Neurophysiological foundations of organ electrodermal diagnostics, acupuncture, TENS and other reflexive therapies

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Summary
The nervous system is the primary computing system of the human body. The sensory nervous system detects any damage done to the body from both outside and inside and sends the information, at the earliest stage of pathology, to the central nervous system (CNS), which controls potent self-defense mechanisms. The CNS cannot simultaneously process all available information, originating internally and externally, due to limited capacity. The necessity to eliminate information which is less important at the time, created the specific converging structure of the sensory nervous system. Due to this structure, signals sent from internal organs to the CNS can also reach certain skin areas influencing their electrical characteristics. In this way organ electrodermal diagnostics (OED) may get access to this 'first hand' source of diagnostic information. The CNS gives higher priority to signals resulting from external stimuli (skin) than to messages coming from internal organs: information coming from sensory organs is generally more important for the organism's self-defense and survival. This is why signals generated by internal organs can be blocked by even mild stimulation of the relevant skin areas. 'Convergence modulation theory' is introduced, which proposes that acupuncture and other reflexive therapies function by controlling the flow of information in the nervous system and thereby reprogramming the powerful self-defense systems according to actual needs.

Key words: *Nervous system, skin impedance, electrical rectification, electroporation, breakthrough effect, convergence modulation theory*

Introduction

There is a lot of controversy surrounding the so-called reflexive therapies i.e. therapies in which the skin is stimulated in order to obtain specific medical benefits, not related to the skin itself. These include acupuncture, acupressure, analgesic electrostimulation (TENS), laser therapy, magnet therapy, reflexive thermotherapy ('moxa', cryotherapy) and 'reflexology' (reflexive massage of feet). Shortwave and microwave diathermia as well as ultrasound therapy are not usually categorized as reflexive therapies. However, the reflexive mechanism may also be the leading therapeutic mechanism in these methods, since they are known to stimulate free nerve endings through superficial heating.[1] Of particular interest is pulsed magnetic field therapy with modification 'microTesla magnetic fields' / 'magnet stimulation', which is still effective despite transmitting very low energy levels to the body tissues.[1] All methods of reflexive therapy, irrespective of the nature of the stimulus, produce very similar clinical effects: pain relief, improved local blood circulation, reduced inflammation and oedema as well as increased metabolic rate. The majority of reflexive therapies have gained acceptance from mainstream medicine but their modes of action are still not fully elucidated.

Organ electrodermal diagnostics (OED)[2-15] is a new, clinically proven (CE certificate C52113) bioelectronic method of noninvasive medical diagnostics (Fig.1). OED utilizes the elec-

Fig.1 Organ electrodermal diagnostics by means of the "Diagnotronics" device. The measuring electrode (1 mm diameter) is placed on a skin area corresponding to the examined internal organ and the reference electrode (area 4 cm2) is held in the hand.

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trical 'breakthrough effect' of the skin[2-22] to estimate the extent of the rectification / diode phenomenon[2-15] in skin areas corresponding to particular internal organs. Alternatively OED estimates the difference in impedance in these areas. In this way OED identifies diseased organs and estimates the intensity of pathological processes within these organs. The same skin areas are used by reflexive therapies and OED.

Many authors have tried to explain the mechanism of reflexive therapies and many hypotheses exist.[23-41] Some of them are based on scientific research while others are less substantial. However, even the most well known and outstanding theories adopted for this purpose, e.g. Melzack and Wall's 'gate control' theory[42,43] (Zimmermann modification)[44] and the endorphinic theory[25,27,29,30,34-38] show significant drawbacks in this sphere. The 'gate control' mechanism, firstly, may simply lead to self-blocking and secondly, it eliminates superficial dermal pain perception, which is always observed during acupuncture, thermotherapy or electrostimulative procedures. Reflexive therapies, especially those that are more irritating like acupuncture, elevate the beta-endorphin level in blood serum when applied to healthy persons[58], but reduce this level in pain sufferers.[26] Also, the therapeutic specificity of acupuncture points (AP) as well as their utilization for organ diagnostics[2-15] cannot be explained by means of the endorphinic theory.

OED has proven a direct functional connection between the internal organs and the related skin areas. The dependence of AP bioelectrical features on the condition of the corresponding internal organs is now particularly significant, since this phenomenon is not only of diagnostic value but also contains important information concerning the physiological mechanisms which are the basis of both OED and reflexive therapies.

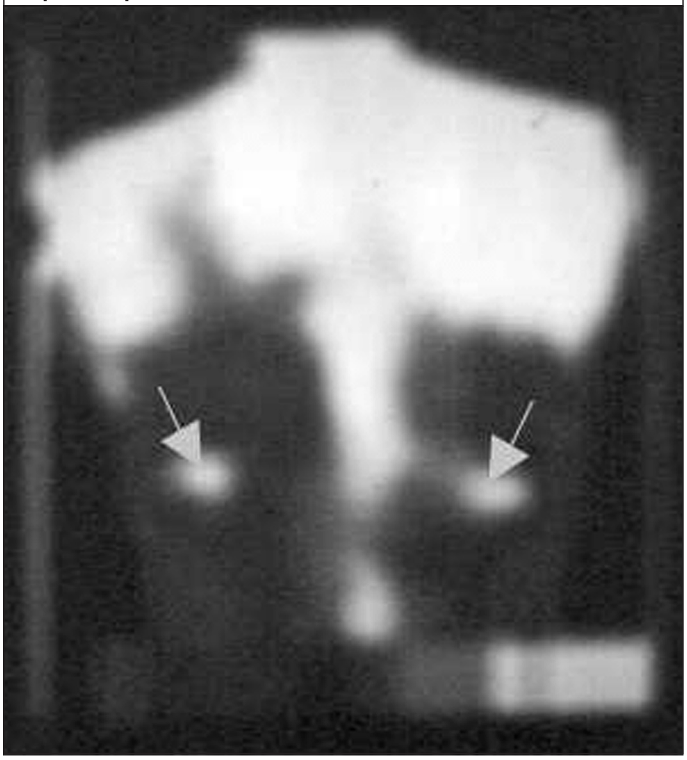
Clinical information

The following facts contribute to an explanation of the mode of action of OED and reflexive therapies:

When an internal organ is diseased, a hypersensitivity is noted at the corresponding dermatomes. So-called trigger points also appear at related skin areas. These points, which still belong to classical AP, distinguish themselves because of their increased tenderness and elevated temperature (Fig.2) compared with the surrounding areas.[45] This is presumably the result of chronic reflexive muscular contraction.

A connection also exists between the state of health of specific internal organs and the electrical characteristics of related, although sometimes remote, skin areas. These skin areas are referred to as organ projection areas and include AP. Pathology of a particular organ causes a related projection area to rectify electrical currents, once the resistance 'breakthrough effect' has been induced in the skin.[2-15] The 'breakthrough effect' is a rapid reversible decrease in skin resistance that takes place under certain electrical stimulation conditions.[2-22] After it occurs, the skin resistance measured by means of a positively polarized point electrode is significantly higher for diseased organs' projection areas, when compared with the resistance for the same but negatively polarized measuring electrode (rectification / diode phenomenon). For healthy organs' projection areas this phenomenon is not observed. The ratio of these two measurements is not affected by the patient's muscular tension, emotional condition, skin hydration, procedure duration, environmental temperature and humidity, or the pressure of the measuring electrode.[2-15] The pathology of an internal organ also increases the impedance of the corresponding projection areas.[4-6,13-15] The location of the skin zone, where a high degree of rectification and increased impedance is observed, indicates which particular organ is diseased. The degree of rectification or difference in impedance indicates the extent of the pathological process within the organ. These findings created the basis for OED.

Fig.2 Thermogram of an upper back pain sufferer (posterior aspect). Upper back muscles and spine display higher temperature (bright region). Two bright 'trigger points' are visible below scapulas at the location of the acupuncture points 'Yishe'.



According to histomorphological investigations, AP are collections of nervous receptors.[30,34,38,46,47] There is also other evidence suggesting the presence of nervous structures within AP – the phenomenon of a sudden decrease in the electrical potential of a needle correctly inserted in an AP.[48]

A needle inserted into an AP stimulates all neighbouring nervous receptors simultaneously, both nociceptive and non-nociceptive e.g. that of palpation, extension, temperature. As a result, information concerning skin irritation is sent via both thick non-nociceptive fibres and thin nociceptive fibres to upper levels of the central nervous system (CNS). However, in the case of AP, stimulation by means of heat, cold, a weak electrical current, low power laser, magnet or massage, only non-nociceptive receptors undergo stimulation. Nevertheless it is well known that such procedures are also therapeutically effective.

A mild irritation of particular skin areas may arrest visceral reflexes and modify nociceptive signals from the damaged organ (vide: experiments with the electro acupuncture blocking of evoked potentials).[31,33,34,38,49,50,51,52] It is remarkable that acupuncture and other reflexive therapies eliminate the pain caused by internal organ pathology while inducing sensations at the stimulated skin zone.

Various methods of reflexive therapy, irrespective of the nature of the stimulus, display a very similar mode of action: relieving pain, improving local blood circulation, reducing inflammation, preventing oedema and increasing the metabolic rate. Improved local blood circulation may contribute to the accelerated healing of damaged tissues and improve conditions such as chronic infection / inflammation or neuropathy.[53,54]

The analgesic effect of local thermotherapy procedures (cryotherapy or heating) depends on both the intensity and the amplitude of the thermal stimulation.[55,56] The most effective electrical current in electro analgesia is that which comprises the most 'irritating' parameters: bipolar impulses with high amplitude and short duration, low frequency and modulation of all parameters.[54,57] Neither perception nor pain thresholds of the skin are changed during these procedures.[55,56]

Reflexive therapies where a constant stimulus is used, such as constant heating or cooling, DC stimulation, static magnetic fields, continuous laser stimulation or classic acupuncture (without needle manipulation) are therapeutically less effective than therapies using the same stimuli in dynamic form, e.g. alternating heating and cooling, AC stimulation, pulsating electromagnetic fields, pulsating laser stimulation or electro acupuncture. Dynamic stimulation, especially with high amplitude and intensity (within safe limits) induces higher frequencies of afferent nervous pulses. The frequency range of these dynamic therapies is generally 1 to 200 Hz, which coincides with the frequency range that is best detectable by dermal receptors. Higher frequencies do not increase nervous activity.

The thalamus and hypothalamus act as a 'transmission station' that induces adequate changes in the hormonal balance in response to changes in the frequency of afferent nervous impulses. Impulse frequency encodes information about the condition of the relevant internal organ (pathology intensity only: no message about the type or the etiology of disease). Therefore, if by means of reflexive therapy some nervous information tracts are blocked, particular hormonal and humoral responses can be expected.[23,26,31,32,34,38,41,58,59]

Diagnostic possibilities based on AP bioelectrical measurements are connected with the sensory and not the autonomic nervous system. OED results obtained by measurement of the AP electrical rectification phenomenon, after the 'breakthrough effect' is achieved, remain unchanged even though cryotherapy (-160°C) procedures were carried out simultaneously in the vicinity of the measuring electrode (unpublished observations). It is well known that cold is a potent factor influencing the autonomic nervous system and thus inducing cutaneous blood vessel contraction. Therefore, if the autonomic system was responsible for the nociceptive information supply from the diseased organ to the corresponding skin area, a sudden application of a cold stimulus should influence OED results. This does not happen.

The CNS cannot process all available information, originating internally and externally, at the same time due to limited capacity. The necessity to eliminate information which is less important at the time, created the specific structure of the sensory nervous system where many lower level fibres converge to a single fibre at a higher level (neural convergence principle)[60,61] (Fig.3). Higher priority is given to signals resulting from external stimuli (skin) than to messages coming from internal organs. Information coming from sensory organs, including the skin, is generally more important for the organism's self-defense and survival.

Nociceptive signals sent from diseased organ to the CNS can also reach related skin areas (antidromic direction), since there is a close dependence of the bioelectrical characteristics of particular skin areas, such as AP, on the actual condition of the corresponding internal organs.[2-15] Therefore nerve tracts, that carry information from damaged internal organs, must be linked with nerve tracts that conduct information from the skin surface receptors. This connection, foreseen by Morley[27,60], is in accordance with the convergence principle of the nervous system.[60,61] The contact point (convergence area) is most probably situated prior to the synapse which links the first and second neuron of the afferent tract from the AP (Fig.4). If the contact point was situated after this synapse, such a phenomenon would not be possible, since synapses are thought to transfer information in one direction only.

Stimulation of sensory nerves has been shown to result in the release of neuropeptides not only at the synapse but also at the innervated epidermal area (Fig.4).[60-64] This results in vasodilatation and increased capillary permeability in the vicinity of stimulated nerve. For example, electrical stimulation of the sensory

Fig.3 Neural convergence principle. Nociceptive signals sent from diseased organ to the CNS can also reach related skin areas (antidromic direction). Signals coming from damaged / stimulated Organ Projection Area (AP) are of higher priority, so a temporary blocking of signals originating from internal organs can occur in the convergence point.

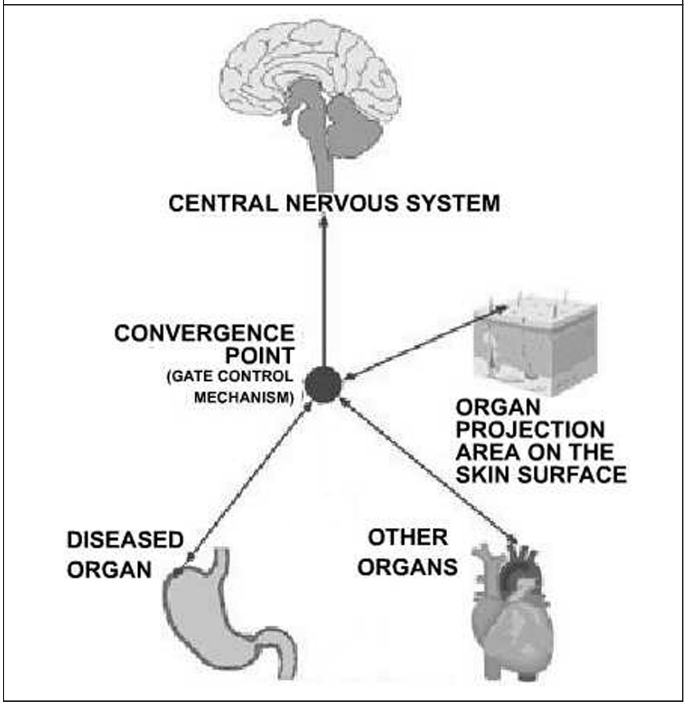
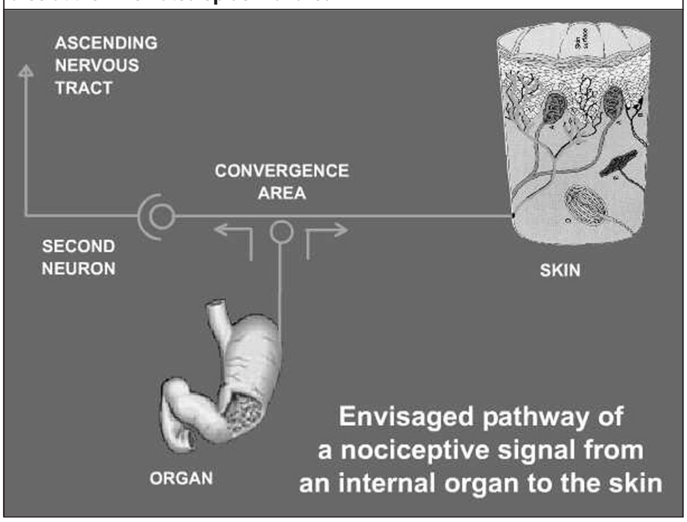


Fig.4 Envisaged pathway of a nociceptive signal from an internal organ to the skin. The release of neuropeptides takes place not only at the synapse but also at the innervated epidermal area.



saphenous nerve of the cat leads to neurogenic oedema formation in the innervated area of the paw.[62]

OED is able to provide reliable diagnostic results even on unconscious patients[9] and fresh corpses.[46] The latter means that the changes in the skin, which are responsible for the appearance of the rectification phenomenon in the case of pathology of corresponding internal organs, are still preserved after death. This implies that these changes are of a morphological rather than functional nature.

Convergence modulation theory

The following hypothesis explains the abovementioned data:

If a specific internal organ indicated in Fig.5 as 'O' underwent damage (e.g. stomach with an acute ulcer), then nociceptive receptors located in its wall commence transmission of information regarding the tissue destruction to the corresponding second neuron 'CN' in the spinal cord. This information is coded in the increment of frequency of afferent impulses. The information is then transmitted to higher levels of the CNS. However, the local visceromotor reflex arc starts to act simultaneously (resulting in a strong tension of abdominal muscles 'M' in this example). In accordance with the convergence principle the nociceptive fibre from the skin 'AP' can be attached to the same second neuron 'CN' as indicated in Fig.5. This type of fibre connection, namely the 'addition' of the fibre arising from an organ to that arising from the skin, before the first synapse of the converging neuron 'CN', allows stimulation of the entire neuron which is transferring information from the skin. This results in the appearance of afferent impulses at corresponding AP. The second neuron 'CN' which is common to both the diseased organ and the related skin area, although able to provide CNS with information regarding pathology, is unable to differentiate whether it is the organ or the skin affected. At the same time however, information concerning changes in the diseased organ (e.g. temperature, tension), is also transmitted along thick non-nociceptive fibres 'QF' arising from the affected organ. This assists the CNS with the above differentiation.

During skin stimulation e.g. by means of needle, heat or cold, laser, magnetic stimulation, massage or electrical current application, the abovementioned physiological mechanism which gives priority to information arising from the skin, is taking place. Thus, a temporary blocking of thin nociceptive fibres from the diseased organ 'O' may occur. This may be due to the action of the hypothetical inhibitive neuron 'IN' described by Melzack and Wall[42], which is thought to be located within a gelatinous substance of the posterior horn of the spinal cord. The neuron 'IN' would then be stimulated by the branch of non-nociceptive fibre 'QF' arising from the stimulated skin area 'AP'. Instead of this hypothetical neuron, an inhibitory synapse may simply function here in a similar manner. AP stimulation does not however exclude dermal sensitivity. Therefore this hypothesis takes into consideration the existence of a second branch of non-nociceptive fibre 'QF' arising from the skin 'AP', which would lead to higher levels of CNS information regarding e.g. skin temperature or pressure. In reality the patient experiences an improvement in pain originating from the diseased organ 'O', while still feeling a low intensity pain caused by AP stimulation. Perception of pressure, temperature or touch originating from both organ and skin are not blocked. This is compatible with the sensations experienced by patients who undergo reflexive therapy. However, the visceromotor reflex arc is halted, as a result of blocking of afferent impulses originating from the diseased organ 'O'. This may lead to muscular relaxation, improved local blood circulation, and sometimes to the total disruption of the 'pain-muscle spasm' vicious circle. In such a case even the cause of complaints could be removed, as it is usually observed e.g. during an electro acupuncture treatment of ureterolithiasis[30,37,38,65], when the stone can easily move down thanks to both pain blockade and the ureteric spasm relaxation. In the case of non-painful conditions e.g. asthmatic bronchospasm, the blockade of afferent impulses originating from bronchi will secondarily result in the spasm relaxation.[23,30,37,38,65,66]

Reflexive therapy controls frequency of afferent impulses reaching the thalamus and hypothalamus, thereby inducing changes in hormonal levels.[23,26,31,32,34,38,41,58,59] Since the leading mechanism of reflexive therapy is synaptic blocking of pain signals, so a reduced level of e.g. beta endorphins will be observed in patients' blood serum after each reflexive treatment.[26] This, although a secondary effect, allows the control of hormonal levels and other self-defense systems in a natural way.

The stimulating action of reflexive therapies on internal organs e.g. induction of contractions of an atonic bladder[29,37,65] or uterus (unpublished observations), achieved by means of irritation of related skin areas, is also possible by the utilization of the above described reflexive mechanism. In this case it is a result of the stronger stimulation of nociceptive receptors of the skin 'AP' and secondary mobilization of the appropriate visceromotor reflex arc 'M'.

The way in which nervous afferent impulses arising from the diseased organ cause the phenomenon of electrical rectification in corresponding skin areas still has to be clarified.

According to the hypothesis described above (and illustrated in figure 5), damaged organ 'O' causes antidromic stimulation of sensory nerve fibre 'SF' arising from corresponding skin area 'AP'. This results in the release of neuropeptides at the innervated epidermal area.[62-64] Increased capillary membrane permeability can therefore be expected in the vicinity of the nerve[62], which allows extravasation of blood plasma protein molecules (mainly albumin).[67,68] Intercellular fluid has the same composition as blood plasma except that the concentration of protein in blood plasma is much higher than in intercellular fluid.

Electrical stimulation of the skin surface, e.g. with the OED measuring electrode, leads to structural changes in the stratum corneum known as electroporation.[16,17,19] The stratum corneum

Fig.5 Convergence modulation theory (description in text).
AP – acupuncture point, O – internal organ, M – executive organ of reflex arc, QF – thick non-nociceptive nerve fibres, SF – thin nociceptive nerve fibres, CN – converging neuron, IN – inhibitory neuron (gelatinous substance), AT – ascending nervous tracts (specific and non-specific), o – excitatory synapse, • – inhibitory synapse.

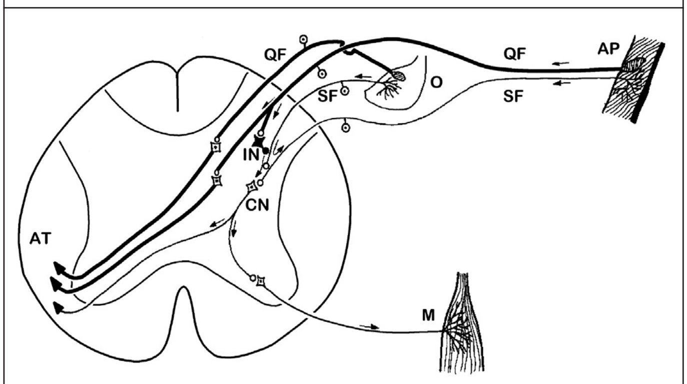


Fig.6a Molecular structure of the outermost layers of the skin.

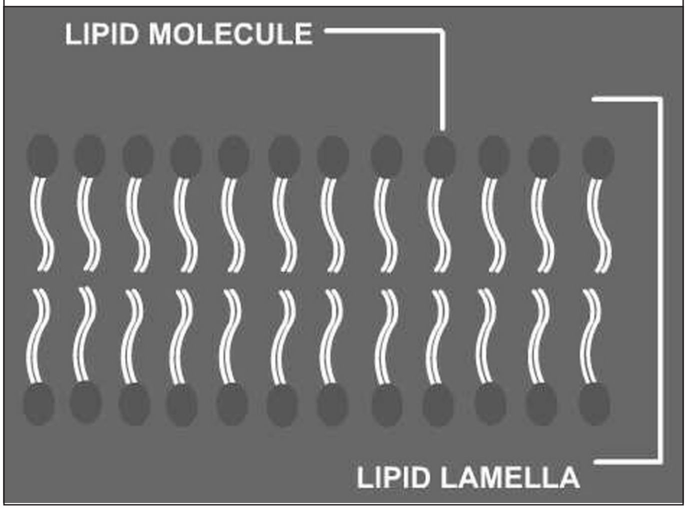


Fig.6b Electropore.

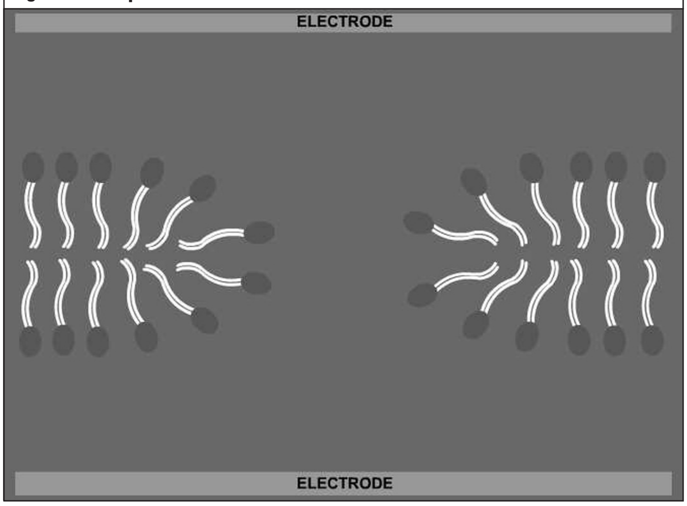


Fig.7a Blocked electropore.

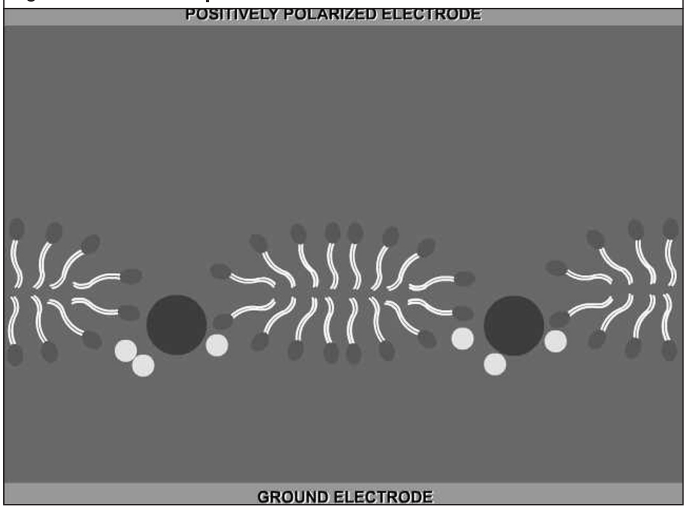
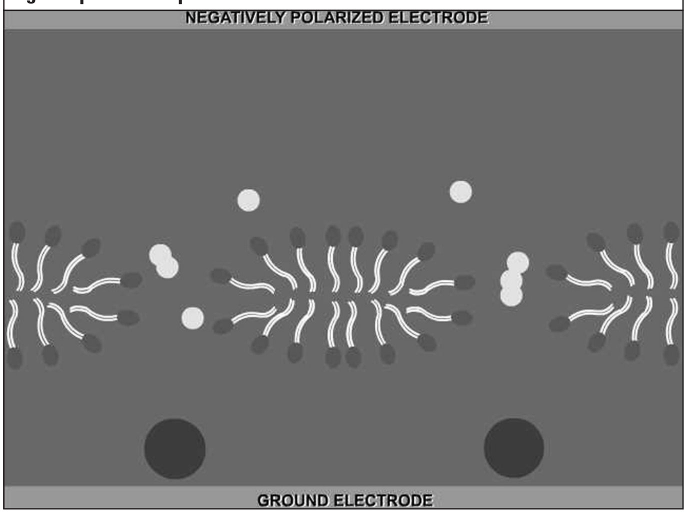


Fig.7b Open electropore.



consists of layers of lipid lamellae (Fig.6a). Due to lateral thermal fluctuations of lipid molecules, pores are spontaneously formed in these lipid membranes. These pores are randomly and continuously created and destroyed. However under the influence of an electric field, they enter a stable state (Fig.6b). The pores are pathways through which ions can move more freely across the membrane and therefore increase membrane conductance.

Under sufficient electrical stimulation the stratum corneum undergoes a rapid resistance decrease known as reversible ‘breakthrough effect’.[2-22] Recent evidence suggests that this phenomenon is due to electroporation.[20-22] The pores created in the stratum corneum allow ionic current to pass through the skin more easily. However, it has been shown that large molecules can act as pore blockers in electroporated bilayer membranes.[16] Albumin molecules have the correct dimensions to act as pore blockers.

The rectification / diode phenomenon[2-15] is only seen after the reversible ‘breakthrough effect’. Under these conditions the skin resistance measured with a positively polarized electrode is always greater than the resistance measured with a negatively polarized electrode. A positively polarized electrode attracts the negatively charged albumin molecules in the extracellular fluid to the skin surface. These molecules block the electropores, reducing the conductance (Fig.7a). A negatively polarized electrode repels the albumin molecules thereby increasing the conductance (Fig.7b). In this way the signals sent by damaged organs to the CNS can be detected at the skin surface.

The extent of damage done to an internal organ determines the degree of electrical rectification observed at the related skin area.[2-15] The higher the level of tissue damage, the higher the frequency of afferent nervous action potentials and the amount of neuropeptides released at the related epidermal area (AP). This would result in a higher local concentration of albumin molecules which would increase the degree of electrical rectification observed at the skin area.

Discussion

The hypothesis presented still requires experimental support in certain areas. Nevertheless it is an attempt to explain the phenomenon of OED as well as reflexive therapy, based on contemporary scientific principles.

The neurophysiological mechanisms described above filter information directed to the CNS from inside and outside and give priority to signals originating from sensory organs, in this case the skin. This is why painful sensations generated by internal organs can be blocked by mild stimulation of the relevant skin areas. In addition, by breaking the relevant reflex arc, chronically contracted muscles can be relaxed and local blood circulation improved. Also, adequate changes can be induced in hormonal levels. This explains why reflexive therapies are used not only for pain management but also for symptomatic treatment of various disorders (e.g. bronchial asthma, spastic colon, atonic bladder or uterus) and the accelerated healing of damaged tissues (wounds, chronic inflammations, neuropathies). In general, the reflexive therapies seem to function by controlling the flow of information in the nervous system and thereby reprogramming the powerful self-defense systems, according to actual needs.

Pain = afferent pulsesXcentral modulation (this can be influenced pharmacologically, psychologically or surgically). The OED is able not only to trace the source of painful sensations but also to assess the frequency of afferent pulses sent from damaged tissues to the CNS, i.e. if OED does not detect afferent pulses, there is no basis for organogenic pain.

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