Wireless Micro-current Stimulation WMcS

A new technique in Electrical Stimulation in Wounds Healing

By

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Abstract

Micro-current stimulation and its effect on the human body has been researched and reported since the early 1990’s. Its application for the healing of wounds is also well documented.

The skin possesses an electrical field, and the presence of a wound disrupts this electrical field. Electrical Stimulation is believed to mimic the current and then improve the wound healing process. ES may help this effect to happen through a stimulation of cell activities, improvement of arterial blood flow, reducing tissue oedema and improving microvascular permeability, but the exact mechanisms are still unclear.

To date the current has been introduced to the body by the use of electrodes, but a new method is now available which utilises the current carrying capacity of charged gas ions by using the ability of Oxygen and Nitrogen to donate electrons. This method is known as Wireless Micro-current Stimulation (WMcS).

The purpose of this paper is to show the mechanism of current production and how it is applied, to illustrate that WMcS is a true micro-current stimulation.

It also compares the affectivity of WMcS versus electrode micro-current by means of an in-vitro experiment on Mast Cells.

Introduction

Electrical stimulation in wound healing is defined as the use of an electrical current to transfer energy to a wound. The ordinary way in practising ES it to transfer the current through an applied surface electrode pad that is in wet, electrolytic, contact with the external skin surface and the wound bed. Two electrodes are required to complete the electric circuit.10

There are several theories as to how ES may stimulate wound healing. When wounding occurs, there is a weak but measurable current between the skin and inner tissues called the current of injury. It is thought that the current continues until the skin defect is repaired and that the healing process is interrupted if the current ceases. ES may mimic the current of injury restarting or accelerating the wound healing process.4

Electrical currents are believed to stimulate several cell activities e.g., deoxyribonucleic acid [DNA] synthesis, cell proliferation, synthesis of the extracellular matrix, collagen, expression of growth factors and receptors.11

Cell membranes possess a membrane potential, which is the electrical potential difference or voltage across the membrane. Cells within intact skin are negatively charged on the inside whereas the exterior of the cell, the extracellular space, is positively charged.

The difference in charge arises because cell membranes posses “pumps” that move sodium ions out of the cell in exchange for potassium ions, which are pumped into the cell. For the skin this results in the epidermis being negatively charged relative to the deeper tissues that carry a positive charge.8
Electrical currents are believed to stimulate several cell activities e.g.,
deoxyribonucleic acid [DNA] synthesis, cell proliferation, synthesis of the
extracellular matrix, collagen, expression of growth factors and
receptors\(^1\).

Electrical stimulation is defined as the use of an electrical current to
transfer energy to a wound. Two electrodes are required to complete the
electric circuit. Electrodes are usually placed over wet conductive medium,
in the wound bed and on the skin a distance away from the wound\(^10\).

However, optimal delivery techniques for ES therapy have not been
established to date. A study of stimulation current effects on wound
healing in a pig model has shown that direct current (DC) stimulation is
most effective in wound area reduction\(^3\).

**An optimal delivery technique**

An optimal delivery technique transferring a charge through the air to the
wound without touching the wound or the surrounding skin, resulting in
the current of injury measurable by an amp metre can be achieved by
using the ability for Nitrogen and Oxygen to donate electrons.

Such a method, named Wireless Micro-current Stimulation WMcS, will be
demonstrated in this article.

**Glossary and technical concepts in this article**

**Electric current**\(^1\) is defined as the flow of electric charge. The SI unit of
electric current is the ampere (A), which is equal to a flow of one coulomb
of charge per second.

An **electrometer**\(^1\) is an electrical instrument for measuring electrical
charge or electrical potential difference.

**Electropositivity**\(^1\) describes an element's ability to donate electrons.

**Electric charge**\(^1\) is a fundamental conserved property of some subatomic
particles, which determines their electromagnetic interaction. Electrically
charged matter is influenced by, and produces, electromagnetic fields.

The interaction between a moving charge and an electromagnetic field is
the source of the electromagnetic force, which is one of the four
fundamental forces. Electric charge is a characteristic of some subatomic
particles, and is quantized when expressed as a multiple of the so-called
elementary charge e. electrons (a fundamental subatomic particle that
carries a negative electric charge, by convention have a charge of -1,) while
protons is a subatomic particle with an electric charge of one positive
fundamental unit (1.602 × 10\(^{-19}\) coulomb), and has the opposite charge
of +1.

A subatomic particle\(^12\) is an elementary or composite particle smaller than
an atom.

The **electromagnetic field**\(^1\) is a physical field produced by electrically
charged objects. It affects the behaviour of charged objects in the vicinity
of the field.

**Electromagnetic force**\(^1\) is the force that the electromagnetic field exerts on
electrically charged particles. It is the electromagnetic force that holds
electrons and protons together in atoms, and which hold atoms together to
make molecules.
The amount of electric current\(^1\) (measured in amperes) through some surface, e.g., a section through a copper conductor, is defined as the amount of electric charge (measured in coulombs) flowing through that surface over time. If \(Q\) is the amount of charge that passed through the surface in the time \(t\), then the average current \(I\) is:

\[
I = \frac{Q}{t}
\]

The coulomb\(^1\) (symbol: C) is the SI unit of electrical charge. It is named after Charles-Augustin de Coulomb. 1 coulomb is the amount of electric charge transported by a current of 1 ampere in 1 second.

\[
1\text{C} = 1\text{A} \times 1\text{s}
\]

Electrons\(^1\) have an electric charge of \(\approx 1.6021766 \times 10^{-19}\) coulomb. The common electron symbol is \(\text{e}^-\).

Atmospheric air\(^{(1,2)}\) consist of almost 80% Nitrogen and 20% Oxygen and because of the property of nitrogen being electropositive and oxygen being electronegative, some of these molecules may receive ionization energy, either from a colliding particle or from a quantum of electromagnetic radiation energy, necessary enough to create air-ions with opposite polarity.

Natural air ions are, in the lower atmosphere, predominantly produced by radiation from radioactive materials in the soil, in building materials and first of all in the air. Although all three types (alpha, beta and gamma radiation) can ionize the air, in practice only alpha radiation needs to be considered\(^1\).

An air ion is formed, when a neutral nitrogen molecule loose an electron and is left as a singly charged positive elementary ion. Within less than a microsecond the electron will combine with (usually) another neutral molecule, normally oxygen, forming a singly charged negative elementary ion.

Both polarities of elementary ions will, within a fraction of a second, by polarization bind a number of 10-20 molecules (water, nitrogen oxides and others) round itself forming a molecular cluster. When we talk about ions, we are usually only referring to these small ions.

If the air is exposed to an electric field the ions (caused by the natural radiation) will move in the field and collide with (neutral) molecules after travelling the mean path, characteristic for the ions. One might expect this to cause ionization in the same manner as with collisions between alpha particles and molecules. The energy of the ions at the end of the mean free path is, however, not even at very high field strengths, high enough to knock off an electron.

The electrons freed by the natural radioactive ionization, will of course also move under the action of the field, and although they, over the same distance, receive the same energy as any other particle carrying a single elementary charge, the mean free path is so much longer for an electron, that it, when exposed to an electric field of about \(3 \times 10^5\) Vm\(^{-1}\), is able to ionize molecules of the air.
The electron being knocked off the molecule will also be accelerated and ionize and so on in the whole region until it reach the point where the field strength exceeds the critical so-called break down field strength. This technology is able to produce a large number of charged particles, depending of the potential in the technical system

**The WMcS technology**

A method which transfers e.g. a negative air born current into a wound by the use of oxygen’s ability of donate electron, requires technical accelerator equipment with such a specified voltages potential, that the break down field strength is exceed in a region of some mm from the accelerator.

In this region we then have so-called corona discharge where $N_2^+$ and $O_2^-$ are formed and separated by the electrical field. If the voltage of the equipment is negative the positive Nitrogen molecules $N_2^+$ will move to the equipment and become neutralized here while the negative Oxygen molecules $O_2^-$ will be repelled and move away from the equipment in the field created between the equipment and the target (patient).

Oxygen $O_2^-$ is very unstable, but stable enough in the short term to be moved in the electric field and neutralised by the so called plateout effect, on the surface of e.g. the skin of the patient, where $O_2^-$ will be separated to a normal uncharged $O_2$ and a released charge of $e^-$ with a voltage of $-1.6021765 \times 10^{-19}$ coulomb

By using equipment based on WMcS technology, the practitioner will be in total control.

The patient being treated has to be connected within an electrically complete system with the equipment. This is achieved by using straps connected to intact skin, a distance away from the wounds. This will enable the precise control of the current measured in $\mu$A.

The equipment to be used in WMcS technology is able to produce such a specific number of e.g. Oxygen $O_2^-$ molecules that the target to be treated, will be covered with charged particles realising a micro-current into the wound of between one and three micro amps, so that a current of injury is generated.
Let us assume that the optimal treatment is the transference of a minus current of 2µA through the area of a wound per second. The control system in the equipment will then be set to 2µA for 60 minutes. The electrical charge can then be measured in coulomb (C) to be \( A \times t = C \) or \( 60^2 \times 2 = 7200 \mu\text{C} \).

**The mast cell trial**

In order to investigate if ES have any influence on cell activity and if so, if there then are any difference between the use of electrodes and the use of WMcS the following trials was established on mast cells.

Mast cells can be isolated, and have for many years successfully been used to investigate cellular changes taking place during the secretory process.

By use of a chemically manufactured secretory substance, e.g. Compound 48/80, the process which takes place in the body when mast cells secrete histamine can be simulated. Then we can investigate the relation between the mode of treatment and the production of histamine.

**Example 1**

Using the set-up system as shown in Fig. 1, it is thus possible to measure the result of providing an electrical current between electrodes 2 and 3 through the mast cell containing liquid in container 1. A set-up system like this is the optimal delivery system using electrodes. The current will flow in essentially direct lines from the entire upper surface of the fluid to the bottom electrode 3. Such an optimal system would not be possible to use in a human or animal treatment.

![Fig. 1](image-url)

With the first series of experiments, the fluid in the insulating container was a cell suspension containing mast cells. The purpose of these experiments was to determine if mast cells react to ES.

After a current had been sent through the suspension at a time interval varying from experiment to experiment, compound 48/80 was added in various concentrations, and the reactions of the mast cells in terms of histamine secretion were studied.

There was no doubt that the reaction of the mast cells depended on the current treatment, but the results were rather variable.
If, for instance, an experiment was repeated the following day with the same current intensity in the same time interval, the reaction of the mast cells was sometimes very different, and a positive reaction might even be replaced by an overreaction.

Such results are obviously not easy to interpret, but they suggest that the properties of the mast cells vary from time to time.

We now developed the theory that the treatment with ES directly on a fluid containing cells primarily is too powerful, and that the effect observed on the cells was caused by a subsequent interaction between the cell fluid and the cells.

In order to find out whether this was the case, a series of experiments was carried out with a cell fluid without mast cells.

With this treatment, currents of positive as well as negative charge were passed through the fluid samples for a period of one hour, using the set-up shown in Fig. 1. The same (numeric) current intensity was used for all experiments. After the exposure to current, mast cells were added to the samples treated as well as to untreated samples.

After a period of 30 minutes, compound 48/80 was added to concentrations of 0.1, 0.2 and 0.3 µg/ml.

The results show that the production of histamine increases dramatically with the concentration of compound 48/80, but also that it is possible to reduce the production of histamine considerably by treating the cell fluid with Electrical Stimulation but that it seems to be difficult to do it directly on a suspension containing cells, even by using a current at 1.5 µA.
Example 2
To investigate if using WMcS technology would give a similar result, a system for delivering ionized gas molecules to a mast cell suspension is shown in Fig. 3.

In this figure, 1 is the target to be treated, 3 is the bottom electrode, over the target is the WMcS transmitting device, and between the bottom electrode and the WMcS transmitting device is an amp meter.

This set-up system is eagle to a set-up system if a human or animal should be treated. If the WMcS unit is placed in a distance from the target to be treated equal to the radius of the target e.g. a wound, the field strength at the centre of the wound is greater than at the perimeter of the wound. This means that the current densities will vary in a similar way, and that the density of the energy dissipated will be greater in the middle than at the perimeter.

The purpose of these experiments was to see if mast cells react to treatment with ionized gas molecules in comparison to Example 1 where electrode was in use.

Both $\text{N}_2^+$ and $\text{O}_2^-$ was dispensed over the suspension at a time interval varying from experiment to experiment, compound 48/80 was added to various concentrations, and the reactions of the mast cells in terms of histamine secretion were studied.

With the first series of experiments, the fluid in the insulating container was a cell suspension containing mast cells.

There was no doubt that the reaction of the mast cells depended on the current treatment, but the results were again rather variable.

If, for instance, an experiment was repeated the following day with the same current intensity in the same time interval, the reaction of the mast cells was sometimes very different, and a positive reaction might even be replaced by an overreaction.
Such results are obviously not easy to interpret, but they suggest that the properties of the mast cells vary from time to time.

We used our theory that the treatment with gas ions as well as the one with ES directly (as in Example 1) on a fluid containing cells primarily is too powerful, and that the effect observed on the cells was caused by a subsequent interaction between the cell fluid and the cells.

In order to find out whether this also was the case in this set-up system, a series of experiments was carried out with a cell fluid without mast cells.

With this treatment, currents of $\text{N}_2^+$ as well as $\text{O}_2^-$ were deliver to the fluid samples for a period of one hour, using the set-up shown in Fig. 3. The same (numeric) current intensity was used for all experiments. After the exposure to $\text{N}_2^+$ and $\text{O}_2^-$ current, mast cells were added to the samples treated as well as to untreated samples.

After a period of 30 minutes, compound 48/80 was added to concentrations of 0.1, 0.2 and 0.3 µg/ml.

The result is shown in the graph in fig 4.

![Fig. 4](image)

The results show that the production of histamine increases dramatically with the concentration of compound 48/80, but also that it is possible to reduce the production of histamine considerably by treating the cell fluid with WMcS technology.
The purpose of this experiments was to show if WMcS could replace the use of electrode in ES stimulation. The result shows that this could be possible and the experiment even indicates that the use of WMcS technology might give a better result. The set-up system in the first example using plate electrodes is in the authors point of view the best set-up system when using electrode, but a system like this is not possible to be taken in use when treating a human or an animal.

In comparison with what is possible in human or animal treatment, two needle electrodes should have been in use instead of the two plate electrodes. The field strength would in such a set-up system been centred between the two needle electrodes which means that the current densities and the density of energy would be most in the area between the two needle electrode.

If such a needle electrode set-up system was been in use in example 1 we would properly have seen a weaker result against the WMcS example 2 that the credibility of the trial would have been disputed.

**Conclusion**

The use of non-invasive WMcS technology could show the way to a new method in ES. The WMcS technology is easy to handle, non traumatic, painless and with no risk of infection. Preliminary results are promising for the initiation of wound healing and no side effects have been found. A randomised study is planned.

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