects, stimulatory effects in cells, antibacterial effects, increased epithelization, neutralized superoxide anions and/or increased blood flow have been demonstrated in many clinical studies (1, 4-10). All these effects are related to skin surface electronegativity. The skin has electrical potentials across it and it acts like a battery (5). Therefore, a current can flow between parts of the skin if the circuit is completed. This electronegativity with respect to deeper skin layers is important to explain the results of Group D. The electrical current which was applied under the skin flap did change the electronegativity of skin layers as applied on the skin.

Vasoconstriction in the distal part of the flap causes necrosis. For preventing cell death, vasodilatory agents have been used in animal studies. Low doses of calcium channel blockers have been shown to decrease systemic vascular resistance by smooth-muscle relaxation and reduce ischemic cell injury (11-13). β -adrenoreceptor antagonists were also used after surgery to inhibit β -adrenoreceptor stimulated metabolism (14). These systemic agents may have systemic side effects. So, we used a topical vasodilatory agent for determining the effect on ischemic flap survival. Xylol did not provide any significant changes in flap survival. Macroscopically, it was seen that there were hyperemia and edema at the base of the flaps. It was thought that this peripheral venous dilatation did not increase blood flow, but caused edema formation.

Although not investigated in this study, oxygen-free radicals are believed to be the immediate causes of cell death in ischemic skin flaps. Prolonged ischemia followed by reperfusion causes microvascular occlusion, extravasation of intravascular fluid, and tissue necrosis (1, 3, 15, 16). Oxygen-free radicals have been shown to have an important role in such processes (1, 3, 15-19). For blocking the consequences of ischemia before necrosis, superoxide dismutase or electrical stimulation was used in clinical studies (1, 3, 15). It was suggested that external application of direct electrical current causes a decrease in tissue oxygen tension, and the production of oxygen-free radicals is decreased in the presence of low tissue pO_2 (1). Theoretically, positive electrode stimulation can neutralize superoxide anions by the flow of protons, and treatment with positive electrode stimulation may prevent oxygen-free radical mediated tissue damage (1). It was shown that negative electrical

current blocks sympathetic vasoconstriction (1, 10). Depending on these suggestions, we used bipolar electrical current at the base of ischemic skin flap.

Our results suggest that electrical currents may play an important role in the healing of ischemic skin flaps possibly by blocking vasoconstrictory mechanisms and by preventing free radical-dependent chain reactions.

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