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RESEARCH ARTICLE

Influence of Electroacupuncture on Thermal Changes in a Soft Tissue Defect

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Abstract
This study investigated thermal changes in the skin at locations where soft tissue defects existed and acupuncture needles stimulated by using bipolar electroacupuncture (EA) had been inserted. Under general anesthesia (GA), experimental defects were made at the dorsum site of five New Zealand rabbits. Bipolar EA was used for 20 minutes to stimulate the experimental defects, and the skin temperature was monitored at the sites where the acupuncture needles had been inserted and the soft tissue defects existed. The initial thermography of those defects had the same trend as that of the negative pole of EA stimulation at the first acupoint. Skin thermography during the first 3 minutes of bipolar EA indicated a centrifugal vasoconstriction and a vasodilatation at the negative and positive poles, respectively. After that, the thermal change in soft tissue undergoing EA stimulation was not modified by a different EA polarity. The local temperature at the defect and its surroundings under both positive and negative electric loads was increased by 0.2–0.3 °C for vasodilatation. This study indicates that EA influences sympathetic modulation of soft tissue defects and that selective sympathetic modulation caused by bipolar EA is responsible for the clinical perception.

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1. Introduction

Use of electroacupuncture (EA) during the soft tissue healing process aims to provide an electrical stimulus to tissues in order to speed up the regeneration of cells in the wound. Some studies have illustrated an bioelectric activity at the border of the experimental incisions which may primarily subserve wound healing [1], and the idea of using an external electric source (EA) has been proposed to demonstrate temperature changes at the level of the EA stimulus and to correlate the changes in temperature with the bipolar output (minus and plus), as well as with the thermal changes at the level of the wound.

As the skin is an organ of the body with a large area where heat exchange with the external environment occurs, the thermal behavior of a wound, as well as the neighboring intact tissues undergoing EA, is a subject on which a lack of knowledge exists in medicine. Correlation of thermal changes with electrical loads provided by EA provides information about selective electrical changes at the level of the stimulated tissues. Comparing the measurements of the temperature at locations on the skin's surface undergoing EA with those at the locations of tissue defects should offer new information concerning both the neurovascular activity in the process of skin homeostasis and the temperature feedback due to the external stimulus. Thus, the aim of this study was to investigate the reaction of the autonomic system of a soft tissue defect undergoing bipolar EA in order to obtain more information about the influence of the external stimulus on the healing process, which is an important aspect of clinical therapy.

2. Materials and methods

This study was performed according to the guidelines on the use of living animals in scientific investigations. All experiments were approved by the Ethical Committee of the University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania (No. 10473/24.07.2012).

The experiments were conducted using five 2-year-old New Zealand white rabbits (Micro-farm rabbits, Mr. Petru Pestean, Cluj-Napoca, Romania), weighing between 2.5 kg and 2.8 kg. The use of rabbits ensured a large skin area for the placements of both the acupuncture needles with a deep insertion (2-cm depth) and the electrodes to monitor the physical parameters. Also, the results obtained in the rabbits can be extrapolated to other species (e.g., horses). In rabbits, we managed the formation of homogenous groups by genetic origin, age, weight, etc. In the initial experimental research, involving thermographic changes in the vicinities of the acupuncture needles and above the tissue defects, only five rabbits were used.

The electronic devices included an Infinity Delta monitor (Draeger Medical Systems, Inc., Telford, USA), an AWQ-104E multi-purpose electronic acupunctoscope (T.E.N.S.) (TENS PLUS IND. CO., Kln., Hong Kong), and a digital non-contact infrared thermometer (Shenzhen VCare Technology Co., Ltd., Guangdong, China). Other materials included Natural 0.2/25-mm acupuncture needles (Shanghai Xinhua E-General Merchandise Co., Ltd, Shanghai, China) and a 4-mm Φ biopsy instrument (Integra Miltex, Plainsboro, USA).

The experimental plan was designed to ensure that the rabbit was under general analgesia (GA) while three consecutive soft tissue defects (skin and muscle) with a large and plain enough area were formed on the surface of the rabbit's body without involving large blood vessels. In addition, the plan provided for a bipolar EA stimulus to be administered at the site of the tissue defects, the skin temperature at the base of the acupuncture needles and above the tissue defects to be monitored, the internal temperature and other clinical observations to be recorded, and the skin area surrounding the needles of the negative and positive poles to be monitored to establish the temperature and the temperature changes during EA.

GA was carried out using neuroleptanalgesia (NLA), 50-mg/kg ketamine administered intramuscularly (i.m.), and 5-mg/kg xylazine (i.m.). The rabbits were positioned in sternoabdominal recumbency to highlight the dorsum area of the thorax, which had been prepared by using local trimming and asepsis. During the surgical procedure, the rabbits' bodies were not warmed externally so as not to induce artifacts in the thermal behaviors of the skin layer and the muscles.

The experimental defects in the soft tissue were formed by using a biopsy instrument to cut a round fragment of skin and muscle tissue (4-mm diameter, 5-mm depth). The topographies of the soft tissue defects were established paravertebrally (1.5 cm to the midline) on the dorsal thoracic area between T1 and T8. The imaginary line through the needles inserted at the three defects was parallel with the midline. Soon after the defects had been formed, all defects were flanked by two acupuncture needles, which were inserted 1 cm from the border of the lesion perpendicularly to a depth of 2 cm (Fig. 1).

Acupuncture needles were connected via conducting wires to an electroacupuncture device (AWQ-104E T.E.N.S.). EA stimulation of the tissue lasted for 20 minutes; in the first 10 minutes, the direction of the stimulus was set to "minus," and in the second 10 minutes, it was switched to "plus." The frequency of the EA was 80 Hz, and the intensity was 2.0 V. The main reason for choosing a high frequency (80 Hz) was to induce a local sedation [2]. At a high frequency, EA can induce local sedation, which is commonly used in surgical analgesia [3] or the treatment of painful conditions in animals [4]. By adjusting the frequency of the EA machine, a dense or disperse wave could be formed. Skin temperatures were monitored by using a digital non-contact infrared thermometer to measure the thermal changes at the surface of the skin in contact with

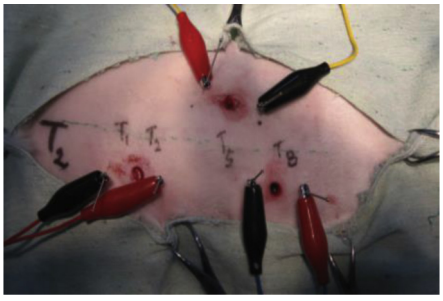

Figure 1 Local stimulation of soft tissue defects by using bipolar electroacupuncture.